ICT for disaster-resilient education and training

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Abstract

The 3L-Person 2022 workshop was held in Kryvyi Rih, Ukraine, on October 25, 2022. The workshop aimed to provide a platform for researchers and practitioners from different domains and regions, who are interested in exploring the opportunities and challenges of information and communication technologies (ICT) for lifelong learning and professional development. The workshop addressed various topics related to the design, development, evaluation, and application of ICT for education and training, such as personal learning environment design, advanced ICT for professional retraining and training in the workplace, blended and remote learning/teaching with emerging ICT, educational robots, databases and language technologies for open learning and research, ICT in education of a person with special needs, ICT in education safety and security, ICT-support of STEM education and professional career, and synthetic learning environment. The workshop featured 13 papers selected by a diverse and qualified program committee. The workshop also facilitated the discussion and networking among the participants, who shared their experiences and insights on the emerging trends and issues in this interdisciplinary field. This paper presents the theme, aims, topics of interest, program committee, accepted papers, and outcomes of the workshop.

Keywords

ICT, education, training, learning, workshop

1. Introduction

1.1. 3L-Person in a glance

The **International Workshop on Professional Retraining and Life-Long Learning using ICT: Person-oriented Approach** (3L-Person) is a peer-reviewed workshop. The work-

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shop's goal is to bring together researchers and practitioners from the areas of Information/Communication Technologies (ICT) and Education/Training (E/T), to support the bridging process between ICT opportunities and education/training needs. ICT have a profound impact on education and training, offering new opportunities and challenges for learners, educators, and researchers. However, there is a need for a better understanding of the potential and limitations of these technologies, as well as the best practices and methodologies for their design and implementation. The workshop is cover such topics as ICT tools' design for: remote learning, adaptive learning, day-to-day support for individual's learning, synthetic learning environment, life-long learning of individuals, learning in the workplace, learning/training process of individuals with special needs, teaching/learning safety and security, vocational training and carrier guiding, etc.

The workshop is also address the issues of time, space, and cultural differences of learners and teachers, and how ICT can help to overcome them. The specific goal of this activity is to facilitate a broader understanding of the promise and pitfalls of these technologies and working (learning/teaching) environments in global education/development settings, with special regard to the human as subject in the system and to the integration of humans with the technical, didactic, and organizational subsystems.

Figure 1: 3L-Person logo.

1.2. 3L-Person aims

The workshop aims to achieve the following objectives:

1. The identification of needs and opportunities in which coordinated research efforts are required to expand and understand the emerging technologies in education (such as cloud computing, mobile tools and services, network infrastructures, systems of computer modeling, simulation, AR/VR/MR etc.), their effectiveness, the potential risks, and the potential benefits of new ways to educate, learn and collaborate.
2. The presentation and discussion of novel ICT solutions in E/T that can support and enhance lifelong learning and professional development of individuals and organizations.
3. The dissemination of information and experiences about the current trends and future prospects of global education in the near future, and how ICT can facilitate them.

1.3. 3L-Person topics of interest

3L-Person topics of interest since 2019 [1, 2]:

- **Personal Learning Environment Design**: person-oriented tools, adaptive and intuitive learning, cloud-based learning environment, social networking, etc.
- **Advanced ICT for Professional Retraining and Training in the Workplace**: cloud-based learning tools, mobile-based learning, learning networking tools, etc.

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

This volume contains the papers presented at the VII International Workshop on Professional Retraining and Life-Long Learning using ICT: Person-oriented Approach (3L-Person 2022) held on October 25, 2022 in Ukraine.

The workshop received 19 submissions. Each submission was reviewed by at least 3 program committee members. On average, each submission was reviewed by 3.2 program committee members. Based on the reviews, 13 papers were accepted for this volume as regular papers, 11 as full papers, and 2 as short papers.

2. Program committee

- *Marc Baaden*, CNRS, France [3]
- *Liudmyla Bilousova*, Academy of Cognitive and Natural Sciences, Ukraine & Israel [4]
- *Pablo Garcia Bringas*, University of Deusto, Spain [5]
- *Oleksandr Burov*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine & University of Vienna, Austria [6]
- *Nadire Cavus*, Near East University, North Cyprus [7]
- *El-Sayed M. El-Horbaty*, Ain Shams University, Egypt [8]
- *Ramón Fabregat*, University of Girona, Spain [9]
- *Irina Georgescu*, Bucharest University of Economics, Romania [10]
- *Mustansar Ali Ghazanfar*, University of East London, United Kingdom [11]
- *Anita Goel*, University of Delhi, India [12]
- *Carina S. Gonzalez*, Universidad de La Laguna, Spain [13]
- *Sven Hartmann*, Clausthal University of Technology, Germany [14]
- *Michail Kalogiannakis*, University of Crete, Greece [15]

- *Arnold Kiv*, Ben-Gurion University of the Negev, Israel [16]
- *Hennadiy Kravtsov*, Kherson State University, Ukraine [17]
- *Olena Kuzminska*, National University of Life and Environmental Sciences of Ukraine, Ukraine [18]
- *Francesco Lelli*, Tilburg University, Netherlands [19]
- *Chung-Sheng Li*, PwC, United States [20]
- *Piotr Lipiński*, Technical University of Lodz, Poland [21]
- *Alessandra Lumini*, University of Bologna, Italy [22]
- *Svitlana Lytvynova*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [23]
- *Maiia Marienko*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [24]
- *Rashid Mehmood*, King Abdulaziz University, Saudi Arabia [25]
- *Iryna Mintii*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [26]
- *Natalia Morze*, Borys Grinchenko Kyiv University, Ukraine [27]
- *Vincenzo Moscato*, University of Naples "Federico II", Italia [28]
- *Thomas Moser*, St. Pölten University of Applied Sciences, Austria [29]
- *Ranesh Kumar Naha*, University of Tasmania, Australia [30]
- *Viacheslav Osadchyi*, Borys Grinchenko Kyiv University, Ukraine [31]
- *Liubov Panchenko*, Igor Sikorsky Kyiv Polytechnic Institute, Ukraine [32]
- *Stamatios Papadakis*, University of Crete, Greece [33]
- *Olha Pinchuk*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [34]
- *Michael M. Resch*, HLRS, University of Stuttgart, Germany [35]
- *Nina Rizun*, Gdańsk University of Technology, Poland [36]
- *Abdel-Badeeh M. Salem*, Ain Shams University, Egypt [37]
- *Demetrios G. Sampson*, University of Piraeus, Greece [38]
- *Antonio Sarasa Cabezuelo*, Universidad Complutense de Madrid, Spain [39]
- *Olena Semenikhina*, Sumy State A.S.Makarenko Pedagogical University, Ukraine [40]
- *Serhiy Semerikov*, Kryvyi Rih State Pedagogical University, Ukraine [41]
- *Liying Shen*, Anhui University, China [42]
- *Prem Kumar Singh*, Gandhi Institute of Technology and Management, India [43]
- *Mariya Shyshkina*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [44]
- *Oleg Spirin*, Institute for Digitalisation of Education of the NAES of Ukraine, Ukraine [45]
- *Andrii Striuk*, Kryvyi Rih National University, Ukraine [46]
- *Daniel Thalmann*, Swiss Federal Institute of Technology in Lausanne, Switzerland [47]
- *Tetiana Vakaliuk*, Zhytomyr Polytechnic State University, Ukraine [48]
- *Vladyslav Velychko*, Donbas State Pedagogical University, Ukraine [49]
- *Kateryna Vlasenko*, National University of Kyiv Mohyla Academy, Ukraine [50]
- *Longkai Wu*, National Institute of Education, Singapore [51]
- *Eftim Zdravevski*, University Ss Cyril and Methodius, Macedonia [52]

3. Articles overview

The paper "Online training of youth volunteers for projecting socially significant actions in the COVID-19 pandemic" [53] by Oleksandr G. Kucheryaviy and Dmytro G. Gryshchuk addresses the challenge of engaging youth volunteers in meaningful social projects during the COVID-19 pandemic, which has disrupted many aspects of life and increased the demand for humanitarian assistance. The paper proposes a novel online training program that aims to equip youth volunteers with the necessary competences and skills to design and implement socially significant projects in the context of the global health crisis.

The paper presents the theoretical and practical foundations of the program, which is based on several principles, such as: online dominance, ICT literacy, project-based learning, gerontological and psychotherapeutic knowledge, self-preservation and self-organization skills, emotional and personal support. The paper also describes the content and methods of the program, which include: motivational and organizational techniques, stimulation of project activity, humanistic and interactive approaches.

The paper reports on the experimental testing of the program and the assessment of its effectiveness using the criteria of readiness for volunteer project action. The paper shows that the program has a positive impact on the participants' knowledge, skills, attitudes, and values related to volunteer projects. The paper concludes with some implications and recommendations for further research and practice.

The paper "CoCalc: an integrated environment for open science education in informatics and mathematics" [54] by Pavlo V. Merzlykin, Maiia V. Marienko, and Svitlana V. Shokaliuk, delves into the exploration of CoCalc, a cloud-based platform designed to facilitate open science education. CoCalc serves as an integrated environment offering a wide array of services and tools that empower users to create, share, and collaborate on computational documents supporting various programming languages and frameworks.

In this comprehensive analysis, the authors aim to identify the structural components of CoCalc ideally suited for educational purposes within the domains of informatics and mathematics. They investigate the potential use cases and benefits of CoCalc for these disciplines while scrutinizing the inner workings of the CoCalc kernel. The paper illuminates the features within CoCalc that can enhance diverse learning activities, including interactive coding, data analysis, visualization, simulation, testing, and assessment.

Furthermore, the authors delve into the challenges and opportunities presented by the integration of CoCalc into open science education. These considerations encompass accessibility, reproducibility, transparency, and ethical aspects. The paper concludes by asserting that CoCalc stands as a promising and versatile environment capable of elevating the quality and effectiveness of informatics and mathematical education. It accomplishes this by providing a comprehensive and adaptable suite of services and tools tailored to the unique requirements of these disciplines.

The paper "Internet resources for foreign language education in primary school: challenges and opportunities" [55] by Inna A. Kravtsova, Alina O. Mankuta, Vita A. Hamaniuk, Olga S. Bilozir and Andrei V. Voznyak aims to examine how Internet resources can be used to improve the quality and effectiveness of foreign language education in primary school in Ukraine. The paper is based on the premise that foreign language education is a key component of the New Ukrainian School concept, which is a reform initiative that seeks to create a school that is

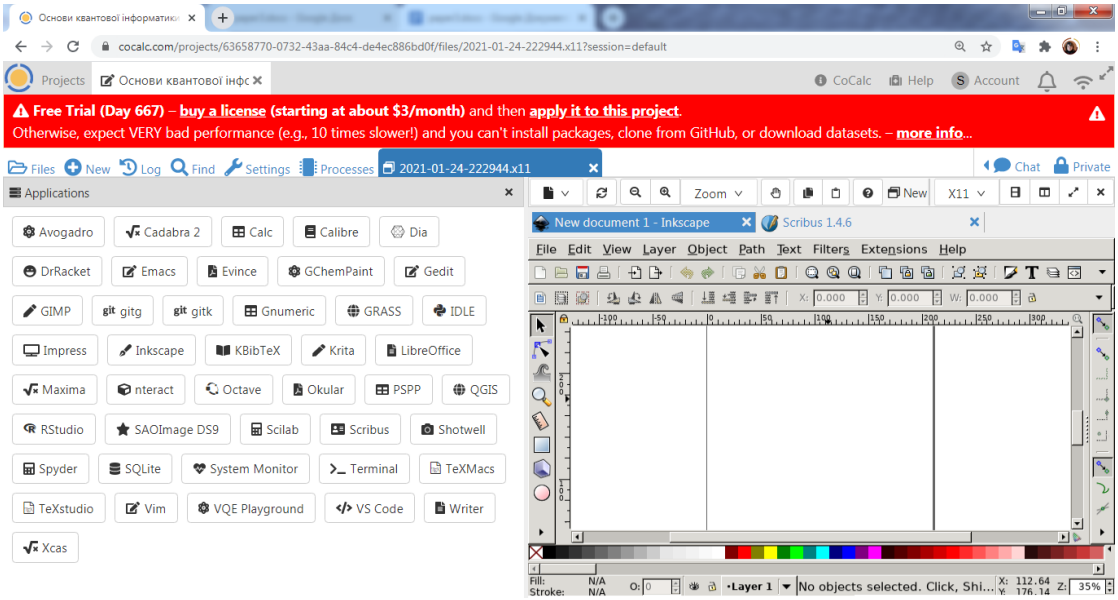

Figure 2: Presentation of paper [54].

pleasant, modern, and relevant for students. The paper identifies the main challenges and opportunities of developing professional competence of primary school teachers in teaching foreign languages, such as the need for updating the curriculum, enhancing teacher training, and reducing bureaucracy. The paper also provides a comprehensive overview of various Internet resources that can support foreign language learning in primary school, such as online platforms, games, videos, podcasts, blogs, and social networks. The paper evaluates the advantages and disadvantages of these resources in terms of accessibility, usability, interactivity, motivation, and feedback. The paper concludes that Internet resources can help modernize foreign language education in primary school and align it with the New Ukrainian School concept, but they also require careful selection, adaptation, and integration into the teaching process.

The paper "Digital resources for developing key competencies in Ukrainian education: teachers' experience and challenges" [56] by Oksana V. Ovcharuk, Iryna V. Ivaniuk, Oleksandr Yu. Burov, Maiia V. Marienko, Nataliia V. Soroko, Olena O. Gritsenchuk and Oksana Y. Kravchyna investigates how Ukrainian teachers use various digital resources in their classroom activities to develop key competencies in their students, such as digital, civic, and entrepreneurship skills. The paper focuses on three key subject areas that are aligned with the European trends and the UN '2030 Agenda for Sustainable Development': STEM education, education for democratic citizenship, and entrepreneurship education. The paper presents and evaluates different online tools and digital resources that support these subject areas, such as online platforms, games, videos, podcasts, blogs, and social networks. The paper also showcases the national online resources that promote a sustainable, multicultural, and democratic learning environment for teachers and students. The paper analyses the teachers' experience and challenges of using digital resources in their teaching practice, such as how they integrate digital technologies into their curriculum, how they identify and address the needs and didactic approaches of their

Figure 3: Presentation of paper [55].

students, how they solve technical problems, and how they assess the gaps in their own and their students' digital and civic competencies. The paper highlights the benefits and challenges of using digital resources for teachers, such as improving and updating their digital competence, creating and maintaining a creative and sustainable digital environment in their schools, seeking opportunities for self-development and digital transformation, and organising distance learning in response to the COVID-19 pandemic. The paper aims to share the examples and the experience of Ukrainian educators who use digital educational resources to build a digital environment and develop key competencies in their students. The paper suggests that the presented experience can be applied in other schools and help to address the existing gaps in the teachers' use of digital learning tools.

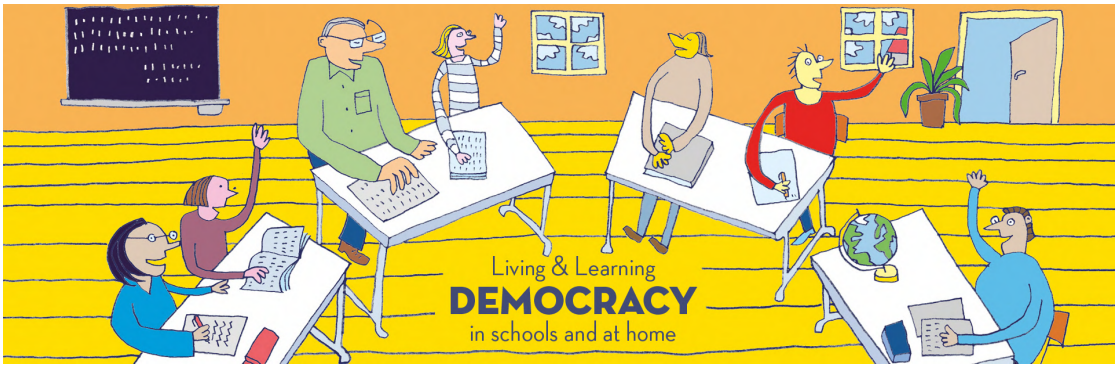

Figure 4: Presentation of paper [56].

The paper "YouTube as an open resource for foreign language learning: a case study of German" [57] by Olha V. Chorna, Vita A. Hamaniuk, Oksana Y. Markheva and Andrei V. Voznyak examines how YouTube can be used as an open resource for learning German as a foreign language in higher education, especially at a pedagogical university. The paper is divided into three main parts:

- The first part provides the theoretical background and context of the paper, explaining the importance and benefits of using information and communication technologies (ICT) and online resources for foreign language learning, especially in the context of distance learning. The paper also reviews the literature on the use of YouTube for language learning and identifies the criteria for selecting and evaluating YouTube video materials for teaching German.
- The second part presents the results of a practical analysis of several YouTube channels that offer video materials for learning German, such as Easy German, Deutsch für Euch, Learn German with Anja, and Deutsch mit Marija. The paper provides a brief didactic analysis of their products and suggests how to transform them into methodological material for the practical course of German language for future teachers. The paper also explores the potential of using alternative YouTube resources for distance learning, such as videos with subtitles, videos with interactive quizzes, videos with role-playing scenarios, and videos with mediation tasks. The paper explains how these resources

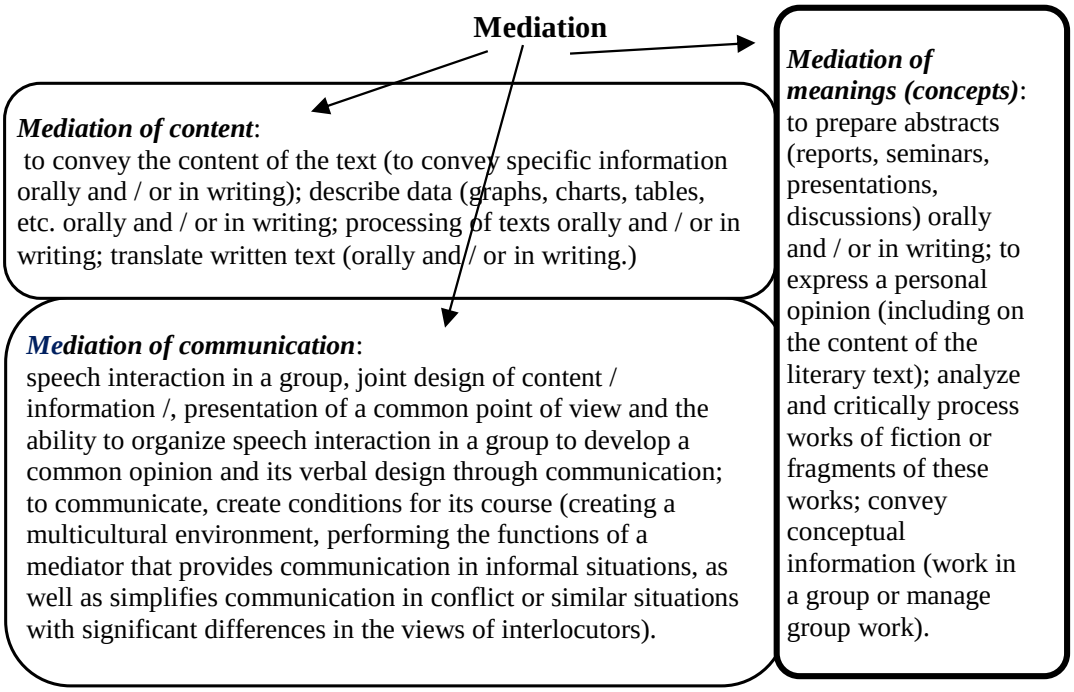

Figure 5: Presentation of paper [57].

can help develop mediation skills as defined by the CEFR Companion Volume with New Descriptors.

- The third part discusses the open resources ONCOO and TWINE, which can be used to foster the autonomy of future foreign language teachers. ONCOO is an online platform that allows teachers to create interactive learning scenarios with videos, texts, images, and audio files. TWINE is an online tool that allows teachers to create interactive stories with branching paths and choices. The paper describes the features and advantages of these resources and provides some examples of their use for teaching German.

The paper concludes that YouTube can be used as an open resource for foreign language learning, especially for teaching German as a first or second foreign language in higher education. The paper argues that YouTube can offer authentic, diverse, and engaging video materials that can support the development of various linguistic and ICT competencies, as well as mediation skills. The paper also suggests that YouTube can be combined with other open resources, such as ONCOO and TWINE, to create interactive and autonomous learning environments for future foreign language teachers.

The paper "Developing digital learning aids for pre-service IT specialists using the functional approach in holistic vocational training" [58] by Liudmyla I. Bilousova and Liudmyla E. Gryzun is a research article that aims to demonstrate how the functional approach can be used to design and implement digital learning aids for pre-service IT specialists in a holistic educational setting. The paper is based on the authors' practical experience of conducting project-based activities with IT students at a university in Ukraine.

The paper begins with an introduction that explains the importance and challenges of developing digital learning aids for IT education, especially in the context of the rapid changes

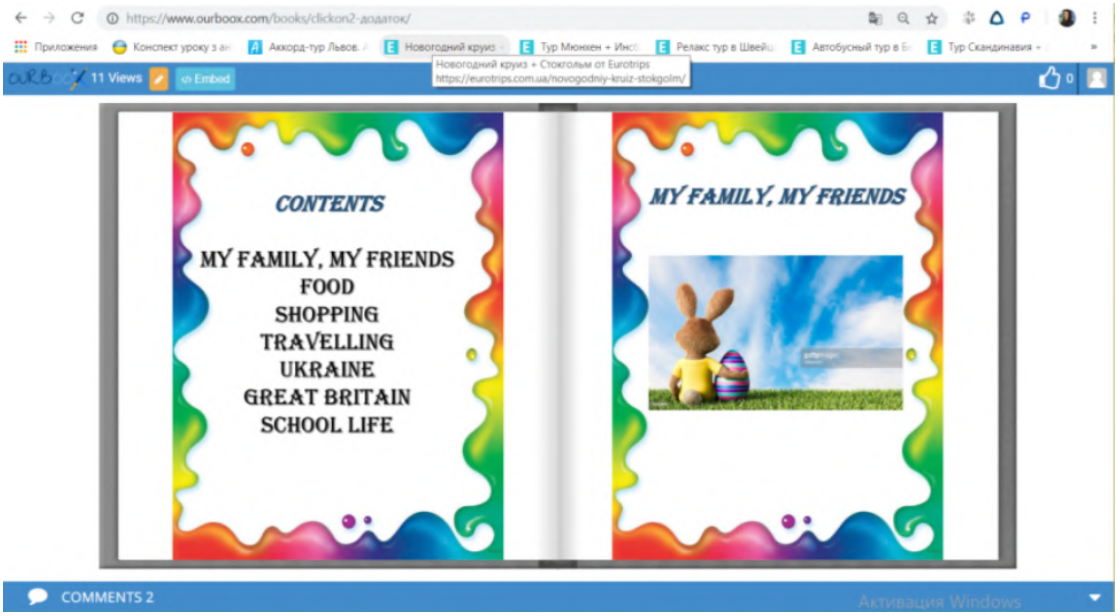

Figure 6: Presentation of paper [58].

and demands of the modern world. The paper then reviews the theoretical background of the holistic educational paradigm and the functional approach to digital didactic aids design, which are the main frameworks that guide the authors' work. The paper also defines some key concepts and terms related to digital learning aids, such as didactic functions, digital didactic design, and digital laboratory centre.

The paper then presents two case studies of students' project work on creating digital learning aids using the functional approach. The first case study describes the design of a multimedia tutorial for teaching English to schoolchildren, which aims to develop their linguistic, communicative, and intercultural competencies. The second case study describes the design of an e-guide on the basics of cryptography for university students, which aims to develop their mathematical, logical, and analytical skills. The paper provides detailed descriptions of the steps and procedures involved in each project, such as needs analysis, content selection, didactic functions determination, digital tools choice, design principles application, implementation, and evaluation.

The paper then discusses the results and benefits of applying the functional approach to the development of digital learning aids for pre-service IT specialists. The paper highlights how the functional approach enables the creation of digital learning aids that are relevant, contextualized, tailored, integrated, interactive, and adaptive to the learners' needs and goals. The paper also emphasizes how the functional approach fosters holistic learning outcomes that encompass cognitive, affective, social, and professional domains. The paper also identifies some challenges and limitations of applying the functional approach, such as time constraints, technical difficulties, and ethical issues.

The paper concludes with some suggestions for future research and practice in the field of digital learning aids development for IT education. The paper proposes some directions for further exploration and improvement of the functional approach, such as incorporating more feedback mechanisms, developing more criteria and indicators for evaluation, and expanding the scope and diversity of digital learning aids. The paper also calls for more collaboration and communication among researchers, teachers, students, and other stakeholders in the process of digital learning aids development.

The paper "Developing professional stability of future socionomic specialists using cloud technologies in blended learning" by Hanna B. Varina, Kateryna P. Osadcha, Svetlana V. Shevchenko, and Valentyna V. Voloshyna is a research article that investigates how cloud technologies can be used to foster the professional stability of future socionomic specialists in blended learning settings. Socionomic specialists are professionals who work with people and social issues, such as social workers, psychologists, educators, and healthcare workers. Professional stability is defined as the ability to cope with the challenges and changes in the professional environment and to maintain a high level of performance and satisfaction.

The paper starts with an introduction that explains the relevance and importance of developing professional stability among future socionomic specialists, who face high demands and expectations in their work. The paper then reviews the literature on blended learning, cloud technologies, and professional stability, highlighting the advantages and challenges of using cloud services, such as Google Workspace for Education and Moodle, to support the learning and development of students. The paper also defines the main concepts and terms related to professional stability, such as its components (cognitive, motivational, behavioral, emo-

COMPONENTS OF THE FUTURE SPECIALIST'S PROFESSIONAL STABILITY

Motivational component	Cognitive component	Connotative component	Reflexive-valuable component	Regulatory-volitional component
Motives related to the attitude to the future professional activities	Awareness of the patterns of future professional activity in the field of practical psychology	Skills of organizing and finding a creative solution of problems in future professional activity	Ability for reflection	Volitional regulation of future activities
	Awareness of the principles, directions, technologies of professional activity		Value orientations in future professional activity	Ability for self-regulation
Motives related to the development of professionally significant personal traits	Subject-specific knowledge	Skills and abilities of professionally stable behavior	Readiness for productive communication and establishment of trusting relationships (level of development of communication sphere and empathy)	Volitional regulation at the stage of self-development
Motives of achievement	Knowledge about oneself	Ability to restructure behavior and activities in changing conditions (adaptive capabilities of the individual)		The level of emotional regulation development

Figure 7: Presentation of paper [59].

tional and volitional), indicators (empathy, emotional self-regulation, vitality), and conditions (psychological and pedagogical).

The paper then presents the methodological framework for designing the process of professional stability development based on cloud technologies. The paper describes the principles, stages, methods, and tools of the cloud-based program, which aims to enhance the ICT competence and the mental capacity of the students through various learning activities and assessments. The paper also provides examples of how cloud services can be used to develop different components and indicators of professional stability.

The paper then reports the results of an empirical study that evaluated the effectiveness of the cloud-based program on the development of professional stability among students in blended learning. The study used a quasi-experimental design with pre-test and post-test measurements of professional stability components and indicators among two groups of students: experimental (who participated in the cloud-based program) and control (who did not). The study found

significant positive changes in the experimental group compared to the control group in terms of cognitive, motivational, behavioral, emotional and volitional components and empathy, emotional self-regulation, vitality indicators of professional stability.

The paper concludes with some implications and recommendations for further research and practice in the field of professional stability development using cloud technologies. The paper suggests some ways to improve and optimize the cloud-based program, such as incorporating more feedback mechanisms, developing more criteria and indicators for evaluation, and expanding the scope and diversity of cloud services. The paper also calls for more collaboration and communication among researchers, teachers, students, and other stakeholders in the process of professional stability development.

The paper "Inquiry-based learning for enhancing students' interest in mathematical research: a case study on approximation theory and Fourier series" by Kateryna V. Vlasenko, Olha H. Rovenska, Iryna V. Lovianova, Oksana M. Kondratyeva, Vitaliy V. Achkan, and Yana M. Tkachenko is a research article that explores how inquiry-based learning (IBL) can be used to stimulate students' interest in mathematical research. The paper focuses on the case study of using IBL to teach approximation theory and Fourier series, which are fundamental concepts in mathematics and computer science.

The paper begins with an introduction that explains the rationale and objectives of the study, as well as the main concepts and terms related to IBL, approximation theory, and Fourier series. The paper then reviews the literature on the benefits and challenges of using IBL in mathematics education, as well as the existing methods and tools for teaching approximation theory and Fourier series.

The paper then describes the methodology of the case study, which involved designing and implementing IBL workshops for undergraduate students majoring in mathematics and computer science. The paper explains the structure and content of the workshops, which consisted of four stages: posing an essential question, conducting an inquiry, presenting and discussing the results, and reflecting on the learning process. The paper also describes the

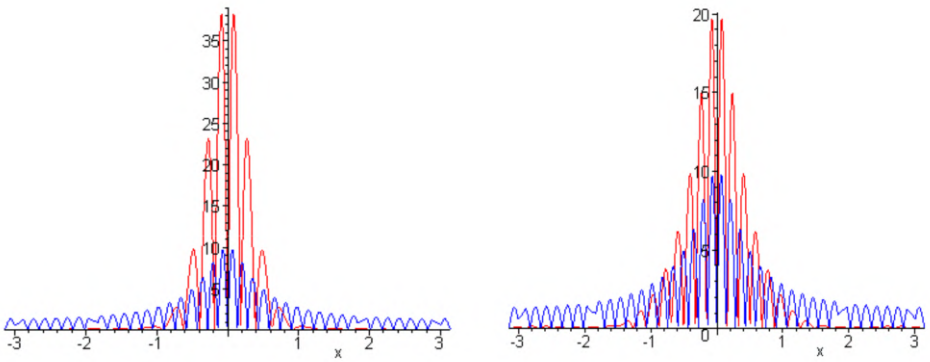

Figure 8: Presentation of paper [60].

instruments and procedures for collecting and analyzing the data, which included a survey questionnaire and the Differential Emotion Scale (DES) by Izard to measure the students' emotional state before and after the workshops.

The paper then reports and discusses the findings of the data analysis, which showed that the IBL workshops had a positive impact on the students' interest in mathematical research. The paper reveals that the students' negative emotions, such as anger, fear, sadness, disgust, contempt, and shame, decreased significantly after participating in the workshops, while their positive emotions, such as joy, surprise, interest, love, pride, and gratitude, increased significantly. The paper also shows that the students' engagement and motivation in the mathematical research activities improved after experiencing IBL.

The paper concludes with some implications and recommendations for future practice and research in the field of mathematics education using IBL. The paper suggests some ways to improve the design and implementation of IBL workshops, such as providing more guidance and feedback to the students, using more diverse and interactive digital tools, and integrating more interdisciplinary and real-world problems. The paper also calls for more studies on the effects of IBL on other aspects of mathematical learning outcomes, such as conceptual understanding, problem-solving skills, creativity, and collaboration.

The paper "Developing digital and ICT literacy skills for future foreign language teachers: a comparative and action research approach" by Tetiana V. Konovalenko, Yuliia A. Nadolska, Tamara B. Poyasok, and Andrii M. Striuk examines how to enhance the digital and ICT literacy skills of future foreign language teachers in Ukraine and the USA. The paper is based on an action research project that involved both quantitative and qualitative data collection and analysis, as well as several interventions to improve the digital and ICT literacy skills of the participants.

The paper starts with an introduction that explains the importance and challenges of developing digital and ICT literacy skills for foreign language teachers in the 21st century, as well as the main concepts and terms related to digital and ICT literacy, action research, and comparative education. The paper then reviews the literature on the current state of pre-service teacher training programmes in Ukraine and the USA, as well as the existing frameworks and models for defining and assessing digital and ICT literacy skills.

The paper then describes the methodology of the action research project, which involved three phases: (1) a baseline survey of students and teachers in Ukraine and the USA to measure their digital and ICT literacy skills; (2) an implementation phase of several interventions based on the courses of Methodology of foreign language teaching and Practical course of foreign language, which aimed to improve the digital and ICT literacy skills of the students in Ukraine; and (3) a post-intervention survey of students and teachers in Ukraine and the USA to evaluate the impact of the interventions. The paper explains the instruments, procedures, and data analysis methods used in each phase, as well as the ethical considerations and limitations of the project.

The paper then reports and discusses the findings of the data analysis, which showed that: (1) there were significant differences between the students and teachers in Ukraine and the USA in terms of their digital and ICT literacy skills at the baseline level; (2) the interventions had a positive effect on improving the digital and ICT literacy skills of the students in Ukraine; (3) there were still some gaps and challenges in developing digital and ICT literacy skills among the

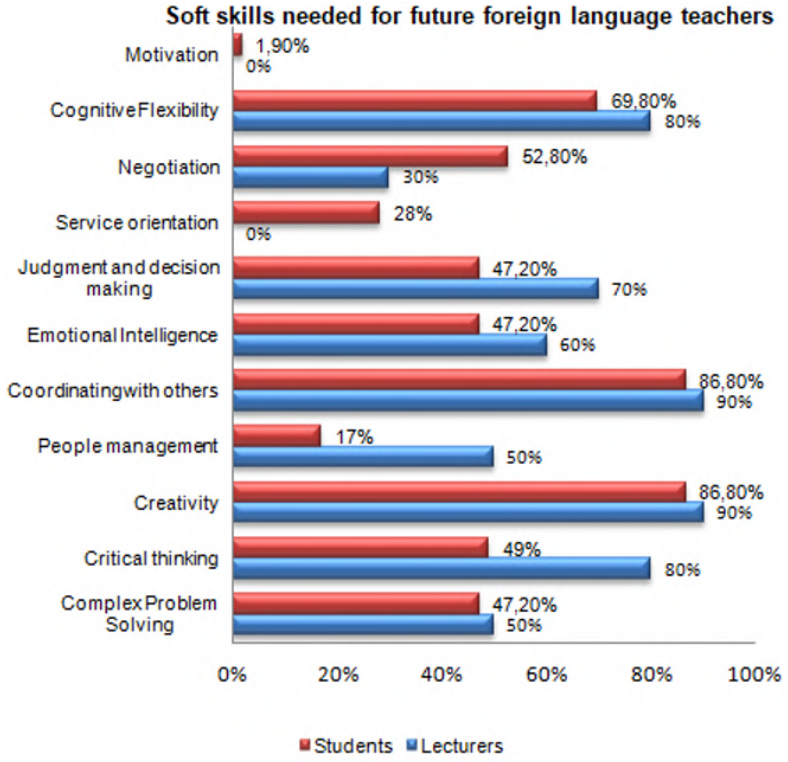

Figure 9: Presentation of paper [61].

participants, especially in relation to critical thinking, creativity, collaboration, communication, and digital citizenship; and (4) there were some positive practices and projects that emerged from the project, such as creating digital portfolios, using online platforms for learning and teaching, participating in online conferences and webinars123, etc.

The paper concludes with some implications and recommendations for future practice and research in the field of digital and ICT literacy development for foreign language teachers. The paper suggests some ways to improve the pre-service teacher training programmes in both countries, such as integrating more digital and ICT literacy components into the curriculum, providing more guidance and feedback to the students, using more diverse and interactive digital tools, fostering more collaboration among students and teachers, etc. The paper also calls for more action research projects that involve cross-cultural comparisons, longitudinal studies, mixed methods approaches, etc.

The paper “Exploring the potential of immersive technologies in university education worldwide” by Kateryna M. Binytska, Olha O. Bilyakovska, Oleksandra I. Yankovych, Galyna V. Buchkivska, Olena P. Binytska, Valentyna V. Greskova, and Inna P. Ocheretna is a research article that examines how immersive technologies can be used to enhance the learning and teaching experiences of university students and teachers across different disciplines and contexts. The paper defines immersive technologies as those that integrate technology with traditional methods of education, providing a more realistic and stimulating environment for growth1.

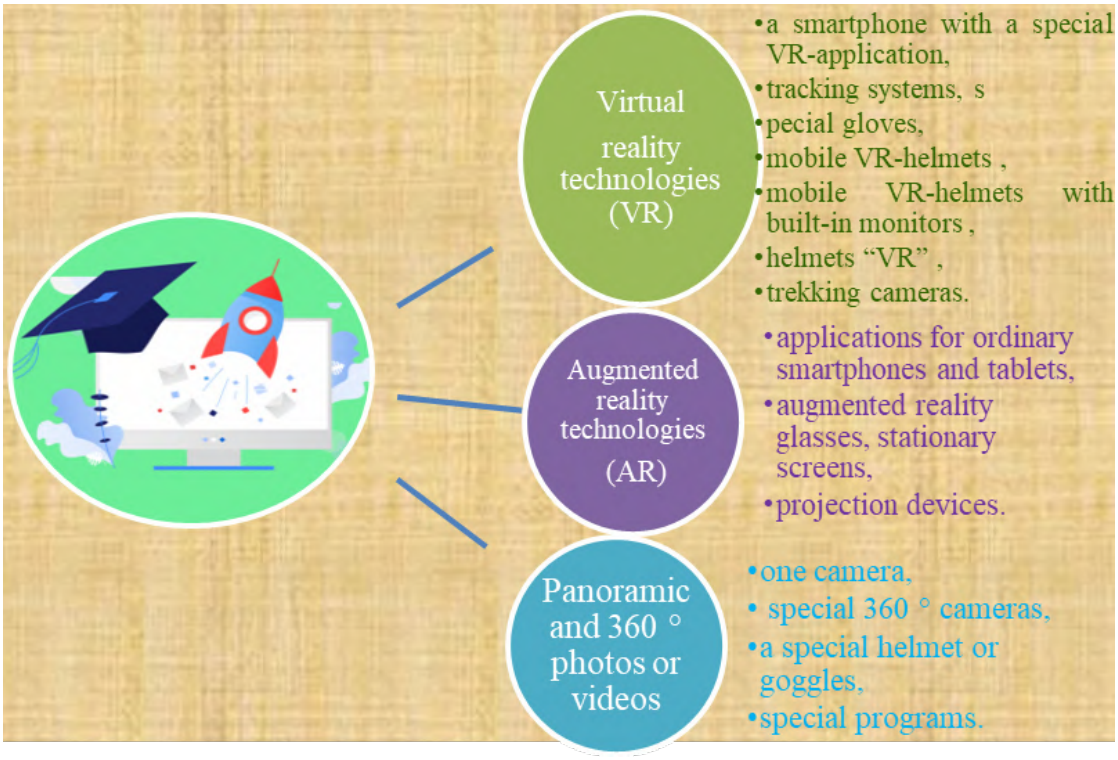

Figure 10: Presentation of paper [62].

The paper begins with an introduction that explains the importance and challenges of using immersive technologies in university education, as well as the main concepts and terms related to immersive technologies, such as virtual reality, augmented reality, mixed reality, and extended reality. The paper then reviews the literature on the advantages and disadvantages of using immersive technologies in university education, such as increasing engagement, motivation, creativity, collaboration, and accessibility, as well as raising ethical, technical, and pedagogical issues.

The paper then presents the main part of the analysis, which is divided into two sections: (1) the use of immersive technologies in professional training for various fields of study, such as archaeology, architecture, engineering, aviation, rescue, and medicine; and (2) the use of immersive technologies in creating inclusive learning environments for students with special educational needs. The paper provides examples and evidence of how immersive technologies can facilitate the acquisition of knowledge and skills, as well as the development of attitudes and values, among students and teachers in these fields and contexts.

The paper then discusses the global experiences with immersive technologies in university education, highlighting some innovative and impactful examples of their use in distance learning, empathy training for social issues such as homelessness, and environmental education on topics such as ocean oxidation and coral reefs. The paper shows how immersive technologies can be used not only for professional training but also for gaining social and emotional experiences

and raising awareness of environmental issues.

The paper concludes with some implications and recommendations for future research and practice in the field of immersive technologies in university education. The paper suggests some ways to improve the design and implementation of immersive technologies in university education, such as involving more stakeholders, conducting more evaluation studies, addressing more ethical and technical challenges, and exploring more interdisciplinary and cross-cultural applications.

The paper "Designing a cloud-oriented methodological system for training science and mathematics teachers in scientific lyceums" by Maiia V. Marienko proposes and evaluates a cloud-based system for preparing teachers of natural and mathematical subjects to work in scientific lyceums. A scientific lyceum is a new type of secondary school in Ukraine that focuses on mathematics, physics, chemistry, biology, and other sciences.

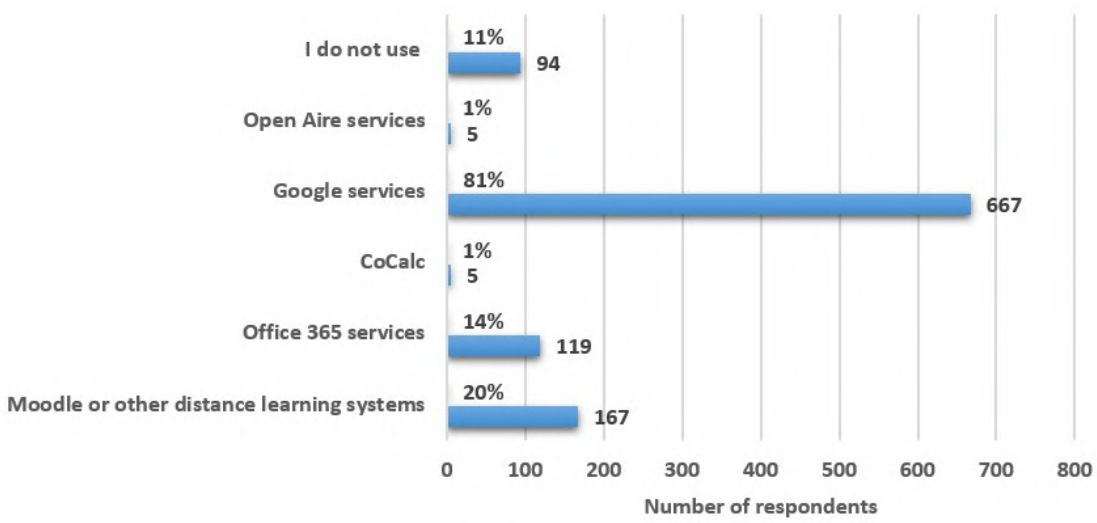

Figure 11: Presentation of paper [63].

The paper starts with an introduction that explains the importance and challenges of reforming teacher training in the context of the rapid development of science and technology, as well as the main concepts and terms related to cloud-oriented systems, open science systems, and scientific lyceums. The paper then reviews the literature on the current state of teacher training programmes in different countries, as well as the existing frameworks and models for designing and implementing cloud-based systems of open science.

The paper then describes the methodology of the pedagogical experiment, which involved designing, modelling, and testing a cloud-oriented methodological system for training teachers of natural and mathematical subjects to work in a scientific lyceum. The paper explains the structure and content of the system, which consists of three levels: basic, intermediate, and advanced. The paper also describes the instruments and procedures for collecting and analyzing the data, which included a survey questionnaire and a test of open science competencies among teachers.

The paper then reports and discusses the findings of the data analysis, which showed that: (1) there was a significant increase in the use of open science services by teachers after participating in the system; (2) there was a significant improvement in the readiness and skills of teachers to conduct research after participating in the system; (3) there was a significant increase in the awareness and understanding of teachers about the functions and requirements of scientific lyceums after participating in the system; and (4) there were some positive practices and projects that emerged from the system, such as creating digital portfolios, using online platforms for learning and teaching, participating in online conferences and webinars, etc.

The paper concludes with some implications and recommendations for future research and practice in the field of cloud-oriented systems for teacher training. The paper suggests some ways to improve and optimize the system, such as involving more stakeholders, conducting more evaluation studies, addressing more ethical and technical challenges, and exploring more interdisciplinary and cross-cultural applications.

The paper "Serverless computing for data processing in open learning and research environments" by Ihor A. Bezverbnyi and Mariya P. Shyshkina investigates how serverless computing can be used to facilitate data processing in open learning and research environments. Serverless computing is a paradigm that allows the execution of code without provisioning or managing servers, which reduces the cost and complexity of cloud-based applications.

The paper begins with an introduction that explains the importance and challenges of data processing in open learning and research environments, as well as the main concepts and terms related to serverless computing, such as lambda functions, cloud services, and hybrid clouds. The paper then reviews the literature on the advantages and disadvantages of serverless computing, as well as the existing applications and frameworks for data processing using serverless technologies.

The paper then presents the main contribution of the paper, which is the proposal of a concept of a hybrid serverless cloud, which combines different types of cloud services to provide access to various tools and resources for learners and researchers. The paper explains the architecture and components of the hybrid serverless cloud, which includes a cloud storage service, a cloud computing service, a cloud database service, a cloud messaging service, and a cloud orchestration service. The paper also describes the functions and features of the hybrid serverless cloud, such as scalability, cost-efficiency, ease of development, security, and interoperability.

The paper then demonstrates the feasibility and effectiveness of the hybrid serverless cloud by presenting a case study of wave files processing using a lambda function. The paper describes the steps and procedures involved in the case study, such as uploading wave files to the cloud storage service, invoking the lambda function to process the wave files, storing the results in the cloud database service, sending notifications to the users via the cloud messaging service, and managing the workflow via the cloud orchestration service. The paper also provides some screenshots and graphs to illustrate the results and performance of the case study.

The paper then discusses the challenges and opportunities of integrating serverless components within open systems of learning and research. The paper identifies some issues and limitations of serverless computing, such as cold start latency, vendor lock-in, debugging difficulties, and security risks. The paper also highlights some potential benefits and applications of serverless computing, such as supporting data-intensive tasks, enabling real-time collaboration, enhancing accessibility and mobility, and fostering innovation and creativity.

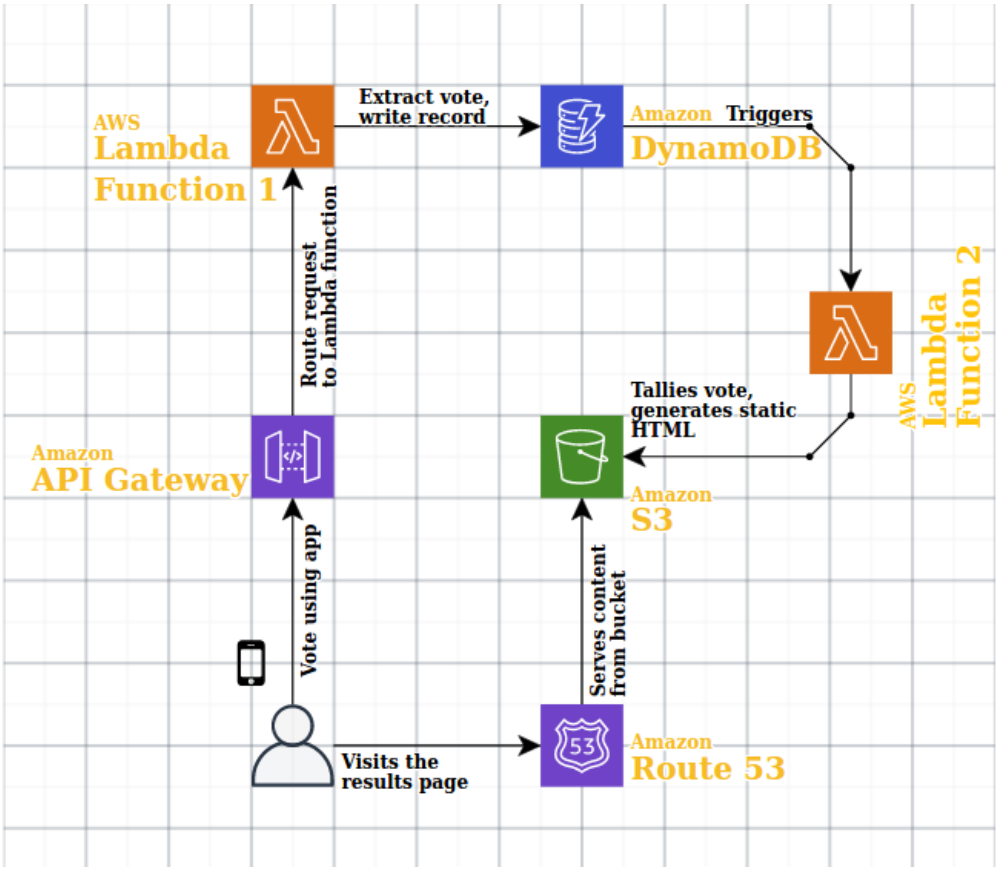

Figure 12: Presentation of paper [64].

The paper concludes with a vision of a cloud-based open learning and research university environment that leverages serverless technologies to improve the quality and accessibility of education and research. The paper envisions a scenario where learners and researchers can use various serverless components to access, process, analyze, share, and publish data in an open and collaborative manner. The paper also suggests some directions for future research and practice in this field.

The paper "Teaching computer game development with Unity engine: a case study" by Natalia V. Moiseienko, Mykhailo V. Moiseienko, Vladyslav S. Kuznetsov, Bohdan A. Rostalny, and Arnold E. Kiv reports on the design and evaluation of a course on computer game development for master's students in the specialty 014.09 Secondary education (Informatics) at the Kryvyi Rih State Pedagogical University. The paper aims to fill the gap in the literature on how to effectively teach computer game development in the context of secondary education.

The paper begins with an introduction that explains the importance and challenges of teaching computer game development, as well as the main concepts and terms related to computer games, software engineering, and Unity Engine. The paper then reviews the literature on the existing courses and methods for teaching computer game development in different educational levels

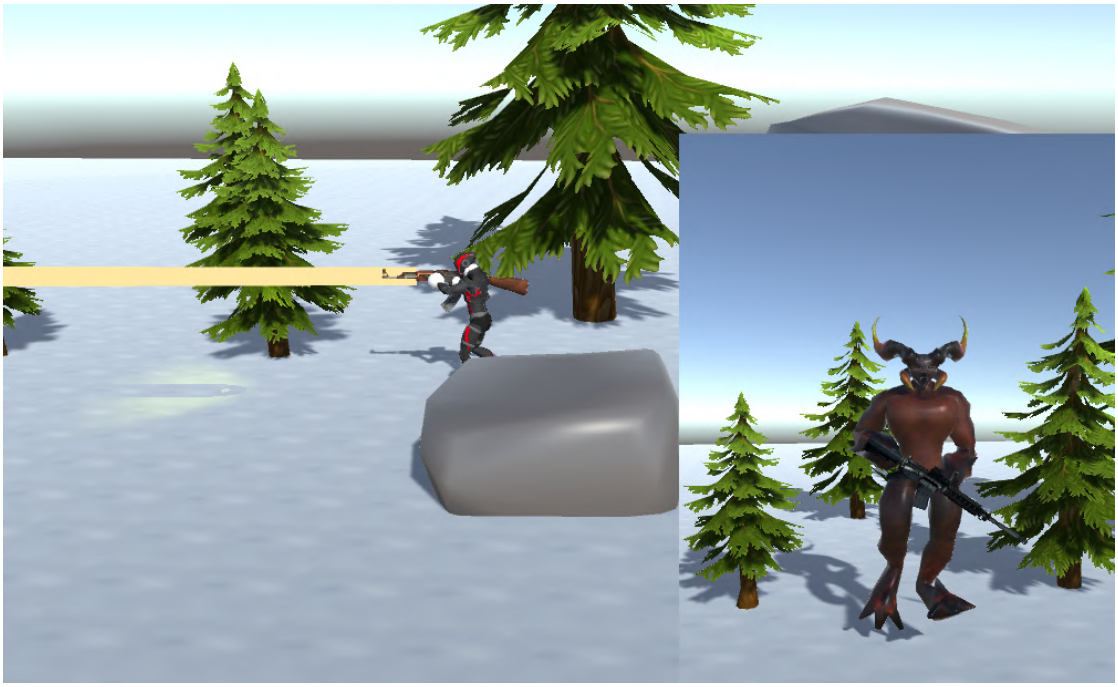

Figure 13: Presentation of paper [65].

and settings.

The paper then describes the methodology of the case study, which involved designing, delivering, and evaluating a course on computer game development for master's students in the specialty 014.09 Secondary education (Informatics) at the Kryvyi Rih State Pedagogical University. The paper explains the objectives, content, software tools, and teaching methods of the course, which was based on Unity Engine, a popular and powerful platform for creating games. The paper also describes the challenges and outcomes of implementing the course, such as technical difficulties, student engagement, project quality, etc.

The paper then presents the results of the evaluation of the course, which was based on a framework proposed by Ritzhaupt, which consists of four dimensions: (1) student satisfaction; (2) student learning; (3) instructor satisfaction; and (4) instructor learning. The paper shows that the course was successful in achieving high scores in all four dimensions, indicating that the course was effective in enhancing students' knowledge and skills in game development, as well as satisfying both students and instructors.

The paper then discusses the implications and recommendations of the case study for future practice and research in the field of computer game development education. The paper suggests some ways to improve and optimize the course, such as providing more guidance and feedback to students, using more diverse and interactive game genres and mechanics, integrating more interdisciplinary and cross-cultural elements, etc. The paper also calls for more studies on the impact of computer game development education on students' cognitive, affective, social, and professional outcomes.

The paper concludes with a summary of the main points and contributions of the paper. The paper highlights that Unity Engine is a suitable platform for teaching computer game development in secondary education, as it offers a low barrier to entry, a rich set of features, a cross-platform compatibility, and a wide adoption in the game industry. The paper also argues that a team-based approach is beneficial for fostering collaboration and creativity among students.

4. Conclusion

The 3L-Person 2022 workshop provides a unique opportunity for researchers and practitioners from various fields and regions to exchange ideas and experiences on the use of ICT for lifelong learning and professional development. The goal of 3L-Person 2022 is to create a forum for presenting and discussing the latest research findings, innovative solutions, and best practices in this interdisciplinary field. The workshop also promotes collaboration and networking among participants, who will benefit from the exchange of knowledge and feedback.

We are grateful to all authors who submitted papers and to the delegates for their participation and interest in 3L-Person as a platform for sharing their ideas and innovations. We also thank all program committee members for their continuous guidance and the efforts of peer reviewers who helped improve the quality of papers. The constructive criticism, improvements, and corrections provided to authors are greatly appreciated for their contribution to the success of the conference. Additionally, we would like to thank the developers and other professional staff of the *Not So Easy Science Education* platform (https://notso.easyscience.education) and the Academy of Cognitive and Natural Sciences (https://acnsci.org) for making it possible for us to use the resources of this excellent and comprehensive conference management system, from calling for papers and inviting reviewers to handling paper submissions, communicating with authors, etc.

The war in Ukraine has had a devastating effect on the country and its people, including its scientific community, with many researchers forced to flee their homes and laboratories. Despite being held in the shadow of this war, the 3L-Person 2022 workshop serves as a testament to the resilience of Ukraine's scientific community. The workshop provides a platform for Ukrainian researchers to share their work and connect with colleagues from around the world. We hope that the workshop will aid in rebuilding Ukraine's scientific community and contribute to the country's recovery.

We also hope that the conference will increase understanding of the war in Ukraine and its impact on education. The papers in the proceedings address a variety of topics related to this disaster.

In conclusion, we express our solidarity with the people of Ukraine and hope for a swift and peaceful resolution to the war.

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Online training of youth volunteers for projecting socially significant actions in the COVID-19 pandemic

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Abstract

The COVID-19 pandemic has posed unprecedented challenges for the society and created a need for effective volunteer actions. This paper presents a novel online training program for youth volunteers who want to design and implement socially significant projects in the context of the global health crisis. The program is based on the following principles: online dominance, ICT literacy, project-based learning, gerontological and psychotherapeutic knowledge, self-preservation and self-organization skills, emotional and personal support. The program aims to develop a set of volunteer project competences among the participants, such as: problem identification, goal setting, action planning, resource mobilization, teamwork, communication, evaluation, and reflection. The paper describes the content and methods of the program, which include: motivational and organizational techniques, stimulation of project activity, humanistic and interactive approaches. The paper also reports on the experimental testing of the program and the assessment of its effectiveness using the criteria of readiness for volunteer project action. The results show that the program has a positive impact on the participants' knowledge, skills, attitudes, and values related to volunteer projects. The paper concludes with some implications and recommendations for further research and practice.

Keywords

online education, volunteer projects, information and communication technologies, project method, crisis management

1. Introduction

The volunteer movement is one of the forms of civic engagement that can contribute to the social well-being and resilience in the face of the COVID-19 pandemic [1]. However, the lockdown measures imposed by the authorities have limited the opportunities for face-to-face volunteer activities and increased the demand for online solutions. According to a survey by the Democratic Initiatives Foundation, more than 80% of Ukrainian citizens reported some impact of the pandemic on their public involvement, and many of them shifted their activities to the Internet [2]. However, compared to the previous years, there was no significant surge

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in volunteerism in Ukraine in 2020s, which can be attributed to various factors, such as: the ongoing war, the state's response to the crisis, the uncertainty and fear caused by the virus, and the information policy regarding COVID-19 [3, 4].

In this context, it is important to explore how youth organizations, which are a key source of volunteer potential, can adapt to the new reality and provide effective assistance to people in need. In particular, it is essential to examine how online education can be used to train and prepare young volunteers for designing and implementing socially significant projects that address the challenges posed by the pandemic. Online education has been widely adopted as a response to the lockdown [5, 6], but its effectiveness depends on various factors, such as: the content, methods, tools, and outcomes of the educational process. Moreover, online education can have an impact not only on the cognitive and professional development of learners, but also on their personal and social development, which are crucial for volunteerism [7].

However, there is a lack of research on the theoretical and practical aspects of online education for youth volunteers in Ukraine. Specifically, there is a gap in the literature on how to design and deliver online courses that aim to develop volunteer project competences among young people. These competences include: identifying social problems, setting goals, planning actions, mobilizing resources, working in teams, communicating effectively, evaluating results, and reflecting on experiences. Furthermore, there is a need for empirical evidence on how such online courses can affect the readiness and willingness of young volunteers to engage in project-based volunteer activities during the pandemic. Therefore, this paper aims to fill this gap by presenting a novel online training program for youth volunteers who want to create and implement volunteer projects that help people cope with the COVID-19 crisis. The paper also reports on the experimental testing of the program and its outcomes.

2. Related work and literature review

Volunteerism is a form of civic engagement that can have positive impacts on the society, especially in times of crisis such as the COVID-19 pandemic. However, volunteer activities require adequate preparation and training, which can be challenging in the context of lockdown and social distancing. Therefore, online education can be a viable alternative to provide young volunteers with the necessary knowledge, skills, attitudes, and values for designing and implementing socially significant projects that address the needs and problems of people affected by the pandemic.

In this section, we review some of the relevant literature on volunteer projects and online education. We first discuss some of the psychological and pedagogical principles and recommendations for fighting the coronavirus infection and providing volunteer assistance to people in need. We then examine some of the theoretical and methodological approaches to social projecting and project-based learning. We also explore some of the information and communication technologies (ICT) that can be used to support online education and volunteer activities. Finally, we identify some of the challenges and opportunities of online education for youth volunteers in Ukraine.

2.1. Psychological and pedagogical aspects of volunteerism during the pandemic

The COVID-19 pandemic has posed unprecedented challenges for the society and created a need for effective volunteer actions. However, volunteer work during the pandemic requires not only practical skills and knowledge, but also psychological preparedness and resilience. Therefore, it is important to provide young volunteers with psychological and pedagogical guidance and support that can help them cope with the stress, fear, anxiety, and uncertainty caused by the virus [8].

One of the sources that addresses this issue is the online manual "Psychology and Pedagogy in Fighting the COVID-19 Pandemic" [9], which provides a comprehensive overview of the psychological and pedagogical aspects of fighting the coronavirus infection. The manual covers topics such as: psychological characteristics of different age groups during the pandemic; psychological effects of quarantine and isolation; psychological support for people with COVID-19; prevention and overcoming of panic, depression, aggression, and addiction; development of self-regulation, self-care, self-organization, and self-education skills; promotion of health culture and healthy lifestyle; formation of civic responsibility and solidarity; organization of distance learning and online communication; etc.

Another source that offers some useful insights for volunteer work during the pandemic is Kabysh-Rybalka [10], who formulated some psychological principles and rules for safe and effective behavior in the lockdown. These include: maintaining a positive attitude; avoiding excessive exposure to negative information; seeking reliable sources of information; following hygiene recommendations; keeping a regular routine; engaging in physical activity; maintaining social contacts; seeking professional help if needed; etc.

These sources provide valuable information and advice for young volunteers who want to help people during the pandemic. However, they do not address specifically how to design and implement volunteer projects that are relevant and meaningful for the target groups. Therefore, we need to explore some other sources that deal with social projecting and project-based learning.

2.2. Social projecting and project-based learning

Social projecting is a form of social activity that aims to solve or improve a certain social problem or situation by applying scientific knowledge, creative thinking, teamwork, communication, planning, evaluation, etc. [11, 12]. Social projecting can be seen as a way of implementing social innovations that bring positive changes to the society [13]. Social projecting can also be used as a method of learning that engages learners in authentic tasks that are relevant to their interests, needs, values, etc. [14].

Project-based learning (PBL) is an instructional approach that involves students in designing, conducting, presenting, and reflecting on projects that address real-world problems or questions [15]. PBL can foster students' motivation, engagement, cognitive, social, and emotional skills, such as: critical thinking, problem-solving, creativity, collaboration, communication, self-regulation, etc. [16]. PBL can also enhance students' interest and achievement in various subjects, such as: science, technology, engineering, mathematics, arts, humanities, etc. [17].

PBL can be applied to various educational contexts and levels, including online education and youth organizations. In particular, PBL can be used to train and prepare young volunteers for designing and implementing volunteer projects that are socially significant and relevant for the pandemic situation. Volunteer projects can be seen as a specific type of social projects that aim to help people in need or improve the quality of life in the society. Volunteer projects can also be seen as a form of experiential learning that involves young volunteers in meaningful and authentic activities that foster their personal and social development [18].

However, volunteer projects require a set of competences that enable young volunteers to identify, plan, execute, evaluate, and reflect on their actions. These competences include: problem identification, goal setting, action planning, resource mobilization, teamwork, communication, evaluation, and reflection. Therefore, online education for youth volunteers should aim to develop these competences through appropriate content and methods. In the next section, we review some of the ICT tools that can support online education and volunteer projects.

3. Results and discussion

3.1. Background information on the work of youth territorial clubs Falcons before and at the outbreak of the pandemic

The network of youth territorial clubs Falcons (hereinafter clubs Falcons) began operating in 2015 as a statutory activity of the public organization Love. The clubs were set up in many schools in a number of regions of Ukraine.

The main goal of the youth territorial clubs Falcons is the promotion of spiritual and patriotic education of adolescents and youth by means of various educational programs (e.g., the Cossack Magazine and The Pages of Eternal Stories programs). The main values that are fostered in the "falcons" include faith in God, love for Ukraine and respect for its history, language, and culture, brotherhood and sisterhood, high motivation for social work in the community, purity of body, soul and intersex relations, respect for the elderly, mercy for the needy, and patience for the little ones. The club members' leading activity is planning, organizing and conducting social projects during the year. Before the pandemic, the results of the work were presented and evaluated in the form of a team competition at the annual Falcon Games, where the winners were determined and future projects were presented to apply for a grant. During the summer, club members were involved in holding summer camps for young local community members, during which the "falcons" developed such important character traits as purposefulness, resilience, leadership, responsibility, and communication. In July, the most active club member took part in a summer falconry camp, where they could continue their patriotic, civic and spiritual training.

The COVID-19 pandemic posed serious challenges to the Falcons clubs. The letter of the Ministry of Education and Science of Ukraine of April 4, 2020 "On the organization of the educational process in out-of-school educational institutions during the lockdown" recommended to develop measures for partial use of telework and, if possible, for conducting educational classes, including, hobby groups, by means of online technologies [19].

Until March 2020, social projecting was part of weekly meetings of club members with their leaders or mentors. The clubs' work was built on the close cooperation between the falcons, as well as with the administrations and students of educational institutions, and the residents of

territorial communities. However, in mid-March 2020, after the imposed lockdown, the activities of the Falcons clubs stopped. The lockdown was felt by absolutely all public organizations. As a matter of urgency, most organizations that focused on direct contact with the population had to limit their activities.

Members of the Love NGO immediately refocused on the volunteer movement. Thus, during March-April 2020, a pilot project Second Wing – Food Delivery as part of the local volunteer initiative Do Not Be Indifferent was launched to deliver food and medicines to the elderly who are at risk of COVID-19 in the town of Irpin. Under this project, more than 100 families were visited by the Falcons club members. In addition to delivering food and medicines, the falcons had short talks with care-receivers on the basic safety rules to reduce the risk of infection. Besides, the elderly were given religious support by pastors of the local Christian community. As part of the Second Wing project, in May 2020, young people from the Kyiv-city Falcons club visited a social hostel for graduates of a specialized boarding school for visually impaired children. The hostel residents were given material (food and antiseptics) and psychological assistance (friendly communication and answers to the questions about safe life in crisis conditions).

Unfortunately, the morbidity rate in Ukraine did not improved, it even worsened, which required better project activities of club members as volunteers and their greater competence in this matter.

3.2. The 2020 Falcons club's Zoom-based project, The Camp Maker

This project was created in order to develop club members' project activity experience. After all summer events were canceled in the spring of 2020 due to the spread of COVID-19, club members were invited to take part in a special project.

The management of Love NGO chose a convenient and easy-to-use Zoom platform to develop, organize and implement The Camp Maker project, which was aimed at involving club members in planning the activities of a day-camp, which has become traditional in recent years. While previously the falcons had been active participants and helpers in day-camps, that time they were invited to author the event program made up of the camp mission, planned activities, their schedule, team organization, etc.

All participants were divided into three large teams. Each team had two weeks to prepare and present a special project to the judges. There were three such projects, so the team-members worked together for 6 weeks. The teams had to prepare:

1. *The camp's business card.* This task included group work on the name, advertisement, logo, and the general concept of the future camp. It was also important to substantiate the choice.
2. *The camp's organization.* This task included counselor work schedule, a daily routine, and an event plan.
3. *The camp case.* The teams had to prepare a draft advertising campaign in the local community, the list of necessary equipment and materials for various clubs (stations), and a camp estimate.

During two weeks, team members met on the Zoom platform to work together. Each team was given a free hand in choosing a teamwork format. Some teams preferred group-work,

others were divided into threes to perform different portions of the task, while still others chose leaders to lead the work. Once a week, online meetings of all campers were held for general communication, data exchange, and interim reports.

The best project received a grant in accordance with the camp's budget, and its authors were given an opportunity to organize a similar camp in the future. The Zoom platform has proven itself effective in this work.

The results of the Falcons club's project activities allowed determining certain advantages of distance training compared to the traditional training. These advantages included trainees' high viral safety through individual and/or mixed work, a higher level of trainees' activity in solving tasks, better opportunities for trainees' mastering new technologies, a better opportunity to unify falcons from different clubs and regions of Ukraine, a good way to bypass direct personal contact restrictions, and a higher level of club members' psychological comfort.

3.3. The theoretical basis for solving the problem under consideration

The following definitions have been proposed based on the following scientific principle: the character of a particular activity is the basis for understanding the content of individuals' training and readiness for it. In our case, we first analyzed the character of pandemic-specific volunteerism, the structure of social projecting, and the online trainers' activities. Besides, Dyachenko and Kandybovich [20] considered individuals' psychological readiness, both general and situational, for an activity as a unity of individuals' motivational, cognitive and emotional characteristics.

Youth club members' online training in projecting volunteer activities during the COVID-19 pandemic is a holistic educational process carried out under the guidance of a distance counselor by means of special tools (Zoom, Moodle, Google Classroom, Google Docs, etc.). The main aim of this training is the development of trainees' readiness to create and implement socially significant projects to help people in avoiding a viral disease.

The appropriate readiness, which includes moral, psychological and practical components, is a complex quality of a young person and an indicator of his/her ability to mobilize their vital and axiological potentials and self-create (self-educate) for spiritual and moral purposes in order to act adequately in the pandemic.

The volunteers' holistic practical readiness to create a socially significant project in the pandemic is provided by their basic project competencies, which include: the ability to develop a logical organizational structure of the volunteer project; the ability to take the initiative and generate innovative ideas to help people during the pandemic; the ability to generate humanistic volunteer projects; the ability to develop a project based on the information about survival rate and economic downturn of people at risk; the ability to provide develop projects to help the community members adapt to the pandemic restriction; the ability to use different work forms, methods and means to get the best results from the volunteer efforts; the ability to find the necessary project resources and to plan and supervise the project's implementation.

Trainees' volunteer project-making readiness can be developed using the systemic, synergetic, axiological, competence, andragogical, personality, activity, and phenomenological approaches.

Theoretical and methodological analysis and synthesis allowed formulating the following principles of online development of youth club members' readiness for volunteer activities

projecting during the COVID-19 pandemic: online motivation of young people for creating socially significant volunteer projects; the focus of young volunteers' online education on communication technologies, project method, gerontopsychology, psychotherapy, psychohygiene, creativity, health culture and willingness to volunteer during the pandemic; the regular update of the content of volunteers' online education by new information on personal self-preservation and on panic, fear and anxiety management; the well-balanced analyses of volunteers' experience in projecting programs to help children with disabilities, the elderly and people infected with coronavirus; provision of personal online support for the youth club members' volunteer activities projecting.

Based on the above-mentioned principles, we have developed a 36-hour-long online training course called "Volunteer Activities Project as a Response to the Pandemic" made up of the following modules:

1. Personal meaning of projects to help people during the COVID-19 pandemic;
2. Essential minimum knowledge as values and means of development of volunteer activities projects;
3. A volunteer as a people's mental health harmonizer and an anxiety-/fear-management counselor during the COVID-19 pandemic;
4. Projecting volunteer assistance for the elderly and children with disabilities during the COVID-19 pandemic;
5. Medical and psychological support for projecting serious COVID-19-patients care programs.

The content of the first module is aimed at developing young people's motivation for projecting volunteer activities during the pandemic. Trainees' online volunteer activities projecting motivation using special techniques is the transformation of trainees' knowledge about the terrible consequences of coronavirus infection and ways and means of helping people into the trainees' personal values and as a result the development of the trainees' personal meanings and aims of appropriate volunteer projects.

The topics of the second module have been selected according to the importance of specific knowledge for quality projects to fight the pandemic. The second-module topics include: "The main competencies of a volunteer as an assistant to people during the lockdown", "The essence of social projects; the project method and its use in volunteerism", "Psychological support for volunteers during the lockdown", "Basic theoretical knowledge in valeology, gerontology and gerontopsychology", "The leading principles of sanitary and hygienic science, psychotherapy and psychohygiene", "Essential characteristics of volunteers' distance learning in the pandemic", "Basic volunteers' self-education and self-development technologies".

The third module aims at developing trainees' skills to control their own psycho-emotional state and to teach children and adults to preserve and harmonize their mental health as well as manage their pandemic-related anxiety and fear. The module trains volunteers to online-teach children and adults to distract from anxious thoughts using exercise, physical activity, and/or developing their sense of beauty/aesthetic taste. Optionally, volunteers can master special psycho-emotional management and resilience development techniques.

The fourth and fifth modules should develop club members' pandemic-specific volunteer activity readiness. This readiness includes club-members':

1) help to care-receivers' in their safe satisfaction of their needs, such as:
    a) timely and trouble-free reception of pension;
    b) reception of food, medicine and hygiene products from supermarkets and pharmacies;
    c) direct, in particular, online contacts with family doctors, relatives and friends;
    d) doing hard household work;
    e) raising the general culture by online means, etc.;
2) ability to provide safe medical assistance to people who are self-isolated at home with a serious form of COVID-19 infection;
3) ability to attend to children with special needs, in particular, visually impaired children.

The methodology of the special online training used the following person-oriented and emotion-developing techniques: a special interactive lecture, emotionally-colored information (about the dangers of coronavirus infection, essentials of the technology of personal self-development, etc finding the personal meaning of specific volunteer activities; person-oriented approach to the educational material; development of trainees' positive attitudes towards volunteer activities (positive feelings towards quality projects, knowledge of their own moral, emotional and physical potentials, willingness to help people, self-education and self-development, etc.); trainer-trainee cooperation in creating bright images-standards of youth readiness for volunteer activity; infecting trainees with positive emotions when assessing their academic progress.

The online training project method has been updated to include volunteer project development exercises. The volunteer project activity development techniques included special online situations of spiritual and moral choice, group discussions, lockdown-specific volunteer project competition, cognitive and assessment games, online classes conducted by counselors and practitioners (psychologists, teachers, psychotherapists, epidemiologists, pediatric ophthalmologists, etc.).

3.4. Experimental verification of the effectiveness of the special training course "Volunteer Activities Project as a Response to the Pandemic"

The special online training course was tested for effectiveness at youth territorial clubs Falcons (Kyiv, Kharkiv, Rivne, Vasylkiv, Gostomel, and Skvira). The sample included 72 trainees who had some experience in volunteer educational and/or social work.

The club members were offered special literature on social projects and had to carry out a set of tasks to develop relevant project competencies. The trainees' self-educational and self-development activity was in line with their project work, in particular, the online project "The Social Project Maker", which was two months long (with general, team and individual meetings three times a week) and used the ZOOM platform. The trainees developed different components of the integrated social project launching competence. This required the trainers to be creative lecturers and discussion moderators as well as encouragers of trainees' innovative ideas. The trainers listened to and initiated discussions of the trainees' reports on volunteer activity projects, interviewed the trainees and gave them creative tasks, combined person-oriented lectures with case-studies on volunteer activity projects.

For example, D. G. Gryshchuk, besides giving open lectures called "Basic competencies of a volunteer as an assistance to people during the pandemic" and "The essence of social projects,

the project method and its use in volunteerism", etc.), shared his rich practical experience of running successful volunteer projects, such as "The mission of service to children is to help orphans" (Donetsk region, 2004–2006), "Good House" (Donetsk, 2011–2013), and "Second Wing – help migrants" (Ukraine, 2014–2015). Other trainers and instructors of the Falcons club and the Love NGO also shared their experience in increasing volunteers' community activities and in changing social values of volunteering into personal values. During the discussions, the trainees most often asked questions about the motivational component of volunteering, the psychological, psychotherapeutic and medical care to certain groups of the population. Often, such questions were answered by the invited specialists (epidemiologists, psychologists, psychotherapists and others).

It should be noted that the Vasylkiv Falcons Club (Kyiv region) and the Kyiv Falcons Club were the winners of the 2018 and 2019 Falcons Games, respectively, in the Best Social Project nomination. At the initial stage of the online training, only one of the three draft projects submitted for evaluation was based on the pandemic-relevant sanitary standards, but none of them contained a clear analysis of the sanitary-epidemiological situation in the neighborhood as a factor behind volunteerism to help those at risk from the pandemic.

Some of the tasks the members of the experiment had to carry out were aimed at developing collective projects. The most conceptually interesting individual volunteer projects were those related to the psychological and material support for the families of the deceased, the assessment of urgent needs of and the delivery of food, medicine and hygiene products to people with disabilities. At the project presentation stage, one of the Falcons teams stressed the importance of a free course to teach the elderly to make online utility payments, make online drug orders, top up cell phones online, and communicate with family members online. Another project team presented several online courses adapted for learning at home, city libraries and/or social centers. One winning project used a special program of communication with social services and local library administration. Another winning project, called SuperSTAR, estimated the purchasing of four computers and special programs to improve online learning. The project, whcich proved to be effective, was run for two months, and helped 30 elderly people to develop their basic Internet skills.

The You are Not Alone project presented to the contest featured a fundraising program made up of a number of special events (presentations, motivational videos, printed materials) to raise money for hospitals and specialized social institutions (rest homes, hospices, boarding schools, psycho-neurological clinics, etc.). The raised money was meant for buying oxygen concentrators to help people with coronavirus. This project also was aimed at providing targeted assistance to people who stayed at home through the purchase and delivery of food and medicines, and walking pets, etc.

At one of the video conferences, the participants of the online training noted the benefits of the information on mental health preservation during the COVID-19 pandemic and anxiety- and fear-management techniques [21, 22]. The trainees also stressed that their knowledge of the sanitary and hygienic principles and the essentials of psychotherapy and psychohygiene improved their project competencies.

Although online training had a number of advantages, it was not devoid of certain shortcomings, which were:

- low level of psychological comfort because of inadequate audio and/or visual perception of other team-members during online team work. Almost every second project participant felt uncomfortable, tired, and irritated after 40 minutes of online communication as a result of poor lighting, technical failures, and inability to see and/or hear other team-members.
- difficulties in moderating a large number of participants in online discussions, brainstorming and other organizational activities. For example, the ZOOM platform does not allow seeing more than 25 people on a single screen, which makes it difficult to respond promptly to the conference participants' remarks and questions, which lowers the quality of heuristic learning. The situation with smartphones is even worse as they fit no more than four conference participants into the screen.

The experiment participants' volunteer activity projects were assessed according to: the degree of the projects' humanistic orientation (focus on satisfying the needs of the most vulnerable community residents), the projects' general concept (the way volunteerism is visioned during the pandemic), the scientific substantiation of the proposed volunteer actions (i.e basing the lockdown-specific volunteer activities on the relevant principles of psychology, psychotherapy, valeology, gerontology, and gerontopsychology; the project teams' ability to build their work with children with special needs on the principles of medicine and pedagogy, etc.); the projects' technological character (a clear description of the stages, content, forms, methods, means, and algorithm of volunteers' social activities); the projects' logical structure (definition of the problem(s) to be solved by the volunteer project; presentation of the ideas about the long-term outcome of the project; setting specific goals and objectives for the near future; description of volunteer services to meet the requirements of people from risk groups, people with special needs and COVID-19 patients; description of the projects' resources; the projects' schedule: the terms of and persons responsible for the realization of each project task; youth club management's control over volunteers' actions); the projects' realism (compliance of the projects' financial, staff and material resources with the possibilities of the youth organization; the projects' sensitivity to the peculiarities of the regional social environment).

The evaluation of the projects presented by the youth club members allowed determining the levels of their readiness to run volunteer activities projects during the pandemic, which were high, sufficient and low, before and after their attending the special online course (see table 1).

Table 1
Distribution of experiment participants by their readiness to project volunteer activities during the COVID-19 pandemic.

Readiness levels	% of volunteers before the experiment	% of volunteers after the experiment
Low	59.7	12.5
Sufficient	37.5	76.4
High	2.8	11.1

As can be seen from the table, the training course increased the total number of volunteers with sufficient and high levels of readiness to run volunteer projects during the lockdown by 47.2%, in particular, the number of those with high readiness increased by 8.3%, while the number of those with low readiness decreased by 47.2%.

The obtained results show that the Love club volunteers have well-developed project competencies and can run high-quality social projects in crisis situations. All the experiment participants became deeply aware of their volunteer assistance's role in helping their community residents in the lockdown, which was demonstrated by their strong training and project-making motivation. In particular, the vast majority of trainees (54 people) developed the ability to set social projects' goals and objectives and determine their organizational structures for at-risk groups. 57 club members (79.1% of the total number of trainees) in their volunteer programs demonstrated knowledge of ways to provide practical assistance to the elderly, children with special needs, and COVID-19 patients.

The trainees had difficulties in generating original conceptual ideas for their pandemic-specific volunteer activities, in developing online/telephone methods for maintaining the mental health of retired people and children with special needs as well as in describing the psychological and sanitary support given online or over the telephone to COVID-19 patients in self-isolation.

4. Conclusions

In this paper, we presented a novel online training program for youth volunteers who want to design and implement socially significant projects in the context of the COVID-19 pandemic. The program is based on the following principles: online dominance, ICT literacy, project-based learning, gerontological and psychotherapeutic knowledge, self-preservation and self-organization skills, emotional and personal support. The program aims to develop a set of volunteer project competences among the participants, such as: problem identification, goal setting, action planning, resource mobilization, teamwork, communication, evaluation, and reflection. The paper also reported on the experimental testing of the program and the assessment of its effectiveness using the criteria of readiness for volunteer project action. The results showed that the program had a positive impact on the participants' knowledge, skills, attitudes, and values related to volunteer projects.

Based on our findings, we can draw the following conclusions:

1. Online education for youth volunteers during the pandemic is a unique and important social phenomenon and a mechanism of supporting volunteerism, which can contribute to the fight against the pandemic. Under certain conditions, online education can enhance the social mobility and engagement of young volunteers by increasing their willingness and readiness to help people in difficult situations.
2. Online education for youth volunteers during the pandemic is effective if: 1) both learners and instructors are proficient in using ICT tools for educational purposes; 2) there are sufficient resources and infrastructure for conducting quality online sessions; 3) the content of online education is based on scientific principles and recommendations for preparing volunteers for work under lockdown restrictions and promoting the safety and well-being of people at risk.
3. The outcomes of online education for youth volunteers during the pandemic can have implications for: a) advancing scientific knowledge about the features and methods of social projecting and training young people in project management under crisis circumstances; b) improving online education practices and policies (in the context of youth organization

members' training); c) forecasting educational trends and challenges in unfavorable social conditions.

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CoCalc: an integrated environment for open science education in informatics and mathematics

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Abstract

CoCalc is a cloud-based platform that provides a variety of services and tools for open science education. It allows users to create, share, and collaborate on computational documents that can run various programming languages and frameworks. In this paper, we explore the potential of CoCalc as an integrator of services for learning informatics and mathematical disciplines within the context of open science. We aim to identify the structural elements of the CoCalc environment that are suitable for these disciplines and to examine the prospects of their use. We analyze the structure of the CoCalc kernel and highlight the features that can support different kinds of learning activities, such as interactive coding, data analysis, visualization, simulation, testing, and assessment. We also discuss the challenges and opportunities of using CoCalc in open science education, such as accessibility, reproducibility, transparency, and ethics. We conclude that CoCalc is a promising environment that can enhance the quality and effectiveness of informatics and mathematical education by providing a rich and flexible set of services and tools.

Keywords

CoCalc, open science, informatics, mathematics, education

1. Introduction

Programming skills are essential for many disciplines, not only for computer science. Therefore, it is important to introduce students to programming concepts and methods in different courses, especially those that involve practical applications. This way, students can learn how to use computational tools to solve problems in their fields of interest. However, learning programming is not only about writing code, but also about collaborating with others and sharing knowledge. This is in line with the principles of open education and open science, which are becoming more prevalent in higher education in Ukraine. In an open learning environment, students, researchers, and teachers are equal participants of the same information community, without

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a rigid hierarchy. However, in reality, there is still a formal hierarchy in most universities. Therefore, the role of teachers is not only to deliver the course content, but also to manage the information environment and support students with technical issues. Moreover, teachers need to foster a culture of cooperation and communication among all users of the digital environment [1].

Another challenge in teaching programming across disciplines is the diversity of computing systems, methods, and concepts that are used in different fields. This makes it difficult to compare, reproduce, and communicate the results of computational tasks. It also hinders the development of common teaching standards and methodologies. Therefore, there is a need for integrating educational computer systems and research support systems that are tailored for specific disciplines. This will help to enhance the scientific component of students' education, not only in humanities but also in technical specialties. Furthermore, such an integration will facilitate the formation of a community of students and researchers within a single information space. The single digital environment can provide such integration tools.

Science is inherently a collaborative endeavor. Researchers often work in teams to conduct experiments, and this trend has been growing in recent years. Moreover, many experiments are performed using cloud services or platforms, which require suitable tools to support the experimental activities. However, not all tools are designed to facilitate collaboration among scientists. Some tools focus on computation, but neglect the communication and coordination aspects of group work. Even if a cloud-based environment offers some features for work or learning management, it may not address the specific pedagogical challenges of collaborative experiments. Therefore, our research aimed to explore the available tools for students to perform group tasks, conduct joint research, and share their results openly. We believe that conducting experimental research with a group of students, faculty, and researchers is a timely and important issue. We also think that it is necessary to examine every aspect of collaboration among these participants, and to identify the current problems and solutions in this area. In particular, we will present some evidence in the following paragraphs that shows how cloud service tools can be used as a means of open science.

SageMath is an open-source computer algebra system that has been widely used for research problems related to algebra and geometry. However, it has also evolved into an open-source cloud service that supports collaboration, and allows users to work with Python, R, Jupyter, LaTeX, and more. Furthermore, the CoCalc cloud service enables teachers to customize their own LMS environment. Programming, LaTeX usage, simulation – these are new skills for mathematics students, and such environments help them develop these skills [2].

2. Literature review

Klaßmann et al. [1] conducted a case study on the evolution of the digital learning and research environment at the Department of Musicology, University of Cologne. They analyzed 14 seminars from 2016 to 2020, and focused on the technological configuration of the digital environment and the curriculum development, which included digital literacy education and interdisciplinary connections [1].

De Assis Zampirolli et al. [3] explored MEGUA (Mathematics Exercise Generator, Universidad-

ede Aveiro) 2 – an open source software that allows users to create databases of parameterized questions and answers in LaTeX. It works with the CoCalc mathematical software, which uses the Python programming language [3]. The databases of questions are called "Books'' and are built with PDFLatex (for printing) or HTML and MathJAX (for web publications) [3]. The creation of questions takes place within the CoCalc tools, and consists of three steps:

1) a new worksheet is created, where a cell is used to import the MEGUA library and open or create a database to store questions;
2) another cell is used to write the question code, which consists of LaTeX text and Python code. The LaTeX block has sections for cataloging and describing the exercise, "% of the problem" (name and question), and "% of the answer'' (solution);
3) CoCalc completes the computation part, which contains two functions: it generates random values for the variables, calculates the correct solution, and generates other multiple choices.

This cell produces two files: one in PDF format and another in text format [3, 4].

MEGUA also has a feature for adding parameterized graphs to exercises, but it does not have automatic correction for printed copies of questions, or a function for grading hundreds of users.

The problem of developing a curriculum for operations research courses has been addressed by Vlasenko et al. [5]. Their research focuses on the use of cloud computing for solving optimization problems. They confirm the suitability of using the CoCalc cloud environment in teaching students.

Bobyliev and Vihrova [6] examined the experience of implementing courses in Calculus and History of Mathematics for future mathematics teachers in the learning management system of Kryvyi Rih State Pedagogical University. They used a block-modular approach to design courses, which allows them to structure the online learning process of fundamental mathematical subjects, and to control the students' pace and depth of learning. They also provide examples of laboratory classes on Calculus that students performed independently in the CoCalc computer mathematics system.

Gavrilyuk [7] discussed the challenges of using cloud services under quarantine conditions. They considered the possibilities of using cloud technologies for distance learning under preventive measures, and highlighted CoCalc as a key cloud service. They also gave an overview of cloud services that can be used to study Mathematics and Statistics related disciplines, and provided their brief characteristics.

The aim of the study is to identify the structural elements of the CoCalc environment that are appropriate to use in the educational process in the context of open science.

3. Results

CoCalc (**Co**llaborative **Calc**ulation and Data Science; mode of access cocalc.com) is a virtual online workspace (cloud-based environment) for calculations, research, authoring documents in collaboration mode.

The learning and scientific activities in the CoCalc environment involve working on a project. The elements of a project are folders and files in different formats.

It is through the project files that the student and/or scientist accesses the main components of CoCalc explicitly (figure 1) or through an “intermediary” (file type “X11 desktop”, figure 2).

According to CoCalc’s statistics over the last month, the most popular environment instrumental and applied components are Jupyter Notebooks, Sage Worksheets, LaTeX Documents

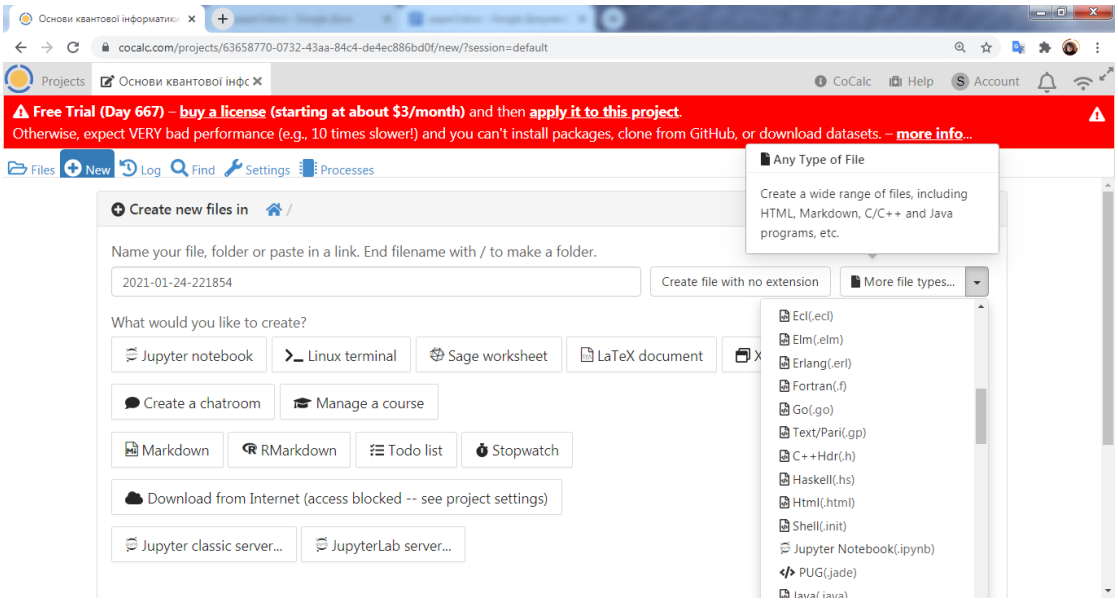

Figure 1: Page to create a new project file.

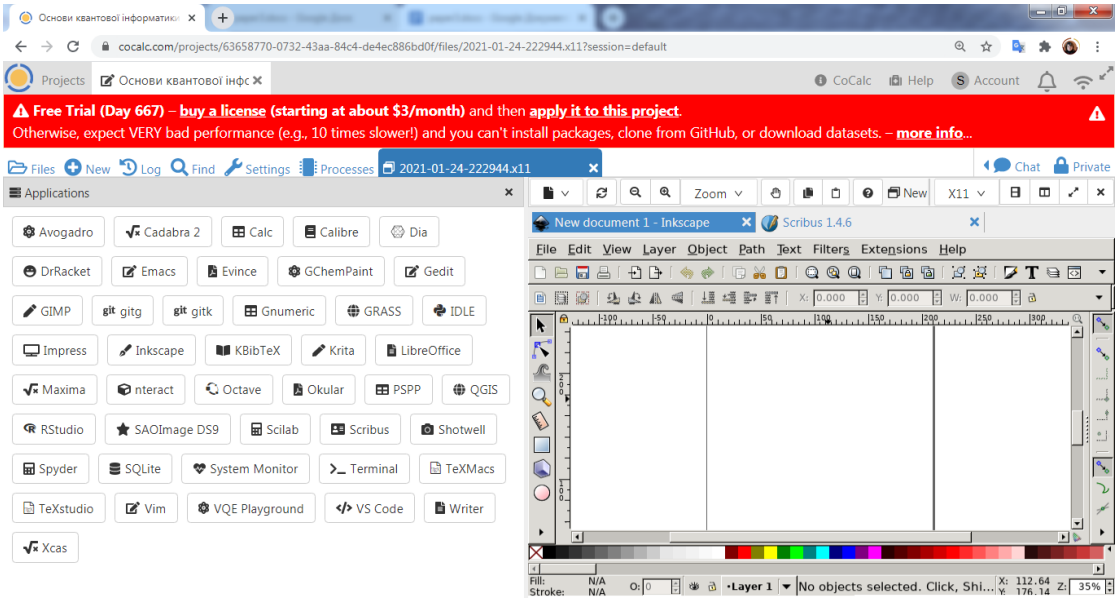

Figure 2: Page of a new file of type “X11 desktop”.

and R Markdown Documents.

The popularity of Jupyter Notebooks is obvious. Because it is on Jupyter Notebooks that you can modeling (calculate, programming, etc.), with the functionality of SageMath or Python or R or Julia.

Before talking about the already popular tools (SageMath, Python, R, LaTeX), let's focus on the latter mentioned, Julia.

Julia is a high-level, high-performance programming language with dynamic typing for mathematical calculations. The syntax is similar to the matlab family, the language is written in C, C++ and Scheme, it is possible to call C libraries.

Julia was designed from the beginning for high performance. Julia programs compile for efficient native code for multiple platforms via LLVM.

Julia plays dynamically, is a scripting language and has good support for interactive use.

Playable environments make it possible to play the same Julia environment every time, on different platforms, with pre-built binaries.

Julia uses multiple sending as a paradigm that facilitates the expression of many object-oriented and functional programming patterns. Provides asynchronous I/O, metaprogramming, debugging, logging, profiling, package manager, and more. You can create entire programs and microservices in Julia.

Julia is an open source project with more than 1,000 authors. It is provided under MIT.

But first of the stages in the development of the CoCalc is a web Computer Mathematical System (web-CMS) *SageMath*.

SageMath is a free open-source mathematics software system based on many existing open-source mathematical packages – FLINT, GAP, Matplotlib, Maxima, NLTK, Numpy, Pandas, Scikit Learn, Scipy, Statsmodels, SymPy, and many others. They can be accessed using a generalised language based on Python, or directly through interfaces or shells.

The available web-CMS tools of SageMath version 4.6 (the latest version before the advent of CoCalc, even earlier than SageMathCloud) were not sufficient to organize all types of learning activities under distance learning or its elements. It was necessary either to organize training or with the involvement of two systems – web-CMS SageMath and any system to support distance learning, such as Moodle, or to integrate them. The first method proved to be inconvenient for neither teachers nor students, the second method – continues to be widely used [8], but it, with the advent and improvement of CoCalc, may lose relevance.

Since 2014, more than 80 students have completed the courses "Computer Technologies in Research" and "Computer Mathematics" for future computer science teachers with the additional qualification "applied programmer". The SageMath toolkit in CoCalc became especially popular with the advent of the ability to work on interactive Jupyter Notebooks instead of Sage Worksheets [9]. While the latter has the advantage of being able to work simultaneously (within one sheet) with different mathematical applications.

In addition, future teachers of mathematics and computer science were offered to master the tools of SageMath in CoCalc within the optional course "Using SageMathCloud in learning mathematics" (by Maiia V. Marienko), the course "Numerical Methods / Methods of Computing / Computational Mathematics", "Discrete Mathematics", "Operations Research", "Mathematical Programming", as well as to perform independent work on the courses "Linear Algebra and

Table 1
The main components (components, software) CoCalc: System software.

Type of software	Name of the software
Request and process user account information	accountsservice
FTP client	CFTP
VNC server	X11vnc
Archiver	7-ZIP, gzip, tar
Free command line utility for data compression	bzip2
Garbage collector	The Boehm-Demers-Weiser
Shell for GNU Screen and Tmux (application)	Byobu
Shell for Python GD library	gdmodule
Program for displaying a list of running processes	htop, ps
SageMath Notebook Server	SageMathNB
Operating System	Debian GNU/Linux

Numerical Systems", "Analytical and Differential Geometry", "Calculus", "Probability Theory and Mathematical Statistics".

The mathematical packages FLINT, GAP, Matplotlib, Maxima, NLTK, Numpy, Pandas, Scikit Learn, R, Scipy, Statsmodels, SymPy, TensorFlow are known as members of the *Python Scientific Computing Ecosystem* or more simply *Scientific Python* because they provides data processing (modeling, experiment control) and visualize results for quick analysis with high-quality metrics for reports or publications.

Among the tools mentioned, the packages *TensorFlow* and *R* are of particular note.

TensorFlow is a comprehensive open source platform for machine learning. It has a comprehensive flexible ecosystem of community tools, libraries, and resources that allows researchers to advance the latest advances in machine learning, and developers can easily create and deploy machine-based applications.

R is an integrated suite of software facilities for data manipulation, calculation and graphical display. Among other things it has

- an effective data handling and storage facility;
- a suite of operators for calculations on arrays, in particular matrices;
- a large, coherent, integrated collection of intermediate tools for data analysis;
- graphical facilities for data analysis and display either directly at the computer or on hardcopy;
- a well developed, simple and effective programming language (called 'S') which includes conditionals, loops, user defined recursive functions and input and output facilities. (Indeed most of the system supplied functions are themselves written in the S language.)

R is very much a vehicle for newly developing methods of interactive data analysis. It has developed rapidly, and has been extended by a large collection of packages.

Since September 2018, almost 50 PhD candidates have been involved with the R toolkit in CoCalc and have successfully completed the Modern Information and Communication Technology in Research course.

To support cumbersome scientific calculations, there is a need to reduce the computational delay. Edge computations adopt a decentralized model that brings cloud computing capabilities closer to the user equipment to reduce computational latency. There are two types of projects in CoCalc: “trial (free) projects” and “participating projects”. Trial projects run on computers that share the same node with many other projects and system tasks. These nodes may also stop at any time, causing the current project to interrupt and restart.

Projects accepted by members are transferred to less loaded machines, which are reserved only for users who have purchased one of the proposed licenses (tariff plans). Those servers are not being restarted daily. The cluster is dynamically scaled to accommodate different numbers of member projects.

Work on members projects is much smoother because commands are executed faster with less delay, and heavy operations of the processor, memory and I/O work faster.

By default, free projects stop working after about 30 minutes of inactivity. This makes the calculations quite time-consuming.

There is an advanced license option to completely prevent downtime. Processes can still stop if they use too much memory, crash due to an exception, or or being restarted by the server on which they are running.

That is, for users who have purchased one of the proposed tariff plans, there are more opportunities to use edge calculations.

Also, it is possible to change the free tariff plan (default) Hub server by clicking “Reconnect” (figure 3). To some extent, this setting may also be considered as a practical use of edge computing [10].

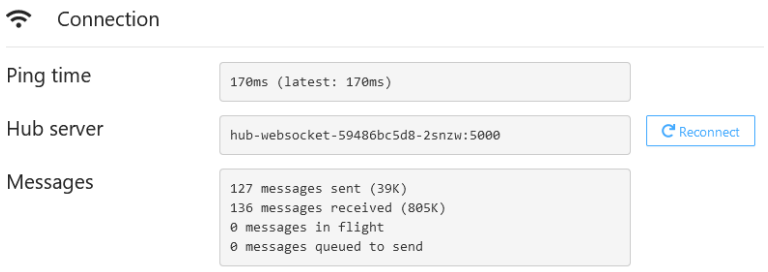

Figure 3: Pop-up settings “Connection”.

In addition, we should mention Big Data. The complexity arises from several aspects of the Big Data lifecycle, such as data collection, storage on cloud servers, data cleaning and integration. But edge computing solves this problem, which is an essential point for working with CoCalc.

CoCalc offers a wide collection of software environments and libraries (see tables 1-4).

A complete list of the current versions of CoCalc (1267 Python packages, 4472 R packages, 447 Julia libraries and more than 243sd files have been installed) can be obtained by using the command `$ sudo dpkg --get-selections`.

Detailed information on the specified in tables 1-4 and other CoCalc components (at the time of publication) can be obtained by direct link https://cocalc.com/help on the official website of

Table 2
CoCalc main components: General purpose application software.

Type of software	Name of the software
Analog screen for graphics programs	Xpra
Database of combinatorial graphs	Graphs
Library for rasterization of fonts and operations on them	FreeType
Library for working with raster graphics in PNG format	Libpng
GNOME tooltip browser	Yelp
File management and collaboration system	Mercurial
Electronic dictionary (thesaurus)	WordNet
Image viewer	GPicView
Interactive editor and macro support	Prerex
Programs for comparing the contents of text files and directories	Meld, diff
Services for reading e-books	Calibre, Evince
Document processing system in HTML, LaTeX or XML document formats	Docutils
Database management systems	RethinkDB, sqlite3
Text editors	GNU Emacs, Vim, nano, mcedit, AbiWord
Utility for finding differences between files	GNU patch
Cloud file storage	Dropbox

the CoCalc project.

Implementation of research projects, term papers with the use of CoCalc involves two ways:

1. Using the individual tools presented in CoCalc.
2. Execution, writing and registration of results of educational and research work in CoCalc without involvement of auxiliary software.

At the same time, teachers and a group of students can be involved in the research project.

The IPython interpreter in the process of training future mathematics teachers can be used to develop dynamic models with semi-automatic / automatic demonstration modes.

The first way involves creating a model (models) of the phenomenon under study on a worksheet using standard controls, HTML tags, LaTeX commands and using CSS.

The disadvantages of this use are that in the process of registration of the obtained results have to involve other software: text editor, software for creating presentations, video editor (if necessary). As a result, only a certain point of the research work was performed using the CoCalc toolkit. In addition, in the process of presenting scientific findings, the student will have to demonstrate to their colleagues in addition to the presentation of the developed model using a browser (or video editor). This can be avoided by using CoCalc tools not only to perform the research part of a particular job. Therefore, it is better to use the built-in LaTeX editor as a CoCalc tool.

LaTeX is a high-quality text document program.

LaTeX is a TeX-based macrosystem that aims to simplify its use and automate many common formatting tasks. This is the de facto standard for academic journals and books, and it offers one of the best free typography programs it has to offer.

Table 3
CoCalc main components: Special purpose application software.

Type of software	Name of the software
Automatic grid generator for geometric constructions	Gmsh
Software package for algebraic, geometric and combinatorial problems on linear spaces	4ti2
Library for performing problems in number theory	FLINT
Library for dynamic work with images	GD Graphics Library (GD)
Library for processing video and audio files	Ffmpeg
Library for working with graphs and other network structures	NetworkX
Library for solving linear programming problems	GLPK
Library for solving convex programming problems	CVXOPT
Library designed for applied and scientific mathematical calculations	GNU Scientific Library (GSL)
Libraries for determining and calculating elliptic curves defined over a field of rational numbers	eclib
Vector graphic editor	Inkscape
Sage versions	Sage.7, Sage.8, Sage.9, Sage.10
Client for Git repository	SparkleShare
Mathematical library	Cephes
Mathematical library for performing actions on complex numbers	GNU MPC
A set of libraries that extend the functionality of C++	Boost
SageTeX package extension	SageMathTeX
Software package for generating three-dimensional models	GenModel
Software package for scientific calculations	Scilab
Software packages for building phylogenetic trees	Phylip
System for mathematical calculations	GNU Octave
Computer algebra systems	Gias/Xcas, Axiom, GAP
Computer mathematics system	Maxima

Performing a term paper or a thesis in the LaTeX editor, the student has the opportunity to print it, preformed on the basis of a resource such as tex PDF-document.

That is, at the same time there is a process of registration of the obtained results, calculations, presentation and presentation of the main provisions of the study (using the presentation developed in the LaTeX editor) and demonstration of the created model. The student does not need to include additional software to perform, design or present the results, because all the work is completely unified within one cloud service – CoCalc.

```
\documentclass{article}
\usepackage[a5paper]{geometry}
\usepackage[utf8]{inputenc}
\usepackage[ukrainian]{babel}
\usepackage{sagetex}
\title{Sharing Sage and LaTeX}
\author{M. V. Marienko}
```

Table 4
CoCalc main components: Software tools.

Type of software	Name of the software
Interactive shell for programming	Jupyter Notebook
Python programming language interpreters	Python 2.x, Python 3.x, Python (Anaconda)
C ++ programming language compilers	C++
Interpreters	CPython, Java, Perl, bash
Compilers	Mono, Embeddable Common Lisp
Functional programming environments	DrRacket, MIT/GNU Scheme
Environment for statistical calculations, analysis and presentation of data in graphical form	R

```
\date {January 13, 2023}
\begin{document}
\maketitle
The easiest way to embed the results of Sage commands
in the tutorials created in LaTeX is to use the sage and
sageplot tags:”
a) finding the derivative:
$(x^3)’=$$\sage{diff(x^3,x)}$
b) plotting:
\sageplot{plot(sin(x),-pi,pi)}
\end{document}
```

You can of course offer an alternative to CoCalc – Jupyterhub and Zoom. However, they do not include the ability to synchronize with other community members in a text file, although Zoom has a basic real-time chat feature. Of course, you can offer to integrate the Markdown hypertext into the configuration by using the Jupyter Notebook, which seemed to be the ideal solution to enable collaboration in a browser-based text document in real time using Zoom, for example in workshops. In addition, HackMD Markdown files will be available to students at any time and will be used for notes during the workshop. In this way, you can create joint documents that implement synchronous and asynchronous discussions. In addition, HackMD will provide tools for documenting group work sessions so that it is easy to share with other users. In this way, you can create templates for courses that will be used later for notes, discussion of seminar topics outside the classroom. Currently, Jupyterlab does not allow real-time collaboration on real-time collaboration due to technical limitations.

CoCalc offers shared computing capabilities to small groups of users. It also includes basic chat and video conferencing features. CoCalc toolkit supports student projects and group assignments that require synchronous collaboration in computer science and math. Because CoCalc is also based on the Jupyter Notebook, integration with individual workspaces will be seamless, as users in the same group can easily transfer individual files between CoCalc to both the shared workspace and their own, private instance of Jupyterlab. Using the advanced

configuration with Zoom, HackMD and CoCalc, seminars can be organized completely remotely [1].

Overall, this configuration is a good starting point for the further evolution of the digital environment and the management of a group of students to increase digital literacy in interdisciplinary research and the teaching of computer science and mathematics. To assess the cloud environment, it is necessary to take into account both the student's opportunities and interaction with them, as well as the success in achieving interdisciplinary learning goals and the level of discussion of the content achieved in seminars. CoCalc cloud service can be recommended to groups of students of all academic levels, from bachelor to doctoral and teachers of various fields of science. The use of a single cloud platform has certain advantages: it will help to form and hold regular meetings to discuss modern computational approaches in interdisciplinary research. This creates a digital environment for developing students and researchers that goes beyond weekly seminars. From the point of view of teaching, seminars conducted in one case study will confirm the potential of a common information environment for teaching computational interdisciplinary research. Thus, students with limited programming experience or no previous programming experience during distance learning workshops will be able to fully learn the basics of Python programming and gain skills in discussing and implementing high-level computational models [1].

The evolution of the configuration of the digital environment demonstrates clear progress, which is closely linked to the requirements of pedagogical and methodological practices within the developing free economic system, students and researchers. Thus, the resulting configuration for the introduction of computational thinking and digital literacy consists of the following tools that support the necessary functions in a single digital environment:

- Jupyter Notebook, which is serviced through Jupyterhub, will provide a basic environment for notes, programming and working with computational methods and concepts without the need for local installation and maintenance.
- GitHub, GitHub Pages, and GitHub Classroom will be used to track file versions, create a course website as an alternative communication channel, and support the logistics of issuing and submitting course assignments.
- Zoom will provide a tool for interactive synchronous social communication in distance and face-to-face learning.
- HackMD is used for synchronous co-writing of hypertext documents.
- CoCalc provides collaborative real-time programming based on the Jupyter Notebook.

4. Discussion

Ukraine has adopted a roadmap for its integration into the European Research Area (ERA-UA) by the decision of the Ministry of Education and Science of Ukraine No. 3/1-7 on March 22, 2018. One of the priorities of this roadmap is to promote the development of open science in Ukraine. Open science means making the research process transparent by publishing all its results and details on how they were obtained, and making them publicly accessible on the Internet.

The practical implementation of the open science paradigm involves [11]: sharing educational materials in open access (data, event program, abstracts, meeting minutes, didactic materials,

data analysis files); publishing materials in open access journals; freely distributing and disseminating educational and scientific materials and data (for example, uploading content to an open repository).

According to Shyshkina [11], the principles of open science include [8]:

- open access to scientific sources;
- open access to electronic resources used during the research;
- free access to data sets obtained during a pedagogical experiment;
- open e-infrastructures.

A common example of open source is the large number of open source virtual learning environments used in the academic setting. The most notable example is Moodle, which is widely used in educational institutions [12].

Therefore, the introduction of open science standards in Ukraine should lead to more exchange, accountability, reproducibility and reliability of scientific materials, and affect the learning process as a whole. In the process of studying domestic and foreign experience, we identified the following benefits of using cloud services for mathematical purposes: resource saving; mobility of access; flexibility.

The use of cloud platforms and services in the educational process leads to the emergence and development of forms of education and research organization that are focused on collaborative learning activities, and create more opportunities for educational and research projects [13, 5, 14, 15, 16, 17, 18, 19]. The methods and approaches of open science have a significant impact on the educational process. Considering the above advantages of cloud-based tools in teaching mathematical disciplines, as well as the prospects of implementing the CoCalc cloud service in the educational process, we consider this service to be a potential cloud component of open science.

CoCalc is a cloud service that provides a virtual workspace for computation, research, collaboration and document creation [4]. It contains a cloud storage where researchers can share files with their colleagues. These include Jupyter notebooks, where multiple researchers can edit scripts in real time.

CoCalc [4] supports query, discovery and visualization subphases. This allows researchers to query the results and history of the experiment, among other data. Users can also visualize results using Jupyter notebooks and libraries, such as matplotlib. They can also use chats to discuss the experiment and its stages.

In this cloud service [4], the entire experimental environment is based on the principle of cloud operation. All changes are made directly in the cloud and synchronized with the user's browser via the Internet, without any blocking.

CoCalc [4] allows users to share various types of files, including scripts in different programming languages. The cloud service tools enable users to share documentation that can help researchers understand what has been done in the experiment and how to better use the shared data and workflows.

The cloud service [4] also allows users to store their interactions in a journal (chronology), but it is more like unstructured information that is hard to reproduce.

CoCalc [4] allows one to share a wide variety of files, including scripts in different programming languages. The cloud service toolkit allows you to share documentation that can help

scientists understand what has been done in the experiment and help them make better use of shared data and scenarios.

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CoCalc [4] enables users to share various kinds of files, including scripts in different programming languages. The cloud service tools also allow users to share documentation that can help researchers understand the experiment and how to use the shared data and workflows effectively.

The cloud service [4] also provides a way to store the interactions of the researchers in a journal (chronology), but it is more like unstructured information that is hard to reproduce.

Although the cloud service is fully ready for use in research [4], it requires a stable Internet connection to work. Working with the service is possible through the browser, but this may cause some difficulties when switching from the workspace, tools and development environments that the researcher is used to. Users can run code from the CoCalc environment, but this method is different from running files from the user's device. There are also some limitations on using a free cloud service account. Another problem worth mentioning is that CoCalc does not capture all the stages of the experiment adequately. It offers features such as time travel" and log'' that allow users to see the history of file changes and project activity. But these data are not detailed enough to ensure the reproducibility of the experiment.

We can conclude that CoCalc meets all the principles of open science. And CoCalc tools can be considered as open science tools that have didactic potential in the learning process.

5. Conclusions

The chronology presented in this paper shows the creation and adaptation of the digital environment based on the specific needs and practical tasks of a group of students, teachers and researchers in interdisciplinary research and education. As the digital environment is constantly evolving, the research cannot be considered conclusive. We plan to integrate the configuration of CoCalc and the curricula of individual disciplines for a deeper understanding of the learning material and to expand the means of forming professional competencies of future specialists in various fields of education and science. CoCalc tools enhance students' ability to organize and perform teamwork by implementing a joint project task. Thus, using the cloud service improves the indicators of scientific research, makes the educational process more open, relevant to human needs and content.

Given the growing popularity of free software and the wide range of applications and services offered by CoCalc, it is important to note that there is a need to develop teaching materials for Computer Science and Mathematics.

The use of cloud services leads to the emergence and development of learning forms that are focused on collaborative learning activities on the Internet. Cloud services should be used in Mathematics teachers training as a means of: communication; cooperation; data storage and processing, which should be the subject of further research. It is advisable to focus further research on the dissemination of open science approaches in Mathematics teachers training process.

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Internet resources for foreign language education in primary school: challenges and opportunities

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Abstract

The paper explores the challenges and opportunities of developing professional competence of primary school teachers in teaching foreign languages according to the New Ukrainian School concept. The paper analyzes and describes various Internet resources that can facilitate and enhance foreign language learning outcomes in primary school. The paper argues that Internet resources can help modernize foreign language education in primary school and align it with the New Ukrainian School concept. The paper also discusses the importance of training primary school teachers in the methods of organizing distance learning, which is a priority for higher education institutions in the context of continuous education.

Keywords

foreign language education, primary school, Internet resources, distance learning, professional competence

1. Introduction

The education system in Ukraine is undergoing a major reform that aims to create a new philosophy of education, based on changing its paradigm, direction, objectives, content, and pedagogical mindset. The reform is guided by key state documents, such as the Law "On Education" [1], "The State Standard of Primary Education" [2], and the New Ukrainian School (NUS) Concept [3, 4], which define the strategy and main directions of education development in Ukraine in the 21st century. These documents set high standards for teachers and their personal development. Therefore, the professional growth of primary school teachers as competitive specialists is an important component of the continuous education system and relevant for the current stage of development of Ukrainian society.

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The education reform involves several aspects, such as adopting new state standards that are based on the key competencies outlined in the Recommendations of the European Parliament and of the Council of Europe [5], which should be integrated into all subjects and are essential for the successful self-realization of individuals; introducing a new approach of "partnership pedagogy" among students, teachers, and parents; increasing the motivation of teachers as leaders of fundamental and systemic changes by increasing their wages, providing academic freedom, and stimulating their professional growth; creating a new school structure; decentralizing management, which will lead to partial autonomy of educational institutions; ensuring fair distribution of public funds to provide equal access for students to quality education; rethinking the role of teachers and students, which is determined by the division of responsibility between them for learning outcomes [3].

These radical changes in the educational process require a new quality of training for pedagogical staff, a scientific rethinking of the values of the system, and the formation of professional competence of primary school teachers [6]. The professional competence is usually divided into two groups: subject-specific (professional) competences, which depend on the subject area, determine the profile of the educational program and the qualification of graduates; and general competences, which are universal, non-subject-related, such as the ability to learn, creativity, knowledge of foreign languages, basic information technologies [7].

The development of a renewed education system requires teachers to effectively master new professional skills, to find solutions for unpredictable situations, to cooperate in teams, to align themselves with specific professional roles and perform them effectively.

Therefore, according to the above mentioned, the main objectives of developing professional competence of primary school teachers are to improve their education at intellectual and general cultural levels, to develop their pedagogical skills in accordance with the strategic goals of the NUS concept as a dynamically developing system.

The purpose of this paper is to address contemporary problems of developing professional competence of primary school teachers of NUS as competitive specialists in teaching foreign languages.

We used the following general scientific methods: analysis, systematization and generalization of scientific literature.

This problem has attracted the attention of many researchers. For example, Kovshar et al. [8], Pavlyk and Lysohor [9], Khyzhniak et al. [10] and others have focused their works on improving the system of training future primary school teachers. The role of person-centered learning as a key condition for developing professional competencies was emphasized by Bennetts [11], Clouston and Whitcombe [12], Denham et al. [13], Derntl and Motschnig-Pitrik [14], Dolezal et al. [15, 16], Harri-Augstein and Thomas [17], Haselberger and Motschnig [18, 19], Korhonen et al. [20], Kyprianidou et al. [21], McGraw et al. [22], Miller [23], Motschnig-Pitrik and Standl [24], Motschnig-Pitrik [25, 26, 27], Motschnig-Pitrik and Rohlíková [28], Motschnig-Pitrik and Derntl [29], Motschnig-Pitrik et al. [30, 31], Motschnig-Pitrik and Figl [32], Peetsma and van der Veen [33], Rowley and Lester [34], Vitsenets [35], Xu and Woodruff [36].

The NUS concept also highlights the problem of using internal resources to increase the effectiveness of students' learning [37].

The main challenge for pedagogical higher education institutions in the context of Ukraine's integration into the European educational space is to prepare a new generation of teachers: the

modern school needs teachers who can unleash the creative potential of students.

According to scholars who study the theory and methodology of vocational training, the preferred form of developing the education system should be the creation of integrative training courses for teachers that reflect the dynamism of the current scientific paradigm [38, 39].

2. NUS requirements and the level of training of primary school teachers

The new school needs a teacher who works in the format of creative searches, based on the achievements of traditional methods and, at the same time, has innovative elements, a teacher who is self-motivated not for reproduction, but for an experiment, research, innovation. At the same time, such a teacher should be responsible for the results of his work – the students' education and upbringing. A modern teacher should make a scientifically and pedagogically sound choice of a curriculum, appropriate didactic means, textbooks and manuals, develop such methodical system of teaching in a subject in order to stimulate students' interest in creative search, to realize the meaningful aspect of certain subject teaching, which provides ensuring that the student's level of education corresponds to the requirements of development of science and practice's current level, that is to be professionally mobile [40, 41, 42].

At the present stage of primary education a significant role is given to the technological approach to the organization of educational activities, that is the use of Internet resources. It is due to the fact that such teaching aids promote purposeful synthesis of methods and open new opportunities in the organization of person-centered educational process.

The current growth rate of scientific information and the educational process's reform require a modern teacher to be able to lifelong learning. The beginning of the information civilization is putting forward an upgrade of the value system for the future generation: from "education for life" to "lifelong learning", that makes the issue of a competitive teacher of educational institution relevant [1].

The formation of primary school teachers and other professionals' competitiveness is a time-delayed process that is based on systemic, activity, competence and other approaches, which facilitates two-way communication between the education system and the labour market, therefore, first of all, the state standards for specialists' training in higher education should be practice-oriented in order to ensure competitiveness.

Higher educational institutions of Ukraine have the task of restructuring the system of pedagogical vocational training in order to develop professional and pedagogical knowledge, skills and abilities which are directed at such an organization of pedagogical interaction that would meet the principles of humanity, democratization, when both a teacher and students are active participants in the pedagogical process during the course of teaching.

An integral and important part of the formation of the New Ukrainian School in the period of development of primary education is characterized by the significant influence of computer technology, which forms a global information space aimed at the harmonious entry of younger student's personality in the information society [43].

Today, Ukraine is on the path of democratic transformations and technological development in all spheres of society caused not only by the need to renew and change society but also

as a result of interactions and transformations that are taking place in the world. On the way to entering the European educational space, Ukrainian education needs to bring all its components to generally accepted world standards, including computer technology. ICT, in particular distance learning tools, occupy a prominent place in the world's best educational models [44, 45, 46, 47, 48].

The activity of a teacher as a competitive specialist requires new approaches to the professional skills' formation, development of creative abilities, and in general – improving the professional competence of specialists who carry out the educational process.

The determinative purpose of primary education should be to organize a joint search for a solution to problems, not to "convey", "explain" and "show", but to organize students' search activity at a lesson, following the principles which the organizing active forms of work's process is based on, in the context of educational reform: principle of interaction, principle of subject-subject relations, principle of activity, principle of reflection, principle of comfort, principle of combination of collective, group and individual work, principle of integration. Thus, a teacher must become an invisible conductor, be able to hear, notice, correct, support each student, and to organize students' collaboration.

In terms of the New Ukrainian School concept, a teacher (coach, tutor, facilitator) should act as the organizer of the training, who is intended to provide an individual approach to each student. The lessons should be dominated with productive, actively-creative methods that offer independent and creative activity of problematic and practical nature, which aim to give not only knowledge but also the experience of their self-acquisition.

The Professional Standard for Primary School Teachers, developed by the Ministry of Education and Science of Ukraine together with the Ministry of Social Policy of Ukraine, outlines functions, including professional competencies, knowledge, skills and abilities. Information and communication competence involves mastering the basics of digital literacy, the ability to use information technology in education. As all subjects are integrated into primary school, namely "foreign language", "technological", "ICT", they are designed to allow a teacher the opportunity to understand their strengths, knowledge, and the ability to be creative [49].

That is why a primary school teacher must consciously and competently learn new achievements of pedagogical activity, the main of which is the development of the child's personality.

In the market of pedagogical services, a contemporary primary school teacher exposes his/her high professionalism in the possession of Internet resources, the ability to interact, teach, educate, in terms of new social needs. The use of Internet tools in primary school, as practice shows, changes the nervous tension of students, gives the opportunity to change their activities, switches attention to various key issues, lesson topics, in addition, develops children's personal skills such as working in a group, a team, individually, resolve conflict situations, actively listen to others, discuss their own opinions, analyze, make decisions.

According to the state documents that regulate educational reforms (NUS Concept, new State Standard, typical educational programs), a primary education teacher should be oriented in changes of teaching methods and introduction of new educational technologies in the educational process.

The development of a specialist's personality should take place in the conditions of constant transformation, which implies internal activity, which allows going beyond the established standards of personality and social necessity, to realize his/her understanding of content, the

purpose of one's own activity.

Today the professional development of teachers is regarded as a continuous process, which must be carried out on the basis of known, modified or newly created, developed forms and methods of organization of professional development. It is a constant process of choosing and combining different forms, methods, technologies that are most optimal in a particular situation, in a particular place. Therefore, in the organization of training and professional development of pedagogical workers on the available technologies, forms and methods of education, which are introduced in the education system, one should choose those that are most contribute to the formation of professional competence (attitudes, values, knowledge, skills, qualities required for effective professional activity) [2].

Important tasks of teacher's professional growth are not only knowledge and skills' mastering of a certain area that are necessary for professional activity, but also mastering the techniques of self-search information, mastering new technologies, solving previously unknown educational tasks [2].

According to the aforementioned, the development of the teacher's professional competence causes an increase of the problem of postgraduate education, which is considered as a process in Ukraine and is aimed at the comprehensive development of an individual, the systematic updating of students' knowledge, the reorientation of psychological attitudes, the change of thinking stereotypes; the orientation of teacher's motivation for self-development, the formation of value humanistic orientations and reflective culture, the realization of new epistemological strategies of education.

The strategy for implementing a teacher's in-service training plan takes place in the current stage of educational reform in a new way. Approaches to evaluating the results of the educational process are changing, which will provide changes in the mechanisms of pedagogical staff's certification partly and will affect teacher's certification processes, which are just beginning to take form.

3. Foreign language education in primary school: problems and ways to solve them

3.1. Experience of foreign countries in the implementation of early foreign language learning

The teaching of foreign languages at preschool age and at the initial stage of school education is not only about language learning, but also about the general development of personality, which is the main goal of primary school education, as well as language and cultural preparation of children for communication in Europe and providing sustainable foreign language skills [50, 51, 52, 53].

The problems of early foreign language learning are the subject of increased attention of scientists in most countries because early language learning is seen as a way to the declared goal in Europe – the real multilingualism of citizens. Therefore, in the system of general education, students have to learn two foreign languages in addition to their native language, which means that the studying of the first language (mostly English) begins in primary school. Germany,

which has experienced several waves of migration and must accept the country's multilingualism and multiculturalism as a fact, began to introduce early foreign language learning in the 1980s, based on the research of scholars in this field. Among the German scholars who have studied the problem of early foreign language learning, it is worth mentioning first of all the works by Hohenberger and Peltzer-Karpf [54], Kopaczyk and Sauer [55], Pelz [56], Schmid-Schönbein and Fröhlich-Ward [57], Fröhlich-Ward [58, 59], Hufeisen and Jessner [60], Marx and Hufeisen [61], Hufeisen [62, 63]. Ukrainian scientists did not ignore this problem [64, 65, 66]. They agree on the importance of taking into account the needs and desires of children of this age in early foreign language learning and avoiding situations that could cause fear and apprehension. Therefore, most pedagogical approaches to teaching foreign languages at an early age follow the model of children's learning of the native language through imitation mechanisms.

Due to the experience of learning the first language, children unconsciously use the learning strategies known to them, so this fact should be taken into account, as well as the fact that success in early learning depends not only on a teacher who influences students of this age group both positively and in a negative sense but also from the educational material that is offered. Therefore, the educational material and the format of its presentation should be selected that would meet the expectations of students. It should be noted that scholars and practitioners show the unity of views on determining the goals and tasks of foreign language teaching at the initial stage. In their opinion, they are the following: students enjoy contact with a foreign language; show interest in them; develop speech and hearing skills; in the process of game learning they learn certain rules and language structures; develop the ability to distinguish the melody, rhythm and intonation of another language; develop language consciousness and a sense of one's own and another language; have the opportunity to look into the world of another culture and get acquainted with the way of life of their peers – representatives of another language community; develop a tolerant attitude, openness and willingness to understand "others".

Material that is both educational and entertaining, which fully meets these requirements, is available on the YouTube platform, where you can find multilingual content on various topics, which is easy to didactic [67]. In addition, there are channels that already offer training programs for young children, taking into account their interests and inclinations.

In addition to the German experience, the positive experience of the Finnish education system in the introduction of foreign languages (not one, but several) in primary school and preschool education also deserves attention, because the Finnish model of education is the basis of the New Ukrainian School concept.

The Finnish authorities recognize the importance of learning several languages for children and promote the education of true polylingual personalities. Thus, Finnish education, satisfying the requirements of society, in addition to learning Finnish and Swedish, introduces early foreign language teaching (L3). In 2003, the National Core Curriculum for Early Childhood Education and Care outlined the position of learning a foreign language other than Finnish and Swedish and recommended the introduction of a foreign language from the age of 3, when native language skills are already sufficiently developed [68], which is entirely the result of the study of Tove Skutnabb-Kangas [69, 70, 71, 72] and the scheme of threshold levels, based on the established relationships between the type of bilingualism and intellectual development [73, p. 273].

In December 2012, the first Government Strategy for the National Languages of Finland was

adopted in order to support two national languages (Finnish and Swedish) and to comply with language legislation. The components of the strategy include: increasing the importance and awareness of national languages, the presence of both languages in planning for the future, good knowledge of languages, etc. [74].

Of particular note is the Finnish government's The Key Project for Languages project, which aims to increase and diversify language teaching, namely: integrating early language learning into Finnish education (with a much wider scope than before); providing students with a wider language repertoire; creating a friendly and encouraging attitude to learning foreign languages. The project is supported by the Finnish National Agency for Education. The aim of this project is to find innovative ways of learning and introducing languages for young children that would motivate and be to the liking of students. Moreover, the project aims to find ways to introduce foreign languages in preschools (kindergarten is compulsory for all Finnish students) for very young children aged 4 to 6 and to encourage the natural interest in learning the language, because it is at this age children are particularly sensitive and prone to language learning. In addition, young children are more open to new experiences and other people, more inquisitive and not ashamed to communicate even with limited knowledge of the language they are learning. Also, the project proposes new and innovative ways to integrate language learning in the teaching of other subjects, such as physical education, music and mathematics. In addition to integrating language learning into other subjects, language learning can also take place outside of lessons [75].

Parallel learning and multidisciplinary modular learning are used in Finnish schools. Songs, games and music can be used in the classroom for young children and preschoolers to diversify and intensify the learning process. Another feature of this learning process is the coordinated interaction of the entire educational community and cooperation with parents, by informing them about the usefulness of learning several languages, which will also encourage and induce parents to support their children in learning several languages. Among the advantages of learning foreign languages at an early stage in Finnish education are knowledge of several languages, improvement of memory, development of multitasking skills, prevention or delay of Alzheimer's disease, etc. And most importantly, by introducing early learning of foreign languages, Finnish education creates a "language path" that begins in preschool, continues to form and develop until the end of basic and secondary education, and continues throughout a person's life.

Obviously, the education system in Finland is recognized worldwide. Equality, comprehensive education, early introduction of foreign language learning are considered as value characteristics of Finnish education. By giving priority to the development of multilingual and multicultural competencies of a democratic citizen, Finnish children have the right and obligation to learn three languages: Finnish, Swedish and one foreign language, mostly English (90%). Also, in addition to English, children are encouraged to learn other foreign languages.

3.2. The results of foreign language learning in primary school through the prism of legal documents

The experience of foreign, primarily European countries in the field of foreign language education in primary school and in the context of early foreign language learning has prompted a

revision of key approaches to the organization and content of foreign language learning in the domestic education system. It is possible to demonstrate changes in approaches to teaching in the New Ukrainian School and, accordingly, to consider the issue of proper training of primary school teachers at the current stage of implementation of NUS's ideas in the education system on the example of foreign language teaching.

Foreign languages have become very popular in recent years for a number of reasons. Globalization processes, mobility [76], informatization of society [77] and availability of information in foreign languages, the ability to travel due to visa-free travel regime with EU countries have highlighted the need for foreign language skills, which, accordingly, became an argument in favour of learning foreign languages primarily for parents who previously had an indifferent attitude to this subject. In addition, the practice of teaching foreign languages prompted changes to many Ukrainian regulatory documents, which regulate foreign language education, after the appearance of "The Common European Framework of Reference for Languages" (hereinafter CEFR) and the additional volume to CEFR. These are, first of all, the project "Language Education Concepts", the State Standard for Pre-school Education, The State Standard of Basic Secondary Education, where the issue of teaching foreign languages is arisen.

The State Standard for Primary Education 2020 defines the goal of foreign language education as "the formation of foreign language communicative competence for direct and indirect intercultural communication, that provides the development of other key competencies and meets the various life needs of the learner" [2].

The text of the document states that "the learner: perceives information expressed in a foreign language in the context of direct and indirect intercultural communication, and critically evaluates such information; understands the read foreign texts of different types for information or for fun, uses the read information and critically evaluates it; provides information, expresses thoughts, feelings and attitudes, interacts with others orally, in writing and in real time, using a foreign language" [2]. The requirements are presented in table 1.

Quantitative indicators are also determined. Thus, almost a third of the total number of hours devoted to language and literature training in primary school is devoted to foreign language education. Detailed information is presented in table 2 [2, Annex 12].

Communicative (receptive and productive) skills for students in grades 1-2 and for grades 3-4 are differentiated among the compulsory learning outcomes and other things according to three criteria in annex 3: perception of information expressed in a foreign language and its critical interpretation; understanding what is read to obtain information and its critical interpretation; providing information, expression of thoughts, feelings and interaction with others (orally, in writing). Italicized skills for each of the criteria allow us to trace the dynamics of students' communication skills, but a document that declares intentions does not always guarantee the achievement of the declared level and, unfortunately, does not always reflect the real state of affairs.

It is clear that for each criterion for 1-2 and 3-4 grades students communication skills are written so that there is an obvious progression in the results, however, the requirements for the level of language proficiency in primary school and the realities of both students and teachers, who teach them, indicate the existence of certain contradictions, that makes it impossible to achieve the goal. This is, firstly, the lack of hours devoted to learning a foreign language; secondly, the unwillingness of primary school teachers to use innovative teaching

Table 1
Requirements for compulsory learning outcomes of learners' training in language and literature education (foreign language education) [2, Annex 3].

General learning outcomes of learners	Required learning outcomes of learners	
	1-2 grades	3-4 grades
Perception of information expressed in a foreign language in the context of direct and indirect intercultural communication, and critical evaluation of information		
Perceives oral information	*understands* short, simple questions, statements, requests/instructions and responds to them verbally and/or nonverbally	*identifies* in the oral message information on various tasks on familiar everyday topics
Critically evaluates oral information	*recognizes* familiar words and phrases during the perception of oral information	*understands* the meaning of oral expression in a familiar everyday context
Understanding of read foreign texts of different types to obtain information or for fun, use the read information and its critical evaluation		
Perceives the text	*recognizes* familiar words based on evidence	*recognizes* familiar names, words and elementary phrases in short, simple texts
Analyzes the read information		*defines in the text information* on various tasks on familiar everyday topics
Providing information, expressing thoughts, feelings and attitudes, interacting with others orally, in writing and in real time using a foreign language		
Performs oral interaction	*asks and reports* information about himself and everyday activities, using short word combinations and using gestures if necessary	*communicates* on familiar topics, responds to simple statements about meeting urgent needs and expresses such needs
Orally expresses his/her own thoughts, feelings, attitudes and positions	*describes himself/herself* and *his condition* in short phrases	*tells about* people, the world around and life in simple, separate phrases and *expresses his/ her attitude*
Makes written interaction	*provides the simplest information* about *himself/herself* in writing (note, questionnaire)	*requests and provides personal information* in writing using simple words, short sentences and word combinations
Expresses his/her thoughts, feelings, attitudes and positions in writing	*writes short* phrases about himself/herself	*provides in writing information* about himself/herself, the world around, life, using simple words and expressions
Interacts in real time	*writes short phrases* in real time using a dictionary if necessary	*creates* real-time *simple messages* with a few short sentences

Table 2
The primary school curriculum.

Title of the educational field	Quantity of hours per year				
	1st grade	2nd grade	3rd grade	4th grade	total
Invariant component					
Language and literature, including:	315	350	350	350	
Ukrainian language and literature	245	245	245	245	1365
foreign language education	70	105	105	105	

technologies, as most of those who work in schools are still members of the "old guard", who do not understand the need for a radical change in approaches to learning and do not always or not fully have the skills to use informative learning tools; thirdly, it is about only partial providing of technical needs in primary school by the state, as the use of innovative methods requires considerable "technical" support in the form of teaching aids (computers, multimedia boards, licensed programs, and, most importantly, stable WiFi).

The lack of certain conditions to provide learning outcomes, that are formulated in the State Standard, can be partially compensated by the technical capabilities available in each family (the presence of a computer, a laptop or a smartphone, as well as the Internet) in combination with a well-thought-out organization of independent work, wide offer of on-line resources.

4. Characteristics of Internet resources as a means of providing the results of foreign language learning in primary school

We researched and analyzed online tools for learning English by younger students. Table 3 provides a general description of online tools that are available and most in-demand in Ukraine.

Table 3: General characteristics of online resources for learning English by younger students.

№	Title	Age	Category	Content	Advantages	Peculiarities
1	Study-languages-online.com	4-7	On-line course	Each lesson is dedicated to a specific topic and consists of five or more stages. Exercises, dictionary, phrasebook, theoretical material, comments, games, the ability to check the results of exercises/tasks are available.	There is a free mobile application that does not require registration and available at any time.	Russian-language resource, learning English only.

Continued on next page

Table 3 – continued from previous page

№	Title	Age	Category	Content	Advantages	Peculiarities
2	cambridge-club	4-12	Online course	Classes include theoretical part; practical part; interactive activities for children in English. The received material is fixed by means of games, songs and practical exercises. Children receive certificates of achievement at the end of the course.	Children can study both in groups and individually, lessons are taught by a native speaker. Each English lesson for children online is stored in the parents' personal account.	Courses are paid for, learning English only.
3	Lingualeo	4-...	Online service	The effective service for language practice, game techniques, training on current videos, texts and podcasts from the Internet. Training in grammar, listening, reading, speaking and vocabulary are available.	Free, available 24/7 from any gadget, there is a Ukrainian-language version.	Registration is required, additional courses are paid for, English and 19 other languages are offered.
4	Iqsha	3-12	Online service	English lessons in the form of games for independent learning. Easy, interesting thematic online lessons.	Free 10 lessons a day, it is possible to practice without internet access, using a mobile application, parental control.	Registration is required, you need to pay for further classes and to achieve the best results, Russian-language service, learning English only.
5	Duo-lingo	5-...	Online service	The interactive service for learning English, both an educational game and an individual motivator. The site offers to understand your level of language and as a result of the test will offer an individual training plan. All training material is divided into 88 topics, to master each of them you need to reach 5 levels (3-6 short lessons on each of which).	Free options are available, no ads. There is a mobile application, there is an opportunity to study offline. The first 7 days you can try the upgraded version for free.	Registration is required, Duolingo Plus version for $ 6.99 per month, learning 4 foreign languages.

Continued on next page

Table 3 – continued from previous page

№	Title	Age	Category	Content	Advantages	Peculiarities
6	Cambly	4-15	Online service	There is an individual schedule of classes. Each lesson is recorded, and there is an opportunity to watch videos in the personal account any time. In the chat you can write in your native language and receive automatic translation. After 10 hours of private lessons it is possible to get a certificate.	The project provides students with teachers with a British and American accent.	Registration is required, education is paid for, recommended for those who speak a little English, learning English only.
7	English-dom	8-9	Online service	Provides replenishment of vocabulary. An additional learning tool is relevant for children who are already able to perceive information independently. Hovering the cursor over a phrase, word or image, a student sees the correct spelling of the corresponding lexical unit on the monitor and listens to its pronunciation.	Free online simulator.	Registration is required, learning English only.
8	Learn-english-kids.british-council.org	5-...	Online program	The program is represented by the British Council, world experts in the field of English language teaching. There are many online games, songs, stories and activities, online courses.	Free, registration is not required.	The platform is only in English, there is a page for parents.
9	Internet-urok	7-...	Online service	It is designed to help students better to learn better. Offered online English lessons are most relevant to school curricula. There are simulators, tests and questions on knowledge of the passed material.	The topics are supported by video lessons conducted by the best teachers.	Registration is desirable, Russian-language resource, learning English only.

Continued on next page

Table 3 – continued from previous page

№	Title	Age	Category	Content	Advantages	Peculiarities
10	Puzzle-English	5-...	Online platform	Independent game training. After each lesson there is a test to check studied material there is an exam , at the end of the topic (10-15 lessons). It is possible to track progress. About 12,000 exercises and simulators are offered and new ones are constantly added.	There is a mobile application and a YouTube channel. There is a plan of perpetual access to all services "Puzzle-English" – you pay once and you use it all your life.	Registration is required, education is paid for, learning English only.
11	Busuu	5-...	Online platform	Profile service for learning English. The site offers partial and full courses. The site has a large number of articles with answers to questions and recommendations.	There is a convenient mobile application.	Registration is required, education is paid for, all material is in Russian, 12 languages are offered for studying.
12	Poliglotiki	1-12	Online platform	It has two directions: 1) HomeTeacher – the first video lessons of each course in recording are available free of charge; 2) OnlineTeacher – online classes in mini-groups / individually. The communicative approach to language learning.	Free test-simulators, flashcards and textbook pages in a convenient PDF format for demo lessons. There is a YouTube channel.	The platform is Russian-language and opens through VPN, English, German, Spanish, French languages.
13	Memrise	5-...	Online platform	Fun educational videos with native speakers give the necessary theory, online games and exercises allow you to practice. It is enough to spend up to 15 minutes a day in such interactive classes to improve your English.	There is a mobile application. The initial course of 90 lessons (20 minutes each) is free.	Registration is required, The first 3,000 words for free, then – $ 30 per year, it is possible to learn English and 9 other foreign languages.

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Table 3 – continued from previous page

№	Title	Age	Category	Content	Advantages	Peculiarities
14	Starfall	4-8	Online platform	There are four sections on the site. 1) ABCs – the alphabet is studied through videos and songs; 2) Learn to read, 15 lessons are offered, where the combination of letters takes place; 3) It's fun to read – learning to read in an entertaining manner, with the help of patter and riddles; 4) I'm reading – a list of fascinating stories for children to read.	Free, clicking on the word in the text, a child hears its pronunciation in a voice of a character.	The menu is only in English, registration is desirable. It is widely used in schools that teach children with special needs and learning difficulties, only English language.
15	Simpler	4-...	Online platform	The application offers to take a test to determine the level of English, and then calculates the complexity of the exercises. Grammar is presented here in the form of visual rules, and new vocabulary is presented through associations.	Learning a language in the form of a game.	There is a mobile application only. Fascinating detective stories, which are used to consolidate knowledge for a fee, learning English only.
16	Cambridge English	6-10	Online games	Cambridge's educational online games help to develop language skills and vocabulary. Focused on children who are tired of boring lessons at school.	Free, interesting and colorful, simple and fun tasks in games.	Registration is required, learning English only.
17	Games to learn English	5-...	Online games	Games of different levels of difficulty, but their task is the same – to help to learn words and to understand grammar.	Free, no registration required.	The platform is in English only.
18	Teremoc	2-12	Online games	A selection of browser games. Game training in the company of funny characters. Some of the games are based on fairy tales (Little Red Riding Hood, Miracle-Yudo). Participating in simple quizzes, children memorize the sound of letters and their spelling.	Free.	Russian-language resource, learning English only.

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Table 3 – continued from previous page

№	Title	Age	Category	Content	Advantages	Peculiarities
19	Nova-kids	4-12	Online school	Online lessons in the form of games with native speakers according to programs that meet European CEFR standards.	The first lesson is free, there is a mobile application, classes are provided by native speakers.	Registration is required, paid tuition, real-time classes, online school is Russian, learning English only.
20	Skyeng	3-...	Online school	Online classes are with teachers, interactive materials and exercises are always available online, automatic check of completed tasks.	The first lesson is free, there is a mobile application, there is an opportunity to transfer or cancel your lesson for free. After the full course (60 lessons) there is an opportunity to pass an exam and get a certificate that corresponds to a certain level of English.	Registration is required, paid tuition, real-time classes, online school is Russian, learning English only.
21	English-Dom	5-...	Online school	50-minute online lessons with Russian-speaking teachers or native speakers, digital textbook is available.	First three lessons are free, there is a mobile application, there is an opportunity to get a certificate after completing the full course.	Registration is required, paid tuition, real-time classes, online school is Russian, from UAH 250 per lesson, learning English only.
22	Preply	5-...	Online school	There are professional tutors from 185 countries, the opportunity to choose your teacher is based on personal interests and preferences, financial capabilities and even the country. The schedule is free and adjustable in the personal account.	An individual study plan is discussed with a teacher at the first lesson.	Registration is required, paid tuition, real-time classes, it is proposed to study 13 languages.

Continued on next page

Table 3 – continued from previous page

№	Title	Age	Category	Content	Advantages	Peculiarities
23	English show	5-17	Online school	The site offers several course options. The full course consists of a minimum of 30 lessons. Each lesson lasts 45-60 minutes. There is an opportunity to track the dynamics of knowledge in the personal account. Studying is according to the program of Oxford University, as well as an application for daily practice with foreigners.	"English show" has one of the best YouTube channel that contains many useful materials.	Registration is required, paid tuition, real-time classes, online school is Russian, learning English only.
24	Doma.uchi	6-14	Online school	Individual 30-minute classes with a teacher. You can choose the frequency, pace and place of classes yourself. Emphasis is made on vocabulary and listening.	The first lesson is free.	It is Russian-language resource, from 720 per lesson, learning English only.

Thus, online courses, online schools, online games, online services, online platforms should be singled out among the online resources for learning English by younger students. Some are free, but most of them require registration and are paid for. These online resources are designed to learn one (English) language or three and more languages, some have a mobile application. Outlined online tools for learning foreign languages by younger students can be both individual and group. Online schools give an opportunity to track learning outcomes, to control, to communicate with native speakers, to get a certificate.

Learning foreign languages in primary school is "the formation of students' communicative competence, which is provided by linguistic, speaking and socio-cultural experience, that are agreed with the age capabilities of primary school children" [78]. Teaching students foreign languages requires the development of communicative activities, that are divided into productive (speaking, writing) and receptive (listening, reading). The following classification (table 4) gives an opportunity to find out the presence or absence of listening, reading, writing and speaking skills in the analyzed media content, as these skills are the psycholinguistic basis of communicative foreign language competence and are needed for further improvement.

The Common European Framework of Reference for Languages identifies three basic components of communicative competence: linguistic, sociolinguistic, pragmatic [79]. The development of linguistic competence of primary school students needs special attention, because the motivation to learn foreign languages is formed, the language system is mastered and the basis of knowledge, skills, practical skills is laid at the initial stage of learning foreign languages, also psychological preconditions are created for the formation of personality and further study of

Table 4
Classification according to the development of skills.

No.	Title	Development of listening skills	Development of reading skills	Development of writing skills	Development of speaking skills	Additional features
1	Study-languages-online.com	+	+		+	Memory development
2	cambridgeclub	+	+	+		Disclosure of a child's talent
3	Lingualeo	+	+		+	
4	Iqsha	+	+			
5	Duolingo	+	+	+	+	Development of logic
6	Cambly	+	+	+	+	
7	Englishdom	+			+	
8	Learnenglishkids.british-council.org	+	+	+	+	
9	Interneturok	+	+	+		
10	Puzzle-English	+	+	+	+	
11	Busuu	+	+	+	+	
12	Poliglotiki	+	+		+	Development of memory, attention
13	Memrise	+			+	
14	Starfall	+	+			Emphasis on research, play and positive reinforcement
15	Simpler	+	+		+	
16	Cambridge English				+	
17	Games to learn English	+	+		+	Entertainment
18	Teremoc		+			Memory development
19	Novakids	+	+	+ (in the presence of a special pen-Novakid)	+	Development of attention
20	Skyeng	+	+	+	+	
21	EnglishDom	+	+	+	+	Result control
22	Preply	+	+	+	+	
23	English show	+	+	+	+	
24	Doma.uchi	+	+		+	

«+» – the development of the specified competence is available.
« » – the development of this competence is absent or insignificant.

Table 5
Classification according to the development of communicative speech competence.

No.	Title	Lexical	Grammatical	Semantic	Phonological	Orthographic	Orthoepic	Socio-linguistic
1	Study-languages-onlinecom	+	+		+	+	+	+
2	cambridgeclub	+	+	+	+	+	+	+
3	Lingualeo	+	+	+	+		+	+
4	Iqsha	+	+	+		+		+
5	Duolingo	+	+	+	+	+	+	+
6	Cambly	+	+	+	+	+	+	+
7	Englishdom	+		+	+	+		+
8	Learnenglishkids.british-council.org	+	+	+	+	+	+	+
9	Interneturok	+	+	+	+	+	+	+
10	Puzzle-English	+	+	+	+	+	+	+
11	Busuu	+	+	+	+	+	+	+
12	Poliglotiki	+	+	+	+	+		+
13	Memrise	+		+	+			+
14	Starfall	+		+	+			+
15	Simpler	+	+		+			
16	Cambridge English	+		+				
17	Games to learn English	+	+	+	+	+		+
18	Teremoc	+		+		+		
19	Novakids	+	+	+	+	+	+	+
20	Skyeng	+	+	+	+	+	+	+
21	EnglishDom	+	+		+	+	+	+
22	Preply	+	+	+	+	+	+	+
23	English show	+	+	+	+	+	+	+
24	Doma.uchi	+		+	+			+

«+» – the development of the specified competence is available.
« » – the development of this competence is absent or insignificant.

foreign languages. In the following classification (table 5) we have identified the components of linguistic competence, namely: lexical, grammatical, semantic, phonological, orthographic, orthoepic competences, as the formation of these competencies is the basis for the development and implementation of all other competencies and competences.

According to the Common European Framework of Reference for Languages, sociolinguistic competence has the following components: linguistic markers of social relations, politeness conventions, expressions of folk-wisdom, register differences, dialect and accent [79]. Analyzing Internet technologies for learning foreign languages by younger students, we singled out sociolinguistic competence as a general component, taking into account the development of knowledge and skills that are required, namely: politeness rules, use and choice of greetings, address forms, conventions for turntaking, use and choice of expletives, expressions of folk-

wisdom. The considered Internet technologies do not provide the development of the ability to recognize linguistic markers of social structures, dialect and accent, for example: social class, regional provenance, national origin, ethnicity, occupational group, etc. and have a relatively neutral register of language acquisition.

The pragmatic competence is also absent in the suggested classification (table 5), as the development of discourse, functional and design competences is absent or insignificant in the proposed Internet resources.

The proposed classification clearly shows the presence or absence of the development of certain communicative speech competence in the studied Internet tools for learning English by younger students.

5. Requirements for professional competence of primary school teachers and ways to improve it

With the formation of the New Ukrainian School, the requirements for the professional competence of teachers have significantly increased, as the loss of the ability to regulate the pedagogical process leads to the inhibition of the harmonious development of interaction with students. The need for professional self-development of a teacher involves the creation of conditions for the implementation of his/her own educational trajectory. The primary task of postgraduate education as an organic part of continuing pedagogical education should be to stimulate self-education and professional competence of teachers [79].

We understand the professional competence of a primary school teacher to implement the tasks of the concept of the New Ukrainian School as the ability of a specialist to apply theoretical knowledge in planned and unforeseen pedagogical situations [49].

Society's need for competent primary school teachers with an arsenal of information technology (able to receive, process and use information with the help of computers, telecommunications and other means of communication) is becoming a leading factor in modern educational policy.

The mobility of a primary school teacher and his/her lifelong learning should help in changing the educational area and in the creation of a school that combines theoretical and practical knowledge of skills namely.

The practice of educational process's realization in the conditions of modern primary school proves that a successful teacher must master not only the theory and techniques of students' personality development, a specific analytical and diagnostic culture, but also be able to predict students' achievements, both educational and personal.

Today, more than ever, the effectiveness of teachers' work depends on the level of professional training and other components of pedagogical professionalism. Diagnosis, prediction, development of author's programs, optimization of all aspects of the educational process are becoming the norm of pedagogical activity in educational institutions of Ukraine.

The new society is forcing a teacher to be a creative, competitive, self-affirming personality. The future of our country depends on how much a teacher will be ready for such challenges because education in the age of high technology is a factor of stabilization, effective economic development and prosperity of a country, its competitiveness and national security.

The modern professional activity of a primary school teacher is based on his/her results of

pedagogical activity as a highly professional specialist, who is acquainted with the modern world requirements for the educational process of the primary level of education; prepared for the organization of educational activities of younger students as a pedagogical (partnership) interaction, that is aimed at the development of each individual and individual's preparation for solving life-giving tasks.

Today, the professional competence of primary school teachers – is the ability to pedagogical activity, the organization of educational process in primary school at the level of modern requirements; the ability to work efficiently, solve standard and problematic professional tasks effectively that arise in the process of education, upbringing and development of primary school students. The basis of this ability is the unity of theoretical and practical of a teacher's readiness to do the pedagogical activity, which is come out in the presence of knowledge, skills, values of attitudes to professional activity's system [1].

Savchenko [80] considers that content and fundamentality are the core of professional competence, which should provide advanced training of a specialist. The academician concludes that it is necessary to update the content of methodological training of teachers according to the principle of integrity, systematic and integration; taking into account those processes that determine the activities of modern primary schools. In addition, it should be taken into account the need for the changes that have taken place in society and are related to scientific and technological progress, enhanced integration processes, informatization and computerization.

According to the State Standard of Primary Education and the New Ukrainian School Concept, the components of the professional-pedagogical competence of primary school teachers are:

- professional knowledge;
- professional art and skills that are necessary for successful completion of job responsibilities;
- business and personal qualities that contribute to the fulfilment of his/her own strengths, abilities and capabilities in the process of fulfilling their functional and official responsibilities;
- general culture that is necessary for the formation of a humanistic outlook, the definition of spiritual values, moral and ethical principles of personality;
- motivation for professional activity [2].

The psycho-pedagogical competence of a teacher in the aspect of the New Ukrainian School concept should include awareness of the individual characteristics of each student, his/her abilities, strengths of will and character; awareness of "the parent-student" communication processes; knowledge of how communication processes contribute to or hinder the achievement of the desired pedagogical results; realization of own optimal choice of teaching methods, search for possible ways of self-improvement.

The professional growth of a teacher as a competitive specialist should be aimed at implementation of the New Ukrainian School's conceptual principles and focused on the development of two major innovations – the competence paradigm of education and pedagogy of partnership.

The educational reform implementation plan provides continuity of realization of its conceptual provisions (1-4 grades), taking into account the appropriate (distance) resource software at

each stage of teaching a younger student (online learning platforms, online textbooks, multimedia boards, media technologies), which requires a teacher to improve his or her skills in the system of continuing education and in the context of social change [81].

This is due to the presence of primary level teachers' stereotypes of thinking that negatively affect the development of younger students; uncertain readiness to innovate, problematic use of active teaching methods, game technologies.

The professional growth of a modern teacher's personality is directly related to the need for modernization of school, scientific, methodological and research work and its improvement.

As a rule, the methods and forms of traditional educational activities are reduced to unilateral influence of a teacher, the role of which is a clear presentation of information. As practice shows, the information-reproductive teaching methods of a descriptive nature are dominated in general education institutions. Problematic and practical methods are mostly used for illustration and clarity, the reproduction of past experience predominates. Individually-collective forms of the organization of training are usually used, according to which the material is assimilated individually, but at the same pace for the whole group [43].

Improving the effectiveness of English lessons in primary school, by strengthening the informational, communicative and emotional saturation of the educational process, is an urgent need of leading modern methodists (Flynn [82], Goh and Fang [83], Hashim and Yusoff [84], Järvinen and Twyford [85], Niyazova and Muratova [86], Pokorna [87], Reid [88], Xu et al. [89]).

The task of a primary school teacher is to make a proper English lesson's plan in order to prevent a decline in children's interest in such types of work that involve student's mobility, such as online games, staging songs and stories, colloquialisms, riddles, fairy tales. Their purpose is to relieve emotional tension during distance learning, to rest eyes, to relax different muscle groups. According to didactics in primary school, it is recommended to take dynamic breaks during classes. Their organization gives students a real opportunity to move, relieve intellectual, physical fatigue, during which children invisibly name and repeat the typical movements of animals, performing poems, speeches, counters in foreign languages.

The current changes in society have a decisive influence on the structure and content of pedagogical education, they orient teachers of higher educational institutions to enhance their mobility by differentiating requirements to the level of education. The rapid changes in society and technological advances are so high that it becomes very difficult to train a specialist who, after graduating, would be able to work in the chosen area of activity without continuing self-improvement, continuous general and professional development.

The focus on the humanization of education in the teaching of foreign languages is present in the orientation of the learning process on the development of the personality of the younger student. Internet tools that stimulate children's creativity and create real conditions for students to achieve practical results play an important role in the development of students' speaking skills.

Technological actions in language learning are a set of actions from determining the purpose of language personality formation, preliminary design of a language learning model to the implementation of tasks in practice. The use of Internet resources in the system of language education is the educational systems that meet the latest advances in didactics, linguistics, theory and practice of language learning.

The need to use Internet tools in language learning is due to the contradictions between

the lack of opportunities in the traditional education system and modern social needs. The objective need for the use of Internet tools in the study of languages is the strengthening of the communicative aspect in the formation of language personality and the intensive development of information technology. The use of Internet tools has broad prospects for use in foreign language learning, as they easily combine a number of technologies: game, interactive, project, technology for the development of critical thinking, technology for the development of critical thinking, early and intensive learning technologies [87].

The use of Internet tools in primary school has its own specifics: it is necessary to take into account the age, individual and psychological characteristics of primary school children. All parts of working with Internet tools require careful monitoring by a teacher, as both theoretical and practical knowledge and skills of younger students are still small. Working with the use of elements of distance learning requires a clear formation of aims, tasks and algorithm of actions: finding information for systematization, generalization, adaptation in future use.

Therefore, special attention in the new paradigm of education in general, and continuing education of primary school teachers, in particular, should be paid to the technologization of the content of the learning process. Such education will become the means of information-modernized perception of the world by a younger student.

Postgraduate education centers are designed to regulate the needs of teachers in their professional growth. Every year there is an opportunity to undergo advanced training (within 50 hours) in order to acquire skills and abilities of free orientation in information flows, the use of various online learning platforms.

The leading direction of the postgraduate educational centers' work (according to the New Ukrainian School Concept) is the unified mechanism of reorientation of training's creation in relation to the updated content, forms and methods of teaching. The creative use of traditional methods and forms, together with the introduction of innovative mechanisms, should facilitate the development of modern approaches in the formation of teacher's professionalism throughout life.

The effectiveness of teachers' further continuing education will depend not only on basic professional training but also on the implementation of daily practical training tasks, improvement of professional skill, level of research work, individual characteristics and actual teacher's needs.

Continuing education should be aimed at developing cognitive skills, the ability to create an individual plan for professional self-development (to construct personal knowledge) independently, the ability to navigate the information space, to generalize and integrate new information from various sources in the process of theoretical and practical learning, the ability to improve yourself constantly.

Modernization of the system of pedagogical staff's professional development, improvement and modernization of postgraduate pedagogical education, as a whole, is one of the most urgent tasks facing the educational sector in Ukraine today. A powerful tool that can increase efficiency and accelerate the pace of its implementation is the monitoring of modernization processes in the sphere of postgraduate education, as well as conducting relevant sociological researches. Such scientific intelligence will allow to branch leadership, individual institutions and other institutions to obtain information about the course of development of postgraduate pedagogical educational system systematically, that is necessary for making management decisions on its

improvement, timely elimination of shortcomings, as well as to provide feedback to direct consumers of educational services, identify their real needs, expectations, and attitudes.

The system of in-service training of primary school teachers in the context of education reform promotes the intensification of educational process, improvement of its efficiency and quality of results; the systematic integration of subject tasks, development of experimental research skills; the building of an open education system that provides each participant with his/her own trajectory of self-education; the formation of teachers' information culture.

The conditions for teachers' professional development during in-service training under the conditions of the NUS Concept are:

- diagnostics of professional competence of educators;
- providing a differentiated approach to the pedagogical staff's in-service training;
- introduction of innovative training technologies;
- updating the content of educational and professional programs;
- introduction of information and communication technologies in the educational process;
- providing practical orientation of in-service training courses;
- feedback organization [3].

The main areas of solving the implementation of training courses according to the concept "online", with different versions of programs that provide the opportunity to study and improve new information technologies, information culture as part of professional competence, the use of multimedia technologies that facilitate learning and memorization of learning material, because their use individualizes the learning process. Programs of advanced training courses for primary school teachers in Kryvyi Rih State Pedagogical University are designed for the needs of teachers of different categories in accordance with the teaching experience and meet the requirements of a teacher in his/her acquaintance with the potential of modern technologies, ability to use them in practice. A student of a group of primary school teachers takes a set of tests to check the level of professional competence at the final stage, this allows mobile, impartial and objective modular control (60 / 30 hours programs).

6. Conclusions and future work

The current demands of society require that primary school students receive a high level of education, which can only be achieved by primary school teachers who are highly professional and competent.

Such teachers should not only have a solid educational background in mastering professional knowledge and skills that correspond to the state of the art in psychological and pedagogical sciences, but also be aware of the purpose and objectives of their professional work in a coherent system of continuous education, be adaptable, responsive to the changes in the social situation of younger students' development; seek self-improvement, self-realization and civic engagement in the context of NUS.

The main goal of all educators today should be to improve the quality of online education. The key factor for improving this quality is the introduction of effective changes in educational

institutions, which can only be carried out by competent teachers who are willing to enhance and work on their own professional development constantly.

Therefore, learning in accordance with the needs of modern society cannot be conceived without a distance mode of learning. Distance learning draws on the best global methodological experience using the most advanced and effective pedagogical technologies. Such learning offers opportunities for using in the educational process: flexibility, modularity, parallelism, a large amount of educational information, efficiency, innovation, social equality. Developing professional competence of primary school teachers in the method of organizing distance learning is a priority for advanced training courses for teachers.

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Digital resources for developing key competencies in Ukrainian education: teachers' experience and challenges

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Abstract

This article explores and evaluates the practical use of digital resources by Ukrainian teachers in their classroom activities with pupils. It presents various online tools and digital resources that support the implementation of three key subject areas: STEM education, education for democratic citizenship, and entrepreneurship education. The article also showcases the national online resources that foster a sustainable, multicultural, and democratic learning environment for teachers and students, covering key competencies such as entrepreneurship, citizenship, civic education and STEM. The article analyses how the teachers use the digital learning tools to creatively integrate digital technologies into their teaching, identify the needs and didactic approaches of their students, solve technical problems, and assess the gaps in their own and their students' digital and civic competencies. The article highlights the benefits and challenges of using digital resources for teachers, such as improving and updating their digital competence, creating and maintaining a creative and sustainable digital environment in their schools, seeking opportunities for self-development and digital transformation in line with the UN '2030 Agenda for Sustainable Development', and organising distance learning in response to the COVID-19 pandemic. The aim of the article is to share the examples and the experience of Ukrainian educators who use digital educational resources to build a digital environment and develop key competencies: digital, civic and entrepreneurship in accordance with the European trends. The article suggests that the presented experience can be applied in other schools and help to address the existing gaps in the teachers' use of digital learning tools.

Keywords

digital resources, digital competence, key competencies, STEM education, education for democratic citizenship, entrepreneurship education, Ukrainian education

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1. Introduction

The COVID-19 pandemic has posed unprecedented challenges for educators worldwide, and especially in Ukraine, where the educational system is undergoing significant reforms and transformations [1, 2, 3]. The pandemic has forced a shift to distance learning [4, 5], which requires the effective use of digital technologies and access to quality educational resources [6, 7]. The sustainability of education in the context of modern educational reforms is a key priority for the Ukrainian state, as well as a part of its European integration and democratization processes [8, 9]. The international education community has responded to the COVID-19 crisis by providing guidance and support to governments and educators on how to improve distance learning, taking into account the diverse educational opportunities and needs in different countries. The development of digital literacy and digital competence of teachers and pupils is a crucial aspect of this response, as well as an important area of work for international organizations such as the Council of Europe, UNESCO, OECD and others [10]. Therefore, the role of the teacher as a facilitator and innovator of digital learning is essential in these processes. The modern teacher needs to follow the best European teaching practices, as well as to keep up with the innovations that are implemented both in Europe and in his or her own country.

The Sustainable Development Goals (SDGs) are outlined in the document 'Transforming our world: the 2030 Agenda for Sustainable Development' adopted by the General Assembly of the United Nations in 2015 [11]. This document identifies 17 SDGs, including education. Goal 4 is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. One of the targets of this goal is to substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship by 2030. Another target is to substantially expand globally the number of scholarships for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes by 2030 [12]. The development of pupils' digital competence is considered today as an integral part of the educational process as a whole. The main purpose is to have an educated personality ready to live and act in a democratic, multicultural and information society who has the necessary abilities, knowledge, skills and information culture. The attention of the teachers should be paid to the acquisition by pupils of digital skills and digital competence. The main components of digital competence include: technical problem solving – the ability to identify technical problems in the operation of devices and the use of digital environments, and to solve them; identifying needs and finding technological solutions based on needs analysis, the ability to identify, evaluate, select and use digital tools; customizing digital environments and creative use of digital technologies: ability to use digital tools and technologies to create knowledge, innovative processes and products; participate individually and collectively in cognitive activities to understand and solve conceptual problems; identifying gaps in digital competence: the ability to recognize the need to improve or update one's digital competence; the ability to support others in the development of their digital competence; look for opportunities for self-development and be aware of modern digital evolution [13, 14, 15, 16].

The modern challenges of society require teachers to act in a multicultural digital environment, be prepared to offer their pupils innovative ways of learning, communication and investigation that will allow them to form not only their digital skills but also prepare them for the labour

market, entrepreneurship and citizenship.

The issues of development of digital literacy and competence of pupils as well as the use of information and communication technologies by teachers are revealed in the works of Ukrainian researchers such as Bykov and Lapinsky [17], Kolomoiets and Kassim [18], Kovalchuk et al. [19], Mintii and Soloviev [20], Nechypurenko and Semerikov [21], Popel et al. [22], Rashevska et al. [23], Shepiliev et al. [24], Trubavina et al. [25], Vakaliuk et al. [26], Zinonos et al. [27] and others.

The article aims to present various digital resources that Ukrainian teachers use to ensure the development of key competencies: digital, civic and entrepreneurial, as well as to reveal how teachers support a sustainable and democratic environment in their schools using ICTs. The study of these tools by the authors led to proposals for Ukrainian teachers on how to improve the existing digital educational environment regarding the challenges of quarantine in 2020–2021 school years.

2. Results

The Council of Europe is one of the international organizations that quickly responded to the COVID-19 pandemic and to the situation with the quarantine in schools in the European countries, and proposed to support digital citizenship through the creation and the support of the digital environment in schools and other educational institutions. As was noted in the CoE Multi-Stakeholder Consultation Report [28], the educational professionals should determine the administrative and legal responsibilities of school principals, teachers, students and parents; make efforts to involve parents in initiatives of pupils and schools on digital citizenship; develop and publish lesson plans and illustrative opportunities for learning digital citizenship and create a database of the most interesting online resources; identify opportunities for the development of this area, its teaching and instilling values, views, skills, knowledge and critical understanding of the digital and real world to their pupils [29].

To ensure the development of the democratic digital environment in the classroom the teacher should first of all take into the account the multicultural composition of the pupils. This makes it possible to include in the curriculum different discourses on the interpretation of history and geography according to a specific cultural context, mutually enriches pupils by exchanging knowledge, experiences, values belonging to different cultures, allows to use the cognitive preferences of bilingual children. The documents of the Council of Europe, the EU, the UNESCO, the UN recognize Multicultural Education as a fundamental principle that guides teachers and schools of different countries to conduct educational activities with the mutual recognition and interaction of cultures [30].

The Multicultural Education strategy emerged in response to the exacerbation of ethnic, national, and religious conflicts in modern society as a result of significant migration processes between countries in different regions of the world. Multicultural competence and multicultural dimension in education with the use of ICT play a special role in lifelong learning today [31].

The Ukrainian NGO Association of Teachers of History and Social Studies “Nova Doba” invites teachers to use electronic teaching materials on intercultural interaction and multicultural education: “Common history. Dialogue of Cultures”, “Together on One Earth. History of Ukraine

is multicultural", "New approaches to historical education in a multicultural environment", "Common stories for Europe without borders", "Multicultural history of Ukraine", "We are among others. Others among us. Forms and methods of multicultural education", "Religious diversity and intercultural education", etc.[32]. The most of the indicated resources are designed as manuals and guidelines for teachers ready to be used for different school subjects. In other hand the Multicultural Interdisciplinary Handbook created as part of an international (EU) project with the financial support of the European Commission (Comenius program) proposes a digital modules of a learning course for training future teachers of history and geography, and professional development of working teachers. The developed teaching materials help teachers to immerse themselves in the culture of other people through the study of geography and history, to motivate them to learn the foreign languages. The handbook presented online is written on six languages and can be used by all history and geography teachers interested in developing Multicultural Education in schools [33].

The Ukrainian experience of implementing multicultural education using ICT includes an integrated e-learning course "European Studies" for pupils of the grades 8–12 on a modular basis. Course modules mix elements of multicultural education for use in lessons of geography, history, and economics [34]. The course is developed on the basis of the Concept of the content of education for the European dimension of Ukraine. Teacher's manual "Media literacy in social studies lessons" provides the use of critical thinking techniques, lesson plans-summaries for teaching courses "History of Ukraine", "World History", "Man and the World" using electronic educational resources [35].

The use of ICT helps to preserve pupils' cultural identity, improves intercultural dialogue between pupils and increases their overall level of academic achievements. A special place in the development of multicultural education is given to online games (multicultural role-playing online game), that reproduce the multicultural model of the world [36]. Distinctive features of these games are: the ability to play at the same time for a number of players from different parts of the world; a variety of virtual worlds games are created using international English and national languages. One of the Ukrainian examples is the game that is widely used by Ukrainian teachers – "Civilization" (http://gamer-info.com/game/civilization-online/). In this game the player acts as the leader of a certain civilization (nation). It allows the participants of the game to develop science and culture, establish cities and colonies, create ways and wonders of the world, conduct wage wars and diplomatic negotiations. The game presents seven religions and cultures: Buddhism, Hinduism, Islam, Judaism, Confucianism, Taoism, and Christianity. It exists in the different languages: English, Spanish, French, German, Italian, Chinese, Russian, Japanese, Polish and Finnish.

Such games increase pupils' language and communicative competence. It should be noted that online games resources should be used wisely by the teacher, focusing on the importance of the fact that some pupils tend to overload their time in favor of computer games. It should also be borne in mind that certain online games can be a threat to students in shaping their behavior in real life. When discussing online games with pupils, the teacher must first determine their attitude to how the game takes place and ask for their assessment of game events, etc. [37].

The multicultural experience of communicating with representatives of other countries and cultures is of great importance for the development of multicultural competence. Therefore, one of the most effective means of forming multicultural competence is the "Culture Assimilator"

method [38]. "Cultural Assimilators" is a training tool that includes: a brief description of situations where there is a problem of cultural adaptation or a problem related to cultural diversity between two interacting representatives of different cultures. Assimilator proposes four options for interpreting the behavior of the acting characters and explanations for each interpretation that involve discussing and determining the most appropriate answer. The methods' goal is to teach a person to consider different situations from the perspective of members of another's cultural group, to understand their vision of the world. The tasks of the cultural assimilator are the following: the acquisition of isomorphic attributions as the ways of interpretation of human behavior by representatives of other cultures; the experience of their emotional reactions in the circumstances of interethnic interactions and their correction; the formation of the tolerant behavior in a multicultural environment.

Another interesting experience is the practice of implementing STEM education and creating a digital learning environment for pupils. The Concept for the Development of STEM education adopted in 2017 proclaims the implementation of STEM at all levels of education, in establishing partnerships with employers and research institutions and their involvement in the development of this education. The training methods and training programs of STEM education are aimed at the development of competencies relevant to the labor market: critical, engineering and algorithmic thinking, skills of information processing and data analysis, digital literacy, creative qualities and innovation, communication skills etc. [39, 40, 41, 42, 43]

Lozova et al. [44] analyze the issue of creating a STEM environment in schools. They draw attention that electronic educational resources of such an environment have to meet the requirements of the intellectual and technological capacities of the pupils and should provide them by the modern integrated knowledge; to promote self-development of the individuality, to support the realization of his/her creative potential.

Stroud and Baines [45] believe that to create a STEAM-oriented educational environment of the school, the electronic platform has to meet the requirements of all participants in the learning process, namely:

- the platform should provide tools for the teacher: modeling of educational STEAM-projects, creation of joint with pupils and other participants of educational process communication, support evaluation of pupils' activities in the project, creation of archive of educational projects and their results;
- the platform should provide for the pupil: feedback from teachers and other professionals involved in the educational project, free access to educational and scientific materials necessary for the project, communication with other pupils and teachers who are part of the group, tools, that can help to obtain data and test designs, models, game resources to motivate pupils to learn, virtual laboratories, etc.;
- the unregistered user should be provided by the access to open educational and scientific resources, news and announcements of STEAM-projects, instructions for using tools, including ICT, for the implementation of STEAM-projects.

Among the electronic educational resources of Ukraine that influence the active development of STEAM education are the following: the Ukrainian project "Quality of education" with the "Web-STEM-school-2020" created by Ukrainian teachers; Distance Academy (https://osnova.

d-academy.com.ua/?s=STEM), that proposes the distance courses and webinars; web portal "Na urok" (https://naurok.com.ua/), proposing the distance education by the different school disciplines; virtual STEM Center of Junior Academy of Sciences of Ukraine (https://stemua.science) that offers plans and guidelines for research work for the STEM disciplines.

It should be noted that the Ukrainian teachers use such international electronic educational resources for the support and development of STEAM-oriented educational environment of the school, as: Simulate the Natural World with Virtual Biology Lab (http://virtualbiologylab.org/) which includes Ecology Models, Evolution Models, Cell Biology Models; Experience a Virtual World of Science Education (https://praxilabs.com/) which includes a number of interactive 3D virtual lab simulations in Biology, Chemistry and Physics; Phet (https://phet.colorado.edu/) which includes 806 million simulations in Physics, Chemistry, Biology, Mathematics, Earth Science; workshop for teachers for their skills development to discover and reflect on the learning benefits of playing with simulations through open play and reflection time; Physics Simulations (https://www.myphysicslab.com/), that provides open source software under the Apache 2.0 License; there are around 50 different simulations in the source code, each of which has an example file which is mainly for development and testing; Go-Lab Platform (https://www.golabz.eu/), which consists of the Go-Lab Sharing and Support platform (Golabz) and the Authoring and Learning platform (Graasp); there are around 240 teacher training events, 1800 Classroom implementations, 19152 Teachers creating spaces (20 of them are in Ukrainian language) [46].

It is important that these environments take into account the following user requirements: providing a virtual lab that allows project participants to conduct scientific experiments in the online environment; remotely controlled laboratories (remote laboratories) that allow experimenting with real equipment at a distance; virtual laboratories that simulate scientific equipment; data sets representing information from already conducted laboratory experiments [47, 48, 49, 50, 51, 52, 53]. The laboratories on the platforms can be combined with special programs to create conditions for other educational projects.

Regarding the actual requirements of STEM education the Ukrainian practitioners propose the online course for teachers "Creation and use the STEAM-oriented learning environment for the teachers' digital competence development" which includes three modules: Module 1 "The STEAM-oriented learning environment for the school", which includes the following topics: theoretical principles of creation and use the STEAM oriented learning environment for the school; creation and use strategies STEAM oriented learning environment for the school; Module 2 "Use of information and communication technologies to organize and support the STEAM approach in school", which includes the following topics: e-Learning resources as the means of teacher's digital competency developing to support STEAM oriented learning environment for school; electronic platform for organizing STEAM oriented learning environment for school; Module 3 "Electronic learning resources on self-assessment and evaluation of teachers' digital competence to support the STEAM oriented learning environment for the school", which includes topics such as requirements for assessing a teacher's [46]. The overarching goal of this course is to develop teachers' information and digital competence, in particular, to help them to learn new information and communication technologies and to improve the quality of their teaching activities.

One of the successful Ukrainian online projects that allows to create a digital environment

for pupils is the "3D Democracy" Project supported by the non governmental organization "Nova Doba". There are few educational environments that aim to build civic competence of pupils and teachers. The NGO "Nova Doba" is the All-Ukrainian Association of Teachers of History and Social Sciences. This organisation proposes the "3D Democracy", "Citizen's Workshop" online environments (https://citizen.in.ua/about.php). The 3D Democracy online resource aims to support teachers who teach civic education or implement its elements into the school subjects. It allows to involve pupils into the online community where they can master their civic competencies. In particular "3D Democracy" contains the following resources: "Teacher online" – is a community of civic education teachers united in a virtual educational environment; "School block" contains information about the institution that has joined the network, provides information about the educational institution on the map of Ukraine, posted on the site; "Journal of pupil achievements" that allows to provide activity of each registered pupil and to make records in the "electronic class journal" (by topics and sections); "Current information" that contains methodological materials, information about webinars, training seminars, conferences for teachers, etc.

Among the opportunities for the pupils that this resource proposes are: the online textbook / manual on civic education (texts, videos, life cases); online community for participants from different regions of Ukraine; simulations, games, polls, petitions, elections, flash mobs (on civic topics); personal offices of pupils' portfolio of civic activities; joint blogs, forums, discussions; the assessment through automatic recording of pupils' achievements (fixing student activity on each topic, a three-pronged competency approach to final the assessment of student works in each section: online testing, situation analysis, practical tasks (essays), and student motivation scale (through automatic scoring) for involvement in the activities of the "Community". Participants will receive information about the beginning of each activity and its results through: news on the site, e-mail or SMS [32].

The Citizen Workshop resource offers tools and steps to engage with the online community. The steps to access the Citizen Workshop resource ("Community" block) are:

step 1: teacher's registration; teacher is registered as "pedagogue" at the website; teacher receives a password to access the site, in particular to the sections "Teacher's" and "Journal of Pupil's Achievement", etc. The site administrator creates a "School Block" on the site;

step 2: pupils' registration; teacher invites pupils from his / her class (s) to register. Each pupil registers on the site; pupil receives the user's personal account, password to access it;

step 3: common activity; working with materials, watching videos, life cases, simulations, games, polls, petitions, elections, flash mobs and new friends for pupils. Methodical materials, webinars, forums, discussions, experiences and new friends for teachers; For students and teachers: additional information, new friends, practical skills and first positive experiences in the field of civic activity / civic education.

The Ukrainian educational platform "Living in Democracy" is supported by the international organizations and proposes the resources of the Council of Europe teaching materials http://www.living-democracy.com.ua. It is launched as a part of the joint Swiss-Ukrainian project "Development of Civic Competences in Ukraine - DOCCU" with the assistance of the Government of the Swiss Confederation, and it offers the Council of Europe resources for

education for democratic citizenship, tools for the lessons and activities on democracy, human rights and civic participation.

The platform contains educational materials, legal documents, videos, illustrated cards on children's rights, a number of textbooks of the Council of Europe in Ukrainian language including: "Teaching Democracy", "Growing in Democracy", "Living in democracy", "Taking part into democracy", "Exploring children's rights "and "Teaching democracy". Pupils, parents, teachers and school leaders can find useful information on NGO issues.They can learn, develop and improve their knowledge and civic competencies.

The DOCCU online platform presents the Swiss-Ukrainian project supported by the Government of the Swiss Confederation. It envisages the implementation of three main and cross-cutting components: Component 1 "Civil Servants". Introduction of EDC / HRE at the national level in the system of training of civil servants and representatives of local self-government bodies of Ukraine; Component 2 "School Leaders" (school principals). Introduction of Education for Democratic Citizensip and Human Rights education (EDC/HRE) in the system of postgraduate education of school principals in Kyiv, Odesa, Kherson, Poltava, Lviv, Luhansk, Ivano-Frankivsk and Dnipropetrovsk regions; Component 3 "Teachers". Introduction of EDC / HRE in the system of postgraduate teacher education in Kyiv, Odesa, Kherson, Poltava, Lviv, Luhansk, Ivano-Frankivsk and Dnipropetrovsk regions. The DOCCU online platform proposes to the wide educational community manuals and online educational resourses (video, posters) than can be used in a daily school activity.

The above mentioned examples of Ukrainian projects that use digital resources and tools serve to the teachers and to the schools as a resource of interesting interactive manuals, teaching materials, tasks for students on various topics (media, human rights, economics, socio-cultural environment, cultural diversity, identity and etc.). These digital instruments are in great demand among teachers and schools: thus, as of August 2020, the 3D Democracy community has 5,035 users, of which about 1,500 are teachers. Such indicators prove the popularity and interest of teachers in digital resource support for civic education nowadays.

In order to ensure the effective use of the STEM instruments in school practices with the pupils the professional development of teachers has to be in the scope of the education policy in Ukraine. In the same time, the international good practices can be used by the Ukrainian pedagogues to improve and to deep the knowledge in the sphere of STEM education. Thus, we have to point the attention on the Massive Open Online Courses (MOOCs) that have being actively introduced in 2008 [54, 55, 56].

The European Schoolnet Academy proposes a free MOOCs that includes theoretical material in the form of texts and video lectures, webinars, videos of teachers of European countries with stories and lessons to share their professional experience, instructions for the practical use of ICT in the professional activity in the classroom, their communication on social networks through course questions and professional solutions, tests for each module of the course and the end result, such as a lesson plan or other ICT training course.

Participation in these courses and analysis of the tasks and topics during 2017–2019 years gave us the opportunity to highlight the following important problems regarding the modernization of the educational process by the teacher according to inquiry-based pedagogy:

- to provide career information to motivate pupils and present a variety of STEAM and ICT-

related jobs and required skills (“Teaching ICT with Inquiry”; “The Networked Teacher – Teaching in the 21st Century”; “Games in Schools”; “Personalised Learning in Practice – are my students driving their own learning?”; “Yes I can” – Empowering Student Learning”; “TeachUP Course: Collaborative Learning in Practice – are my students learning through collaboration?”);

- to become familiar with innovative tools and approaches such as visual programming tools, unplugged activities, robotics, tinkering, and making and coding for all subjects Ukrainian teachers can join to: “EU Code Week - Deep Dive MOOC”; “The Networked Teacher – Teaching in the 21st Century”; “Games in Schools”; “Yes I can” – Empowering Student Learning”; “TeachUP Course: Collaborative Learning in Practice – are my students learning through collaboration?”; “Boosting Bioeconomy Knowledge in Schools”; “Social Media Literacy for Change”;
- to learn about active learning, innovative use of ICT and collaborative teaching and learning teachers can join to: “Teaching ICT with Inquiry”; “EU Code Week – Deep Dive MOOC “; “The Networked Teacher – Teaching in the 21st Century”; “Games in Schools”; “Yes I can” – Empowering Student Learning”; “TeachUP Course: Collaborative Learning in Practice – are my students learning through collaboration?”; “Boosting Bioeconomy Knowledge in Schools”; “Social Media Literacy for Change”; “Become the Next eSafety Champion”.

These courses provide suggestions on how to improve the effectiveness of teaching process in the schools, give advice on how to the use the thematic portals and sites, training programs, computer games, etc.

For example, “The Teaching ICT with Inquiry” course allows to use the Go-Lab ecosystem https://www.golabz.eu/ to enhance:

- students to conduct experiments in on-line laboratories in STEM fields, to participate in educational projects, in the implementation of which they need to use knowledge, skills and competences in the natural sciences, technologies, engineering, various fields of arts and mathematics;
- teachers to create and select didactic materials for teaching their subjects using the STEM approach, to share their pedagogical experience with colleagues from different countries of the world, etc.

Go-Lab ecosystem was launched since 2014. The Go-Lab initiative was created thanks to the successful Go-Lab project, which lasted from November 2012 to October 2016. The goal of the Go-Lab Initiative is to promote the use of online labs and applications for teaching and implementing research projects in schools. The Go-Lab Initiative provides a Go-Lab ecosystem for teachers where they can find various online labs and create their own learning spaces. The Go-Lab Initiative provides training for teachers across Europe on science education in schools and the explains how to use of the Go-Lab ecosystem. The Go-Lab initiative is currently funded by the Next-Lab project. The modern Go-Lab ecosystem consists of two main components. Go-Lab is a Sharing platform that provides hundreds of remote and virtual labs, as well as software and applications for query study. The Go-Lab platform enables teachers to create their

own learning environments, combining labs, applications, and other resources for sharing with their pupils.

What is important about MOOCs, is that the final result of each of these courses should be a personal training event developed by the course participant, such as a training project using the tools offered by the online course. This result is evaluated using the peer-to-peer method.

It should be noted that the content of the courses is renewed every year, namely:

- new topics (e.g., the use of computer games to teach and teach different disciplines, training according to the needs of society, the use of new tools for monitoring, control and self-assessment of knowledge, skills and abilities of students and teachers);
- new tools for improve forms of learning (eg, the use of new electronic platforms for STEAM projects in formal, non-formal, informal and inclusive learning; creation of computer-oriented environments, etc.);
- new lessons learned from teachers' experiences in implementing STEAM education in the schools (eg, teaching STEAM projects, lessons on specific topics in STEAM fields, STEAM weeks, etc. using ICT);
- updated country reports on the use of ICT in support of STEAM education and analysis of the results of implementation of the STEAM approach in the schools (e.g., Science education now: a renewed pedagogy for the future of Europe: https://ec.europa.eu/research/science-society/documentlibrary/pdf06/report-rocard-on-science-educationen.pdf
- new ideas are being generated to implement the STEAM approach in general education institutions (e.g., to create websites that offer weeks of STEAM education in schools around the world: https://www.science-on-stage.eu/page/display/5/28/13343/coding-in-stem-education.

The entrepreneurial education is one of the important issue of the sustainable development and democratisation of education process. The vital importance of the development of entrepreneurial competence is defined in the main basic educational documents of Ukraine. The Law "On Education" proclaims entrepreneurial competence and financial literacy as the key competencies for modern citizens [57].

In 2016 the government of Ukraine approved the Concept for the implementation of state policy in the field of reforming general secondary education "New Ukrainian School" until 2029, which states that one of the areas of education reform is to create a modern educational environment that will provide the necessary conditions, tools and technologies for teaching pupils, teachers and parents [58]. According to this reform, a graduate of a new Ukrainian school must be an innovator, able to change the world around him and develop the economy on the principles of sustainable development, compete in the labor market, learn throughout life. Among the key competencies are the information and digital competencies, entrepreneurship and financial literacy, leading a healthy lifestyle [59].

In September 2020, the State Standard for Basic Secondary Education was adopted, which includes key competencies (entrepreneurship and financial literacy), which include initiative, the ability to use opportunities and implement ideas, and create value for others in all spheres of life; ability to actively participate in society, manage their own lives and careers; ability to solve problems; willingness to take responsibility for decision making processes; ability to work in a team to plan and implement projects that have cultural, social or financial value, etc. [60].

The work of Ukrainian scientists is devoted to the problem of formation of entrepreneurial competence of students as a key competence. Thus, Hilberg [61] believes that entrepreneurship is a person's ability to implement ideas, which involves creativity, the desire for innovation and the ability to take risks, as well as the ability to plan activities and implement them in life. Liskovych [62] defines the entrepreneurial competence of the pupil as a structured set of personal qualities that provide effective problem solutions in various spheres of life related to their own social status and well-being, as well as the development of society and the state as a whole. According to Ovcharuk [63], one of the main characteristics of entrepreneurial competence is transverse, cross-cutting nature and flexibility. The researcher also considers it extremely importance in using and implementation of active methods and ICT in the educational process, to involve representatives of the local community and business, entrepreneurs who have experience and are ready to share it with pupils [63]. In the study of entrepreneurship education Nazarenko [64] proposes to use game technologies that will allow students to try the role of experts in a given situation or the role of an entrepreneur, whose functions include: planning economic activities, creating a business plan, planning marketing and advertising, funds analysis at the firm and running business. Dovgan and Chasnikova [65] deal with the issues of integration of entrepreneurial competence into secondary education curricula. The researches noted that the introduction of a cross-cutting content line "entrepreneurship and financial literacy" is facilitated by such factors as: the use of interactive teaching methods (simulation of life situation in lessons), excursions (bank, enterprise, firm, etc.), project activities (application of knowledge in practice), teamwork, the ability to present pupils' works, analyze information and draw conclusions, etc.), appeal to the experience of pupils [65].

To identify key competencies in the curriculum, the concept of "cross-cutting lines" was introduced. The cross-cutting line "Entrepreneurship and Financial Literacy" aims to educate young people: rationally use funds, plan expenses, save, and implement leadership initiatives, to operate successfully in a technologically fast-changing environment. Programs of the Ministry of Education and Science of Ukraine of this content line for grades 5–9 have been developed. This information is presented on the website of the Institute for Modernization of Educational Content [66].

One of the first educational initiatives on the implementation of entrepreneurship education in Ukraine was the Polish Foreign Assistance Program of the Ministry of Foreign Affairs of the Republic of Poland, the Polish-Ukrainian project "School Academy of Entrepreneurship 3". This project was implemented at the all-Ukrainian level and was aimed at the support of the socio-economic sustainable development of the country introduction of elements of entrepreneurial education in schools. This project is a continuation of the Ukrainian-Polish projects "School Academy of Entrepreneurship" (2012–2013) and "Lessons with an entrepreneurial background" (2014). All information and developments of these projects are freely available on the project website [67]. In particular on the website teachers can find a online guidelines for the organization of integrated lessons with "entrepreneurial background" and sample summaries of such lessons.

The use of ICT in the learning process provides an opportunity to create an effective computer-based learning environment [68, 69, 70, 71]. In Ukraine, there are online resources and online courses that offer education for pupils and teachers on entrepreneurship. Thus, for students of grades 9–11, teachers of Kharkiv Polytechnic Institute together with the platform "For a lesson"

developed a free online course "StartUpCamp: the path to a dream" [72]. With this course, pupils learn the basics of entrepreneurship, they can get the tools for creation of their own project, and start to implement their business ideas, as well as to learn the basics of financial literacy, work in a team to start their own business project. The course consists of 7 sessions and 300 tasks. Learning takes place in the form of online video lessons with the supervision of a teacher. All lessons can be recorded; there is a gamification of the learning process, the pupils can perform interactively and can deliver presentations on their homework. Also there are a lot of interesting materials for different topics: Philosophy of entrepreneurship; Team game; Business pack leaders; We learn to present our idea; Include critical thinking!; Where to get money? and others.

Another useful digital resource is the National Online Digital Literacy Platform "Action. Digital Education" [73]. This platform proposes the educational series "Entrepreneurship for schoolchildren" which consists of 6 modules, and 36 sessions. The first module is devoted to the idea on the topic of "finding ideas", their samples, testing and implementation. The series aims to make pupils aware of the benefits of doing business and forming the traits and positions needed by each person for successful self-realization in today's world. In the process of learning they understand how to find the business idea and test it, promote their own product on the market (from advertising to finding customers), learn about what sources of funding exist and how to attract them. Upon completion of the online course the pupils pass the test.

The Ukrainian online education platform Educational Era is a project that aims to make education in Ukraine at a high quality, accessible and available in a global educational context [74]. This platform offers an online courses for high school teachers, secondary and primary school teachers, social educators, school psychologists, youth workers and parents. The online course "With students about education and career" consists of 4 modules, includes videos, interactive tests, lesson plans. Upon its completion, a certificate (8 hours) is issued. During the training, such issues as educational and career counselling are considered, different tools are available for this; as well as the opportunities for future vocational and higher education in Ukraine and abroad, as well as for non-formal education. Participants are offered tools for working with pupils in grades 8–11: lesson plans, additional materials, presentations, and interactive consultation scenarios. Topics of the modules include: advising pupils on self-knowledge, career and educational trajectory; advising on the choice of vocational education; advising on the choice of higher education; advising on non-formal educational opportunities. To obtain a certificate, participants are tested in each of the modules (middle and end), the final online test is based on the results of the presented materials.

The Educational hub of Kyiv is also one of the useful learning resources [75], that offers its users different courses aimed at the development of soft skills, lifelong learning through blended learning, and serves as a platform for participants' meetings with the famous Ukrainians. Thus, for senior pupils there are the special courses; "Public Speaking", "Career Guidance for Students" and "Effective Job Search" are offered [75]. The course "Public Speaking" is aimed at the mastering the skills of speaking convincingly, clearly, and competently, as well as to interest the audience and hold its attention. The basic public speaking course for beginner speakers consists of 7 video lessons: about the qualities that the speaker should have, what goal he/she can set for himself, what information he/she should have depending on the type of speech; how to learn to control yourself and overcome the fear of public speaking; why for the speaker body

language – gestures and facial expressions – is no less important than a well-placed voice; what are the details of the speaker's image, what are the types and archetypes of speakers; what is the real art of public speaking, what role does improvisation, acting skills, language culture play in it; how to build the structure of the speech and what techniques will help to visualize the information to better convey it to the audience; how to conduct a dialogue and discussion with the audience.

The material of each course consists of theoretical information, tests for understanding certain subtleties of public speeches, illustrative examples of successful and unsuccessful speeches. Subsequent classes include questions on the material of the previous ones, and the participant can move forward only after its successful mastering and proper passing of the online test. The course "Career Guidance for Students" is designed to facilitate the choice of profession by high school pupils before entering higher education. The course raises the awareness of the pupils about the benefits of the subjects they study in school and how they will be needed later in their life, namely: civic education, mathematics, language, literature, physics, chemistry, biology and ecology, history, geography, physical education and computer science. The course "Effective job search" teaches modern methods of job search, the rules of writing a good resume, how to choose the right field of activity, company and interview, how to make a good impression on the first working day and more. There are also other platforms for mass open online courses, such as Google Digital Workshop [76], which offer entrepreneurship courses that differ by the number of modules and their duration. A part of the above mentioned courses are for beginners, others are useful even for experienced participants. After hearing some courses it is necessary to pass testing for consolidation of the received knowledge.

From the above mentioned we can conclude that in Ukraine there are opportunities for entrepreneurship education, but there is a lack of the opportunities to create an effective learning environment in school regarding this issue. It remains an important question that needs further development.

Thus, it is necessary to create the most favorable conditions based on the use of ICT to enhance the cognitive activity of children, the development of their intellectual abilities and communication skills necessary for the successful formation of entrepreneurial competence; to create conditions for training teachers in teaching entrepreneurship, providing them with ICT tools and teaching materials, teach them to use existing resources for learning; to develop educational online resources (textbooks, computer programs, games, virtual communities, portals) on entrepreneurship education to support teachers, students and parents; encourage teachers and students to participate in international projects on entrepreneurship education. The use of the achievements and informational resources by Ukrainian teachers allows creating additional opportunities to pupils in the international perspective. This is why the experience of using digital technology by teachers to gain knowledge in business education is interesting. This confirms the creation of European entrepreneurship education resources, such as the Virtual Entrepreneurship Education Handbook, which allows teachers from different countries to familiarize themselves with and use practical tools for primary, secondary and vocational education in their work.

Teachers from European countries are now successfully using the digital teaching hub (http://content.ee-hub.eu/). It brings together over 60 best practices in promoting entrepreneurship education in Europe on: national entrepreneurship education policy (Germany, Italy,

Netherlands, Flanders, Denmark, Estonia, Croatia, Sweden, Finland, Macedonia, Norway, Denmark); teacher training (Enterprising School Program, Entrepreneurship360, Entrepreneurship Educators Program 3EP, 100 Mirrors, LIFE2 Project, STEP Model 2); partnerships (Cisco Networking Academy Networking, Combining Entrepreneurial Competence and STEM Industry Partnerships Skills, Accelerating the StartUp Ecosystem, YES – Finnish Regional Ecosystem Strategies to Implement National Strategies, Employee Volunteering – Added Value of Practical Entrepreneurial Programs, etc.); Entrepreneurship education ecosystem (integrates educational institutions of Spain, Serbia, Belgium, United Kingdom, Norway, Germany, Finland); tools (Measurement Tool for Enterprise Education (MTEE), Entre Intention Tool: Measuring Impact at the Individual Level Entre Intention Tool: Measuring Impact at Individual Level, EntreComp: Entrepreneurial Competence Framework, etc.); Financial Education (Interaction between Entrepreneurship and Financial Education, Financial Education Programs from Primary to Secondary Levels, MoneyIQ and MoneyOnline, Financial Education Curricula, Your Finances, Your Future; I Can Manage My Money) and others.

In order to effectively integrate entrepreneurship education into the school education process, modern digital tools are being used to help creation of resources and projects involving representatives from different countries. This digital resource is the Entrepreneurial School (http://theentrepreneurialschool.eu/) that is co-financed by the European Commission, which includes 5 key objectives: teachers' continuing professional development and training; establishing quality supporting frameworks to measure best practice and to evaluate impact; development of appropriate support structures and activities; establishing networks between best practices; focusing on the initial education of teachers and the integration in the curriculum etc. The Entrepreneurial School project has trained over 4,000 teachers from 18 countries over the past three years, and has developed a Virtual Guide to Entrepreneurial Learning (http://www.tesguide.eu/default.aspx) [66]. Focus groups from Denmark, Finland, Italy, Norway, Poland, Portugal, Slovakia and the United Kingdom worked on this development. The focus groups consists of representatives of various education, business, governmental and non-governmental institutions who are relevant to entrepreneurship education in their countries and play a key role in promoting entrepreneurship education.

3. Conclusions

The use of digital educational resources in the classroom activities with pupils is one of the vital issues nowadays. The online instruments and digital resources for the realization of STEM education, education for democratic citizenship, and entrepreneurship education are not widely presented in the national educational practice today. These are the modern trends in the world's educational systems that Ukraine needs to adapt to and meet the requirements of a democratic multicultural society. The Ukrainian online resources presented in the article ensure the creation of a sustainable, multicultural, and democratic environment for teachers and students, covering key competencies areas such as entrepreneurship, citizenship, civic education and STEM.

Moreover, the creation of an appropriate educational environment that enables pupils to gain knowledge, skills and competencies for their participation in a democratic society is one of the important tasks for the educational system in Ukraine. It is also important to use the best

experience and educational resources on democratic education, entrepreneurial education and multicultural communication from other countries. Ukrainian teachers should pay attention to the following aspects:

- to integrate entrepreneurship education into the school education process. The use of modern digital educational resources can help teachers to create opportunities for pupils, promote their involvement in creating their own projects and finding solutions;
- to create possibilities for pupils to develop their democratic culture through participation in the decision making process using ICTs. This will allow promoting the development of digital citizenship that is now one of the life realities.

In this view, it should be concluded that the use of digital tools, digital resources and media in the classroom is closely linked to the digital competence. Therefore, achieving a relevant level of digital competence should be one of the main objectives of the teaching process.

Further research should be carried out in developing approaches, organizational and pedagogical conditions in schools in order to create a learning environment for sustainable development that can promote the development of digital competence and digital citizenship, enhance entrepreneurship education of pupils, and improve the methods and forms of using digital learning tools to create a democratic and sustainable environment in schools.

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YouTube as an open resource for foreign language learning: a case study of German

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Abstract

The integration of information and communication technologies (ICT) in education has increased the possibilities and expanded the boundaries of the learning process. It is also a prerequisite for implementing distance learning. Various online resources, such as e-mail, blogs, forums, online applications, and video hosting sites, can be used to create open learning and education environments. This study focuses on the use of informational educational technologies for learning foreign languages, especially German. The article presents the results of a theoretical analysis of the content of YouTube video materials in terms of their personal and didactic relevance for teaching German as a first or second foreign language in higher education, specifically at a pedagogical university. Based on the practical experience of using several popular thematic YouTube channels with a large and stable audience, a brief didactic analysis of their products is provided and suggestions are made on how to transform video content into methodological material for the practical course of German language for future teachers. The article also explores the potential of using alternative YouTube resources for distance learning with regard to the development of mediation skills as defined by the authors of the CEFR Companion Volume with New Descriptors. Four types of resources that can serve as teaching materials are identified and analyzed; some examples of their preparation and use for the training of future foreign language teachers are given. The article also discusses the open resources ONCOO and TWINE, which can be used to foster the autonomy of future foreign language teachers, and describes their features. The proposed recommendations can help to achieve the following objectives: enriching vocabulary; semanticizing phraseological units, fixed expressions, clichés; developing pronunciation skills; enhancing linguistic and ICT competencies; improving listening and speaking skills; increasing motivation to learn, etc.

Keywords

YouTube, foreign language learning, German, distance learning, mediation skills, ONCOO, TWINE

1. Introduction

Information and communication technologies (ICT) have become an integral part of education, creating new opportunities and expanding the scope of the learning process. The global crisis of

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2020 highlighted the need to develop open learning and education based on the latest ICT and open resources, among which web services that allow users to upload and watch videos in their browsers are particularly attractive. The crisis also emphasized the importance of the teacher's role in society. Distance learning [1, 2], digitalization [3, 4] and integration [5, 6] are not just buzzwords; they are now the foundation of the educational process. The problem of training and retraining personnel, developing autonomy as a component of educational competence (for both students and teachers [7, 8]), and enhancing ICT skills [9, 10] became especially relevant, leading to changes in the Qualifications Framework.

YouTube [11] is a video hosting service that provides a platform for amateur and professional videos and videoblogs. It is one of the most visited sites on the Internet due to its simplicity and convenience, its ability to facilitate communication without time and spatial constraints, and its feature of enabling users to share their opinions in the comments on the videos.

According to statistics from recent years, "education'' is consistently among the top ten most popular categories of videos, attracting the attention of billions of regular users from around the world. Education ranked sixth with 38.6 billion views and 2.9 billion regular users. This allows us to confidently consider video hosting as a modern learning tool, especially for learning German.

About 80 million videos were found on YouTube in four languages (Ukrainian, Russian, German and English). You can find videos of different specializations on YouTube. Table 1 summarizes the information of the orientation of the authors of the numerous channels of video materials, which are offered to everybody, who is interested in learning German as a foreign language.

However, the issue of increasing the efficiency of the use of video materials disseminated through the platform in the process of learning German in a higher education institution, in particular in the context of distance learning, remains relevant.

2. Theoretical comprehension of YouTube possibilities in education

Analysis of last researches and publications worldwide indicates an increase of the number of authors who devote their works to the problems of using YouTube in teaching foreign languages. The highest level of interest is shown in learning English as a foreign language. This is due to the status of this language in the modern world as lingua franca.

The subject covers a wide range of issues. In particular, Arndt and Woore [12] aim to compare the processes of forming the vocabulary of the second language as a result of interaction with two network media: written blog posts and video blogs. In this analysis the level of assimilation of various aspects of lexical knowledge (spelling, semantic and grammatical) was a subject. In turn, Saudi Arabia scholars have experimentally demonstrated higher productivity of targeting vocabulary in a multimedia environment using video on YouTube compared to the traditional way of learning with images [13].

Antoro [14] explores the use of ICTs, including YouTube, as key tools for creating training materials in order to support distance learning and language learning.

The experimental study of Iranian scholars Souzanzan and Bagheri [15] is concerned with

Table 1
Orientation of educational videos.

	Personal-definite orientation
by age	– for children – for teenagers – for adults
by level of language proficiency	– for beginners – according to the levels of the European Language Education Recommendations
by line of work of users	– for pupils – for students – for professional purposes
	Didactic-definite orientation
by aim	– development of certain linguistic competence (lexical, grammatical) – preparation for the examination to confirm the level of language proficiency – everyday communication – communication in a professional environment
by the type of speech activity	– lexical trainer – grammar trainer – trainer for improving pronunciation – listening and / or reading
by means and forms of study	– based upon real / educational videos – in the dialogues – by means of exercises – based upon stories – by films – “on the street” – with music

the problem of perceiving English as a foreign language in the context of expediency of ICTs use, in particular YouTube, during individual learning.

Brazilian researchers Chimenti and Lins [16], having analyzed the impact of some digital resources on the quality of teaching English at elementary school concluded that the latest ITs could make learning of foreign languages more contextualized, creative and motivated.

On the strength of the assertion, that life-satisfying learning is the best policy for learning English (especially by children), Lee et al. [17] believe that the video is a good bearer of information that is the most suitable for language learning. First of all, it is a great opportunity to capture real life situations, and secondly, it is easy to access the necessary information through YouTube.

According to Cakir [18], due to the emergence of numerous open sources of information (YouTube, Facebook, Twitter, Internet newspapers and magazines) during the globalization

period, we are able to observe the phenomenon called “Teaching English to the Speakers of Other Languages” (TESOL) as well as “Teaching English as a Language of Open Sources” (TELOS). TELOS can provide expected multimodal and multidimensional support for TESOL (especially in the context of learning English as a foreign language), enabling the acquisition of pragmatic skills (in particular semantic-syntactic skills), which can only be partially formed in traditional lessons, according to Cakir [18].

According to Bastos et al. [19], YouTube acts as a cognitive tool, which is able to promote raise of the level of critical thinking and cognitive ability of students in the process of learning English as a foreign language.

The analysis of experimental data [20] showed that the use of existing videos and creation of their own videos for the distribution through video hosting increases the motivation of students to learn foreign languages.

Multifunctionality and effectiveness of YouTube as a tool for learning foreign languages is thus evident.

The purpose of the submitted report is:

- the illustration of certain aspects of the practical use of commonly used sources of video material in the process of teaching German as the first or second foreign language in a higher school, namely at the pedagogical university;
- the representation of recommendations on the conversion of video hosting content to didactic material while learning Practical Course of German Language by future teacher and the development of educational autonomy of all participants in the educational process.

3. Research results

3.1. German courses on YouTube

The interest of the main German apologists, in particular of the Goethe-Institut [21] and DeutscheWelle (DW) [22], to the platform undeniably proves its availability and effectiveness in influencing the process of mastering foreign languages. In the legitimateness of the said, once again the activity of the German international public broadcaster DeutscheWelle convinces of worldwide popularization of German language and the creation and dissemination of the necessary free study programs for its successful completion. Several video playlists that can be used both during class work while learning language and in the process of individual studying, are presented on “Deutschlernen mit der DW” channel. The differentiation of the levels of language proficiency from the “absolute beginner” to C1 / C2 allows the user independently organize his/her work according to the principle “from simple to more difficult”, and the teacher – quickly orientates in the selection of educational material for a particular audience. The length of the video increases gradually, in order not to overload the viewer and maximize the focus on the didactic material of each lesson or series. It is the series, because most of the educational videos are inherently films whose heroes live a particular part of their lives in the German-speaking environment. Heroes, as a rule, are foreigners, and therefore “they look at Germany and German language” through the eyes of YouTube channel viewers.

In addition to the main theme, the mention should be made of the traditional separation in the structure of the speech activity of the four components: speaking and listening (these two types belong to oral speech), writing and reading (written speech). The exams for determining the level of language proficiency, including the "Goethe-Zertifikat", consist of "Lesen" (reading), "Hören" (listening), "Schreiben" (writing) and "Sprechen" (speaking) (oral or individual exam) "Sprechen" (oral or individual exam). Such a division is quite logical, since mastering the native language takes place precisely in this natural scenario: from listening to speaking, reading, and, finally, writing. The practice of working with students, who learn German, shows, that audio competence is the most difficult to formulate. Although at first glance there may be an impression that listening is the easiest for children, without much visible effort, as opposed to writing. However, before starting to pronounce the first words and construct a coherent phrases and sentences, the child for several years is in an absolute linguistic environment where he/she can hear sounds and words of his/her native language, in fact, 24 hours a day. Learning the same foreign language often begins with reading and writing, and then speaking and listening. The perception of speech in real life rarely occurs without visual support, and therefore a significant percentage of information is transmitted by non-verbal means. Involving video materials for listening to music is much more effective than using audio tracks. When a video hero pick up a certain item, naming it at the same time, the need to accompany the introduction of a new lexical unit by the translation disappears. Contemplating certain actions with the subject and listening to the commentary of the heroes, the viewer learns the linguistic roots and grammatical structures.

Of course, it is impossible to make a training video to explain every linguistic phenomenon, so the effectiveness of this learning tool can be greatly enhanced by fixing the new material with additional exercises. Understanding this, the authors of the training series DW offer users to go to interactive tasks at the specified link to the official personal site of the television and radio company. Given the current tendency to reduce the audience load in higher schools of Ukraine and increase the amount of material for independent learning by the student, the use of educational films with exercise complexes can help to optimize their independent work.

YouTube, with its openness to everyone, can be used by teachers as a space for communication. The format of communication in the form of comments is ordinary for modern youth. Free expression of opinions in a foreign language (i.e. speaking) in classes is often hindered by the fear of a public demonstration of an error. Being in a position of assessment by a teacher places the latter in the eyes of the first as a controller, and not as an equal partner in communication.

Offering students the opportunity to discuss certain video materials in comments without mandatory identification of the person, the teacher uses the opportunity to remove excessive nervous tension of the audience and thus intensify the speech activity. Leading a live dialogue requires a quick reaction of the interlocutors, which is difficult to achieve, especially at the initial stage of language learning. In addition, the limited auditorium time does not allow thinking for too long. Pause reduces the dynamics of conversation, thoughts do not find the personification in the right words, the conversation fails, and thus the ability to feel the language as a means of communication loses. A written discussion of a given topic gives an opportunity to think about a replica, to engage in a conversation in a convenient time, to comment on the previously stated statements more reasonably. The tasks performed during the comments may be verified by the teacher (sometimes by the owner of the channel or by other users). If you

watch online video tutorials, you can also achieve momentary synchronous interactivity that brings the conversation as close as possible to the "live" one, but this format is more likely to be used for individual work at home, since for class usage this can be technically difficult and organizationally incompatible, with the same schedule.

On the other hand, the teacher's own comments (if necessary also incognito) can promote the unobtrusive orientation of the conversation to a certain didactically determined path, and the usage of correct or contextually relevant linguistic constructions, in response to mistaken or misused, will allow correction of errors without causing a psychological discomfort. Observation of the general course of the conversation may become a valuable source of information for revealing personal qualities, preferences, interests and the level of formation of the foreign language competence of its participants. Such a format of communication may become a kind of modernized Socratic dialogue. It will replace the control by monitoring of the quality of education with the subsequent full realization of all the advantages of the latter for the constant improvement of the educational process.

In addition, participants who are not members of a particular training group may be involved in the conversation, so to speak "strangers". To distinguish them from others in the absence of the desire to register under their own names (at least for the reasons above), you can by agreeing to add a certain code word to the name of the subscriber. The presence of "strangers" opens up good opportunities for the search for "pen-friend", because among them there are rarely happen to random people. Users from around the world are usually interested in learning German. Focusing on comments, you can choose a potentially interesting and useful for further private communication with the interlocutor. Not only students but also teachers can find for themselves like-minded colleagues in the hosting. Viewers often conduct didactic discussions and share reflections on problems and difficulties related to the learning of German language, especially difficult topics, stylistic nuances, etc.

The occasional cases of participation in commentary discussions on language video teaching media positively motivate those who are only German learners, to search for a tandem partner not only on educational channels. Having a certain passion or hobby and watching videos of relevant subjects in German, where the language ceases are the subject of study and are used exclusively as a means of communication, one can turn to those, who are interested in the common theme of the language and to establish contacts on the appropriate language basis.

Encouraging students or pupils to review not only educational videos but also native speakers' and various video knowledge departments, you can somewhat make a transition to substantive-linguistic integrated learning in German – CLILIG. Participation in the conference organized by the Goethe-Institute in Kyiv in September, 2017 [23] has become the basis for understanding that learning with the help of the CLIL method allows achieving higher levels of linguistic and substantive competence. The emergence of this methodology has become a response to the needs of the era of technical and digital technologies in specialists of different specialties, which, in addition to specialized knowledge, also speak foreign languages. The combination of professional knowledge, substantive-linguistic and general competences, which is the main goal of CLIL, has become a guarantee of a successful specialist's career. Numerous reports of conference participants from Germany, Italy, Lithuania and Hungary have revealed the specifics of the usage of the CLIL methodology in the process of learning and the experience of foreign colleagues in integrating foreign language learning with other subjects during school education.

Substantially interesting learning motivates learning of German language and creates a linguistic basis, with the help of which it will be possible to build further education, in particular, in a higher school.

The wide theme range of YouTube videos allows you to organize CLIL-based learning not only at school but also in higher school. Implementations of the principle of inter-subject communications are subordinated to the program from all disciplines, regardless of the cycles they belong to. So it only remains to make established communications in foreign languages. We will speculate on the example of students learning German language within the specialty 014.02 Secondary education. Language and literature (German / English) with an additional specialty, accordingly (English / German) language. The main professional disciplines for them are Pedagogics, German and English languages. The vast majority of educational videos, where the German language is the subject of a study as a foreign language, is aimed to the English-speaking audience. They are often accompanied by English subtitles or by the translation of individual lexical units (for example [24]). The experience of using similar videos in the learning of Practical Course of German as a second foreign language shows a significant increase in students' interest in learning material, since they are able to orientate on "native" English. The latter in this case ceases to play the role of the direct object of study and becomes a means of learning, although indirectly it continues to study. The topics of practical classes in German and English are often coincided and studied in parallel, so the use of English-German video as a didactic material contributes to improving the quality of knowledge in both disciplines. It also serves as the development of translation skills. At the very least, practice shows that the quality of the implementation of the author's didactic game "Translator" is significantly increased (according to the rules of the game, one or more participants, performing the role of English speakers, and the other / others German speakers, must be understood on a specific topic, using the participant's help, who is playing the translator).

A narrowly-focused video may be useful while studying a wide range of topics within practical courses and linguistic studies.

As for Pedagogics and German language, it should be noted that it is not difficult to find videos on the YouTube of a particular topic (for example, the Christian Kißler [25] channel). However, the question arises – within which discipline is it more appropriate to use them? In our opinion, it is most appropriate to do this at classes on the methodology of teaching a foreign language, since this discipline is taught, as a rule, by a specialist in Pedagogics and the corresponding foreign language simultaneously. Teacher of pedagogical disciplines who does not speak German can find the necessary material in collaboration with his colleagues, and offer students the opportunity to study individually in order to consolidate the knowledge gained during their class work in their native language.

The video format, which is offered by the "LearnGerman" channel, for example [26], allows you to achieve better results in one more direction of language work. This is a kind of educational activity, such as home or academic reading. Generally, the main goal of individual reading is to develop perceiving skills of written foreign language text, expanding vocabulary and deepening linguistic competence. The accompaniment of audio reproduction of the available for visual perception of the printed source contributes not only to the accompanying development of the above-mentioned listening skills, but also to the improvement of pronunciation. Comparison of the results of text work in two groups of students, one of which used only paper, and the other

– audiovisual, showed that the pronunciation, and most importantly intonation, during the retelling of certain passages of the read (and listened) story in the second group significantly improved.

Returning to the institutions that promote German in the world, the Goethe-Institute should be reminded once more and noted that a significant number of its projects on YouTube and not only there is intended to prepare applicants for exams to confirm a certain level of language proficiency. In collaboration with the institute, there are also numerous printed guides from several German publishing houses, mostly accompanied by interactive exercises and audio materials. This logically updates the question of what is and is there in general the prevalence of video channels over "classical", albeit modernized, learning tools. In our opinion, the advantage becomes more obvious, the higher level of language proficiency of the person who prepares for the exam is.

According to [27], having passed the "Goethe-Zertifikat" C1 / C2 exam, you confirm the ability to "understand a wide range of long, rather difficult texts, also capturing the hidden meaning, ... flexible use of language in public and professional life, ... easy understanding of almost everything, read or heard in German". So, in order to confirm the C1 / C2 level it is not enough just to speak correctly and quickly on all well-known topics, but you must be aware of all topics, understand the current trends in the development of science and culture in the world and Germany in particular, and therefore be able to get the latest information about the country. Despite the fact that exam preparation tools are quite often updated, so that available information at the time of the exam may become somewhat obsolete. It's possible to be informed if you read periodicals regularly, listen to radio or watch videos on television or YouTube channels. However, only special videos are accompanied by subtitles or full text, translations, explanations, and exercises that convert them from the usual source of information to the learning tool. The "LearnGerman" channel offers, among other things, German daily news editions, and adapted by subtitles for foreigners videos, which are published several times a day, for example [28].

The number of educational author channels of various content (from lexical / grammatical explanations and audio exercises to reading / listening to literary texts and preparation for language tests) is constantly increasing. Informal educational videos feature a relaxed atmosphere, relevance, and meta-language reflection opportunity, gaining increasing popularity due to such characteristics. Interested in learning language may choose a teacher not only by the form of teaching didactic material (home videos in the format of communication tete-a-tete or recorded videos), but also by the personal authors' qualities. The latter, in fact, significantly contribute to the promotion of the language and its coverage by a broad audience. It is rarely when a higher schoolteacher may boast thousands of students from around the world who are eagerly awaiting each of his lectures, often defining its topic.

A brief didactical analysis of the general opportunities and practical experience of using the materials of several relevant in the thematic plan channels with a quite wide permanent audience is presented below.

The author of the "Slow German" channel, Anik Rubens, offers users of YouTube audio clips on a wide variety of topics (biographies of prominent German figures, national traditions and customs, domestic issues, social relationships, etc.), dictated at a slow tempo in order to ensure their better understanding. Each lesson is complemented by full written support of the sounded

text. Using the Urlaub (Vacation) [29] material while studying the topic "Travelling" by the Practical Course of German Language (PCGL) program, in combination with self-developed exercises to control understanding showed that the tempo of teaching is optimal for students who speak German at the A2 level / B1, since the vast majority of them understood the general meaning of the heard information after the first listening, and some nuances - after the second or the third.

The "Deutschlernen durch Hören" channel also produces audio tutorials (educational dialogues on various themes, songs) and video materials. In particular, audio texts with control tasks are similar to those used during the "Telc" language exam passing, for example [30]. Doing a trial test on the YouTube platform allows you to feel the atmosphere of a real exam, to assess the difficulty of the task, and to determine the level of your own audio competence by using the correct answer key added to each video. The mentioned above materials may be used as control tasks while the Practical Course of German Language. At the initial stage of learning language, it was quite positive to use a study song which is composed of numerous language cliches typical to the situations "Acquaintance" and "At the cafe / restaurant" [31].

The real master of the visual-dramatic song, which does not leave anyone indifferent and awakens interest to learn language, is Uwe Kind, the author of the "UweKind & LingoTech" channel, and Singling techniques. Thanks to the amusement, the extraordinariness and, at the same time, the noticeable efficiency of the latter is used by the students and teachers of the whole world in studying spoken foreign languages. In collaboration with composer Mark Schaffel, "LingoTech" was created – "it is a music that combines melody, rhythm, drama, movement and linguistic feedback, becoming a common experience that inspires young people to learn languages." LingoTech is based on the assumption that music simplifies the process of memorization, which allows students to improve foreign pronunciation and intonation [32]. It is a song, dance, drama and an interesting way of learning. Due to the understanding interest appears, music (melody) provides the duration of preservation in memory, the dance determines the interaction, and all together contributes to the success of learning. The fact that after the use of the song "Romanze im Perfekt" [33], students easily memorized three main forms of the irregular Verbs mentioned therein and chanted it on breaks, is an irrefutable proof of the effectiveness of this methodology, the basis of which consists a mnemonic technology based on music and motor activity.

The author of the "Deutsch in Bildern" channel creates his own educational videos using the positive aspects of another mnemonic technique, namely, illustrative. In order to demonstrate the syntactic structure of the sentence and the relationship between its members, there was a train, in which the locomotive is as a Subject, numerous wagons replace the Object, and the Adverbial Modifier is associated with railways [34]. According to the laws of mnemonic, an interesting picture, which will appear before the inner sight in the future, at the right moment will help to find quickly the necessary grammatical material in the long-term memory. The channel is created for native speakers to help them learn German and Literature (as native), Physics, Mathematics and other subjects. For this reason, the tempo of the author's speech is fast enough, which complicates the use of materials (in any case at the initial stage and for self-study). However, the expressiveness of graphic illustrations and the non-standard creative approach to the giving complex teaching material make the channel as a valuable source of positive experience for teachers.

Despite the enormous amount of educational YouTube channels, it is difficult sometimes to find "your own channel" – the one that offers comprehensive, competent answers to relevant issues regarding a wide variety of linguistic aspects and promotes the development of speech and meta-language competencies. Before advising a specific video or channel to students, you should critically treat content, format, and the author's professionalism. Three next channels were created by YouTube bloggers who not only studied German as a specialty for a long time, but also have many years of experience in teaching it.

The "Deutsch mit Marija" channel may be useful, first of all, for those who are preparing to pass a language exam, in particular TELC. The author herself is one of the company's examiners (telc GmbH) [35] and has a great practical experience in pre-test candidate training. A series of videos was created in the form of tips on how to avoid typical mistakes while passing the exam and to what features of each type of task should attention be paid to. At the following links [36, 37], for example, we find videos that provide specific recommendations for the successful doing the "Image Description" task. The description skills are necessary for productive communication in real life and are checked not only during the preparation of the above exam. The method of image description is successfully used in Practical classes of a foreign language. In particular, it is the basis for card games that are equally effective at the initial (for the acquisition of the new vocabulary), as well as at subsequent stages of language learning (deploying the speech situation, creating a story / dialogue with the help of the image). Among other things, the author explains what is the difference between doing the "Description" task at the level A1 / A2 and at higher levels, beginning with B / 1; what is the principle of the transfer, according to which the image should be described, in order to demonstrate a good level of language proficiency; how to make the best use of visual information to ensure a productive and informative process of communication; how to make a logical transition from the real image to the situations associated with it, etc. That is why such videos should be used not only while preparing for language tests, but also at Practical Course of German Language as a means of improving communicative competences of students.

In the channel playlists, you can find videos that are dedicated to the enrichment of the vocabulary (Wortschatz). Some of them explain the meaning of constant figures of speech or cliché and contain recommendations on the practicability of using them in speech. Some of them highlight semantic and stylistic features of cognate verbs or nouns. Other video groups are aimed to help you learn grammar and expand your country studying competence. The description of different life situations, seemingly, is devoid of didactic loading, becomes a valuable source of information for those who learn the language in the absence of the possibility of constant communication with its native speakers, who are in modern realities of Germany or another German-speaking country.

Considering information given above, let us note that the author of the next channel has developed a unique method of flooding in a foreign environment. Peter Heinrich, a teacher of German language from Austria, has engaged all his family to create nominal YouTube channel [38]. Based on the fact that "most of those who learn German have little access to authentic everyday language and culture", over 120 videos were made within the framework of the online family project (ONLINE-Gastfamilie), which show the actual everyday life of an ordinary German family: family holidays, traditions, travelling, problematic home situations, typical working days, etc. Video materials are accompanied by vocabulary, which shows the

key communicative structures and reveals important cultural aspects. With a wide range of suggested topics, the training videos can be easily adapted to the tasks of the curriculum of Practical Course of German Language. However, the situation may be somewhat complicated by the fact that not all videos and teaching materials are available on YouTube, but there are more than enough to "catapult your German language from theoretical grammar to active understanding and speaking and make a leap into German culture" [39].

Among the positive achievements of the GermanSkills.com channel, it has to be noted the provided methodological recommendations for the development of pronunciation skills. The proposed exercises, for example [40], brought tangible results in the formation of the correct articulation of one of the most difficult sounds in German language for Ukrainian students, – pronounced in the French manner [r].

The practical application for materials, which appears within the framework of 30 Days Challenge, has also been found at Practical Course of German Language lessons. 30 TageChallenge is dedicated to the problems of learning German language: how to speak correctly and quickly, how to use multimedia to learn language, how to master different types of speech activity, how to avoid mistakes while learning new vocabulary, why there is a fear of speaking in foreign languages, etc. [41]. Students were asked to register as the project participant and to join a peculiar thirty-day marathon. Depending on the level of language proficiency, the participants received an e-mail daily task – the theme of the day from which they had to speak by recording an audio message. The predicted audio format of the answer helped many to overcome the fear of speaking aloud, and the ability to listen to the messages of other participants and discuss them contributed to the activation of speech skills. Several reports by the author of the channel on the issues of challenge were offered for individual extra-audition listening to students who did not join the experiment, which caused an active reflection of the latter.

3.2. Use of alternative YouTube resources for teaching and learning German

Distance learning as a form of organization of the educational process is extremely relevant during quarantine activities. Most educational institutions have switched to online mode and use various resources to do so, which allow both synchronous and asynchronous communication with their students. The use of such resources in independent work is especially effective, because it allows to satisfy the interests of students (they choose the time, the forms, the materials that are convenient and interesting to them), on the one hand, and fill the educational space with educational materials. which are diverse in nature, sometimes offer alternative views on the problem and encourage its critical reflection with the subsequent formation of their own opinion, on the other.

One of such resources is YouTube channels, because they offer not only purely educational materials for learning German (or another foreign language, because these platforms also offer materials for learning other foreign languages), which was analyzed in the previous section, but directly are related to various disciplines in both general and higher education. Obviously, YouTube uploads and stores materials that, regardless of their purpose at the time of creation and placement on the platform, can be used to teach foreign languages, if they are properly prepared.

All these materials can be divided into several groups: materials that include educational con-

tent of different disciplines (geography, biology, physics, history, literature, etc.); informational videos and blogs about interesting facts, events, regions, prominent people, politicians, other information, mainly of an advertising nature; documentaries, popular science short and feature films; feature films and TV series on various topics.

One of the positives of this kind of material is that YouTube presents materials from all 4 groups in several languages, so the content is multilingual and allows you to work with sources that cover the same issue in different languages. This possibility is especially relevant in light of Companion Volume of the Common European Reference for Languages, where mediation is considered as one of the competencies with an appropriate description for each level of language proficiency from pre-A1 to C1. This concept was introduced by authors of Common European Framework of reference for language: learning, teaching and assessment in 2.1.3 – Language activities we can read the folowing: "The language learner/user's communicative language competence is activated in the performance of the various language activities, involving reception, production, interaction or mediation (in particular interpreting or translating). Each of these types of activity is possible in relation to texts in oral or written form, or both" [42, p. 23]. Mediation is one of the types of interaction and cannot be limited only to it, and therefore further in the text the authors specify their understanding of mediation, but through "mediative types" of speech activity, which "make communication possible between persons who are unable, for whatever reason, to communicate with each other directly" [42, p. 23]. These include: translation or interpretation, a paraphrase, summary or record, (re)formulation of a source text.

In addition, paragraph 4.4.4 Communicative and languages activities and strategies take into account the communicative actions that fall under the interpretation of "mediation", because among the examples of mediation activities, the authors call primarily oral and written translation, abstracting and translation of texts in a language understandable to the third speaker. It is emphasized that in mediation the speaker do not express his / her own thoughts but "is acting as a channel of communication (often, but not necessarily, in different languages) between two or more persons who for one reason or another cannot communicate directly" [42, p. 66].

In fact, CEFR understands mediation as translation, as evidenced by explanations of oral (simultaneous, consecutive, informal translation) and written (exact (contracts, agreements), literary (works), transfer of the main content (newspaper, magazine articles), translation (specialized texts for non-professionals) mediation [42, p. 66].

The modern version of CEFR Companion Volume with New Descriptors [43] uses the term "mediation", which is much broader in scope, as it is not limited to the translation and transmission of the main content without taking into account the opinion of the user who performs mediation, but includes those communicative activities that were not considered before. "In mediation, the user/learner acts as a social agent who creates bridges and helps to construct or convey meaning, sometimes within the same language, sometimes from one language to another (cross-linguistic mediation).

The focus is on the role of language in processes like creating the space and conditions for communicating and/or learning, collaborating to construct new meaning, encouraging others to construct or understand new meaning, and passing on new information in an appropriate form. The context can be social, pedagogic, cultural, linguistic or professional" [44, p. 103]. The Companion Volume considers at least three aspects of the concept of "mediation" as a descriptor

and the main activities, which are described in CEFR 2018 and shown at figure 1.

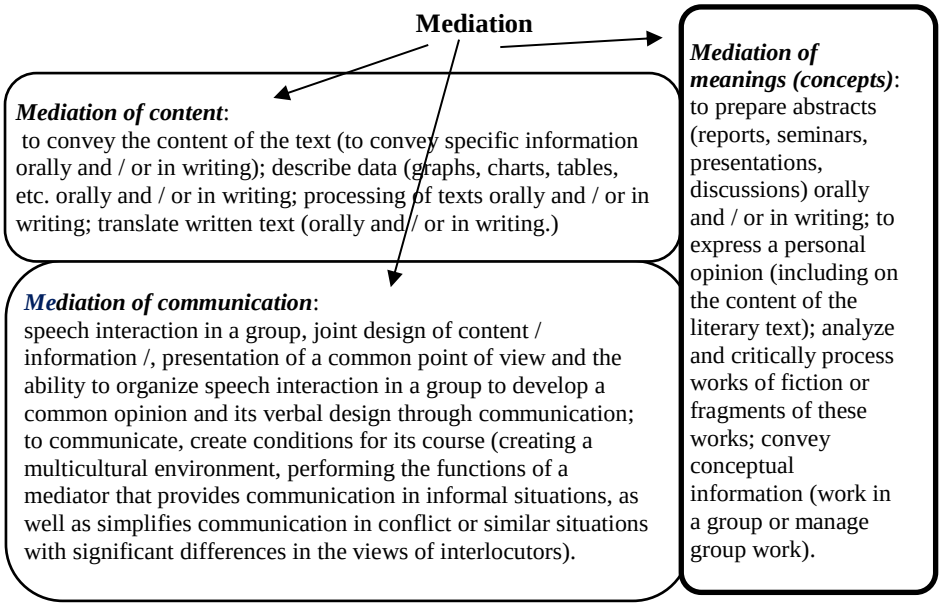

Figure 1: Three aspects of concept of "mediation" and their main activities [44, pp. 109–123].

These actions can be developed by the use of existing YouTube content.

We will analyze the available context of resources posted on YouTube, that can be used in the process of teaching German (as the first and/or the second language) for future teachers. We consider it advisable to observe resources according to the nature of the offered material, after all it is decisive at the didactic stage.

The first group includes educational materials that are not directly related to foreign language teaching, but contain information related to those topics that are included in the program and are studied in practical German course as the first or the second language, or reveal the content of particular modules or blocks of other disciplines of the educational program, such as the history of the German language, literature, stylistics or intercultural communication. The vast majority of such materials are video clips from 3 to 15 minutes, that offer basic information about the essence of concepts, their key features, peculiarities, differences from other similar phenomena and more in an accessible and understandable form. Such information is provided in the form of a lecture given by a teacher, a presentation voiced by a moderator, a story accompanied by fragments of animated or documentary films, comments of a schematic representation of processes, and so on. We consider it possible to illustrate different approaches to the presentation of educational content on the example of the course "History of German Literature", namely the theme "Baroque", because this literary era has certain features in the European context.

The second group includes informational videos and blogs about interesting facts, events, regions, outstanding people, politicians, that contain other information, often of advertising nature. This content is not educational but can be used in the educational process for different educational purposes and in different ways. The main advantage of such content is that

firstly, the duration of video clips is up to 10-15 minutes and commercials last from 1 to 3 minutes; they contain condensed information that is easy to remember because it is supported by graphic images; the same information can be offered in different languages, that encourages the implementation of mediation. The use of such material is especially effective when design work is being done. For example, within the framework of the project "Deutsche Spuren in der Ukraine" [45] students were asked to do a number of tasks using the YouTube resource, the fragment of one of them is offered below.

Arbeitsblatt 8

Aufgabe 1. Sehen sie sich den Kurzfilm über das Leben der Deutschen in Transkarpatien: https://www.youtube.com/watch?v=OarTBeBi1DI

Während des Sehens notieren Sie sich Informationen, die Sie brauchen, um die Fragen zu beantworten.

1. Wie kamen die Deutschen nach Transkarpatien?
2. Wie leben die Deutschen in Transkarpatien? Haben Sie ihre Organisationen? Womit beschäftigen sie sich?
3. Gibt es Probleme in der Kommunikation mit den Ukrainern?
4. Woher kamen die Deutschen nach Swalawa?
5. Was hat Herr Kmeti über seine Familie erzählt?
6. Was hat Herr Zwanko über die Gruppe „Schwalbach" erzählt?
7. Haben die Deutschen Kontakte zu deutschen Firmen, Organisationen? Welche Projekte werden realisiert?
8. Deutsche Bäckerei in einem ukrainischen Dorf. Erzählen Sie darüber.
9. Wie fühlen sich die Deutschen in der Ukraine? Was hat Julia erzählt?

Mehr Informationen finden Sie hier: https:// ukrainer.net/ nmtsi-ukrainy/

Aufgabe 2. *Deutsche Unternehmer versuchen in der Ukraine ihr Glück. Sehen Sie sich den Kurzfilm mit dem deutschen Unternehmer und geben Sie den Inhalt wieder: https:// www. youtube.com/ watch? v=G4oRsnyc8D4&t=155s*

Was lockt die Deutschen an? Haben Sie Probleme? Womit? Oder mit wem? Sind die Arbeiter der deutschen Unternehmen in der Ukraine mit ihrer Arbeit zufrieden?

Aufgabe 3. *Schlechte Erfahrung mit der Ukraine. Der Film aus dem Jahr 2014. Sehen Sie den Film und notieren Sie sich Probleme und Schwierigkeiten, die bei den Unternehmern und Firmen auftreten. Was kann man dagegen tun? https:// www.youtube.com/ watch? v=Tf7vqeAlRwU*

Aufgabe 4. *Lesen Sie die Beschreibung des Filmes und dann sehen Sie sich den Kurzfilm an: https:// www.youtube.com/ watch? v=9i2M7M5K49Q&t=112s*

Table 2
"Barock in der deutschen Literaturgeschichte" on YouTube.

A lecture given by a teacher	Barock kurz und einfach erklärt I musstewissen Deutsch A2	https://www.youtube.com/watch?v=f-75XBb2ZiI
	Literatur des Barock - Barocke Lyrik	https://www.youtube.com/watch?v=wnri4WHOpdg
A presentation voiced by a moderator	Barock - Literaturepoche einfach erklärt - Merkmale, Literatur, Geschichte, Vertreter; A4	https://www.youtube.com/watch?v=Khpxmxy37mQ,
	Literatur des Barock - Barocke Romane	https://www.youtube.com/watch?v=QNROLtbE6LQ, https://www.youtube.com/watch?v=735QsJh-znw
A story accompanied by fragments of animated or documentary films	Wallenstein und der Krieg - Die Deutschen (Staffel 1) - ZDF	https://www.youtube.com/watch?v=za1gJdLzba8
Comments of a schematic representation of processes	Epoche des Barock - (studentische) Einführung | DiB	https://www.youtube.com/watch?v=Fc2VgMyyCuE&list=PLAtaQ-5u2Yrhf75wbrFIY_bM4V4ikonPu&index=2
Full-length educational, documentary or feature film	Johann Grimmelshausen Abenteuerlicher Simplizissimus	https://www.youtube.com/watch?v=L8020Ls8b_Q

The third group includes popular science, documentary short or full-length films that are not designed for a specific target group and contain general information. They can be used first of all for the development of receptive competencies, checking the understanding of what is heard, systematization of the received information, its further consolidation and presentation through the target language. Films of the ZDF channel "Die Deutschen" 1 and 2 are extremely interesting, they tell about outstanding people in the context of German history from the Middle Ages to the Present (https://www.youtube.com/watch?v=F1t6-UyHV8U&list=PLtkAitkGhcGLS1y1xPdxGzBUE45ico2zY); "Wir Europäer", (https://www.youtube.com/watch?v=dax4xCtxPd0&t=71s), which deals with the history of Europeans; films about culture, life, problems, landscapes, historical monuments, etc.

The fourth group includes feature films and TV series which can be used as a means of developing of both receptive and communicative skills, a source of local lore information because heroes of any film live in conditions close to reality that gives an idea of German lifestyle.

The right choice of material and effective approaches to the use of each case of didactic approaches are the key components in work with YouTube videos.

3.3. Tools for developing educational autonomy on YouTube channel

The use of the content of the above-listed channels contributes to the acquisition of professionally significant knowledge and the formation of the necessary skills for the success of a teacher as a specialist in the labour market. However, current trends in society set new demands for the system of professional training of foreign language teachers. The qualification of a

specialist and his/her demand is also currently determined by the level of his/her readiness for further independent professional development and self-improvement and by the formation of educational competence or autonomy in education.

Autonomy is a component of qualification levels in the National and European Qualifications Framework along with knowledge, skills and competences and is defined as the ability to act independently within one's professional competences. Gaining a certain learning autonomy in language learning will allow developing an individual work schedule according to one's learning type, to set educational tasks following one's own goal, to choose the forms and methods of language learning that are the most effective to achieve this goal.

The project ONCOO, designed by Olaf Müller and Thomas Rohde, provides extensive opportunities for the development of educational autonomy [46]. The tools, that are used on this platform, provide support for both classroom and extracurricular cooperative forms of learning. Cooperative methods are useful at different stages of classes (introductory, main, at the stage of delving into the topic, for reflection and evaluation) and can be used for both beginners and students with good language skills. The tool is easy to use: it does not require registration and entering personal data. A teacher provides access to the worksheet by sending students an access code. ONCOO generally offers five tools to organize the learning process more efficiently and interestingly (figure 2).

Card survey (Kartenabfrage): a teacher initiates a survey on a virtual board, students create message cards and attach them to the virtual board. These cards can be sorted and structured using special tools that are located in the active window in the process of further group work.

Assistant system (Helfer-system): this tool has the form of a namelist involving all the students according to their status ("a participant" or "an assistant"), it helps to create atmosphere of competition and to develop the participants' responsibility for their own and partners' achievements. Using the tool "participants" report that they have coped with their own task and in the following stage they begin to act as "a helper" for those who need support and assistance. Thus, those participants who have difficulty completing the task may ask "helpers" for help.

Training tempo-duet (Lerntempoduett): a teacher can effectively manage individual work and work in pairs: students begin to work individually and report with the help of this tool on the readiness to check the task, a teacher divides students into pairs for further processing of the task and its checking.

Placemat is used to support individual work of students and allows a smooth transition to group discussion. ONCOO makes it possible to set the timing for the first phase (thinking and solving a crossword puzzle): firstly, students give answers individually and a teacher can make them available to all other group members at his/her own discretion. Secondly, there is a search for a common solution in the process of group discussion).

Target (Zielscheibe) creates an opportunity to conduct a joint evaluation and reflection on the work done. With the help of this tool, a virtual target is created, which presents various aspects of assessment, and students make their assessments individually using a virtual dart.

The web tool Twine (webtool) is available on YouTube and can be useful for the development of future teachers autonomy in education [47, 48].

It is designed to create interactive texts and can be used both by teachers to create textbooks – tutorials and other materials for independent work, and by students to develop their methodological competence, developing their own learning materials: games, creative interactive

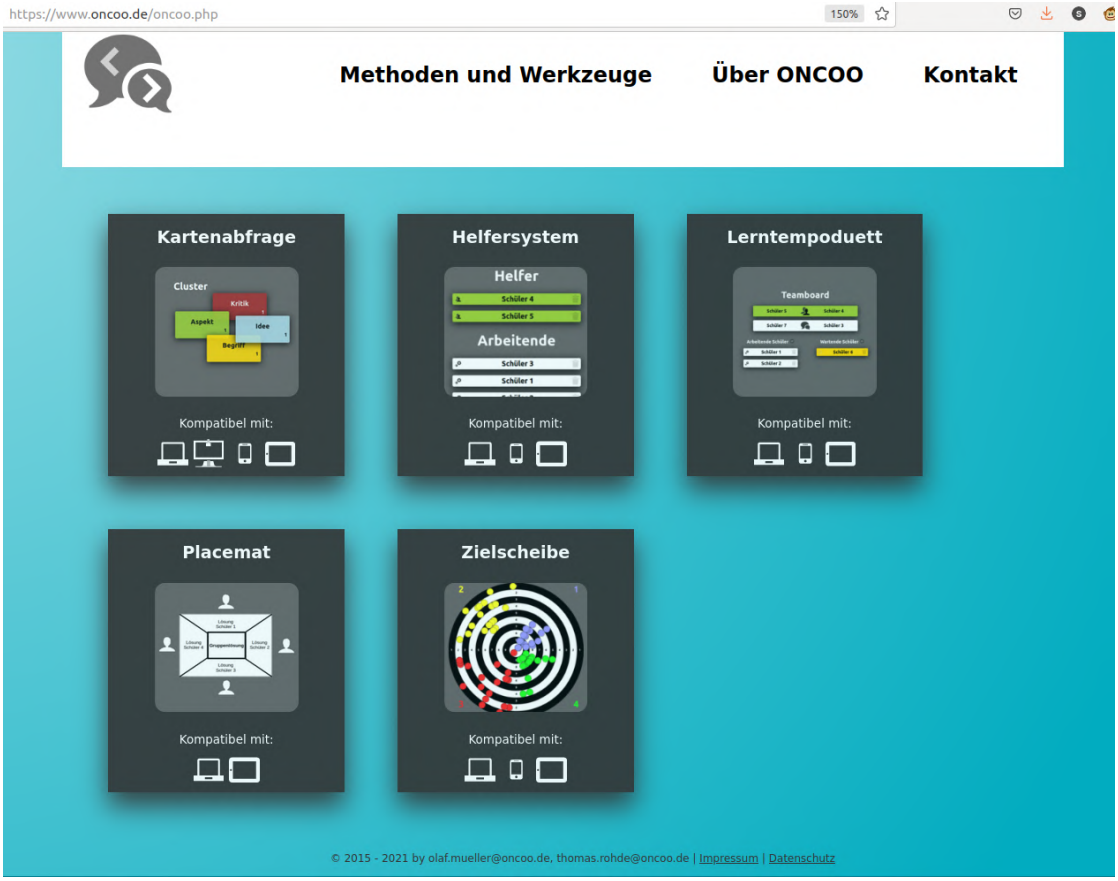

Figure 2: ONCOO tools [43].

stories, etc. If you want to create your own interactive story (Twine) or hypertext you need to go through a few simple procedures: add individual snippets of history, connect them using links, select "stylesheet" in the menu and design appearance of the story with available options, choose the menu "als Datei veröffentlichen", download and share with the group. You can send this file by email or any messenger. Stories are designed in such a way that a reader must choose from the text one of several options for the development of events, creating from the proposed material his/her own story. In this way, a teacher gets an opportunity to conduct a group discussion after a stage of individual work, and to encourage students to actively cooperate, comparing different versions of stories.

H5P is an interesting, useful and at the same time accessible of all types of devices (computers, tablets, smartphones) for creating interactive educational content. Content can be created directly in the browser. It is effortless to work with this tool,and it does not require special skills in working with ICT. A large amount of different content is available on H5P [49] page:

- Audio Recorder (for creating an audio recording);
- Advent Calendar (for creating an advent calendar);

Table 3
Content characteristics and some recommendations toward using YouTube channels.

Channel / Level	Kind of educational material	Subject / additional information	Resource	Scope of use
Deutsche Welle / A1 – C1	video clips	casual situations, intercultural differences	interactive tasks, forum	classwork, homework
Learn German / A1 – C1	video clips	various subjects, news of culture and science	subtitles in English, full text, exercises, explanations	home reading
Slow German / A1 – B1	audio	everyday situations, social problems, country studies	full text, slow speech	classwork, homework, listening
Deutsch lernen durch hören / A1 – C1	training dialogs, video clips, songs	everyday topics, country studies	exam format, task, keys	classwork, homework
Deutsch mit Marija / A1 – C1	video clips	everyday topics, country studies	tasks, grammar- and vocabulary-training	classwork, homework
Materials with learning content	video	various subjects, news of culture and science	information to various subjects; *tasks to be prepared*	homework, project
Informational videos and blogs about interesting facts, events, regions, prominent people, politicians, other information, mainly of an advertising nature	video	various subjects, news of culture and science; casual situations, intercultural differences, country studies	general information to various subjects; *tasks to be prepared*	homework, project
Documentaries, popular science short and feature films	video	various subjects, news of culture and science; intercultural differences, country studies	general or specific information to various subjects; *tasks to be prepared*	homework, project
Feature films and TV series on various topics	video	casual situations, intercultural differences, country studies	features of everyday life, country studies; *tasks to be prepared*	homework, project

- Dialog Cards (for creating text-based turning cards);
- Dictation (for creating a dictation with instant feed-back);
- Essay (for creating an essay with instant feed-back) and many others.

Consider as an example Advent Calendar: a teacher independently fills the calendar with pictures, links, videos, texts focusing on the objectives of his/her training course. There are videos on YouTube that guide teachers on the methodological principles of using such tools and creating their own modern interesting and motivating learning material [50, 51].

Specialized publishers of educational and methodical literature, which organize methodical

Table 4
The logical framework for the development of linguistic and general competences by using YouTube channels.

Channel / Level	speaking competence	listening competence	reading competence	writing competence	cross-cultural competence	methodical competence	learning autonomy	general competences
Deutsche Welle / A1 – C1		*	*		*		*	*
Learn German / A1 – C1	*	*	*	*			*	*
Slow German / A1 – B1		*	*		*		*	*
Deutsch lernen durch hören / A1 – C1		*					*	*
Deutsch mit Marija / A1 – C1	*	*	*	*			*	*
Informational videos and blogs	*	*		*	*		*	*
Documentaries, popular science short and feature films		*			*		*	*
Feature films and TV series on various topics	*	*			*		*	*
ONCOO	*		*	*		*	*	*
Twine	*		*	*		*	*	*
H5P	*	*	*	*		*	*	*
Future-Teach		*				*	*	*

webinars, also help teachers to develop independently their methodological competence and improve professionally. Online webinars later become public on YouTube. For example, the well-known publishing house Klett publishes numerous digital learning webinars, reviews of textbooks with guidelines for their use and much more on its channel [52].

Support for online classes is offered by the YouTube channel Future-Teach [53]. There are practical tips for using Microsoft Teams für Office 365 for educational purposes, tips for creating online surveys and quizzes, using various digital Apps and Tools, Skype and Zoom – conferences that promote the educational students' autonomy and methodological competence of (future) teachers.

4. Conclusions and future work

We have shown that YouTube channels created by professional and amateur authors can be used as supplementary teaching materials in class and outside for students who learn German. The use of these materials has a positive impact on: creating a dynamic learning environment; increasing the motivation of students' learning and cognitive activity by immersing them in the linguistic environment through authentic videos; optimizing individual work aimed at deepening or consolidating knowledge on specific topics, provided that there is professional monitoring and feedback. The use of ICT also creates new opportunities for teachers, but requires a careful and

responsible approach to achieve the goals and objectives of the curriculum. The integration of open information sources into the educational process in higher education institutions requires a rigorous selection and a creative didactic adaptation (in particular, adding training activities aligned with the purpose of each practical lesson) of the available materials. However, the question of whether a certain level of language proficiency can be attained solely based on these sources remains open. This calls for further empirical research.

We have summarized the content features and some tips for using YouTube channels in table 3.

We have also explored the potential of expanding the use of educational videos, which are provided as additional tools for teaching foreign languages on video hosting, on the condition that they are pre-adapted to the requirements of the educational programs. We have presented the possibilities of developing certain competencies by using the YouTube channels mentioned above in table 4.

Therefore, we suggest that it is worthwhile to master the methodological techniques of introducing them into the training process of pedagogical students in higher education institutions and encouraging them to create their own educational videos that are suitable for work in class and outside.

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Developing digital learning aids for pre-service IT specialists using the functional approach in holistic vocational training

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Abstract

This paper explores the practical aspects and benefits of applying the functional approach to the development of digital learning aids for pre-service IT specialists in the context of their project-based and holistic vocational training. The paper draws on the theoretical framework of holistic education and the functional principles of digital didactic aids design. The paper presents two specific examples of students' project work on creating digital learning aids using the functional approach: (1) a multimedia tutorial for teaching English to schoolchildren and (2) an e-guide on the basics of cryptography for university students. The paper analyzes the outcomes and advantages of such project work from the perspective of holistic and functional approaches. The paper also outlines the directions for future research in this area.

Keywords

digital learning aids, functional approach, holistic vocational training, pre-service IT specialists, project-based activity

1. Introduction

The motivation for this research stems from two interrelated factors. First, the increasing demand for digital learning aids that can support the emerging modes of blended and distant learning in contemporary education at all levels [1, 2]. The design of such digital aids requires the adoption of progressive approaches that are aligned with the prospective educational paradigms. Second, the challenge of preparing pre-service specialists for life and successful work in the volatile world of today, which calls for the modernization of the vocational training process in various domains [3, 4]. The current situation with the vocational training is exacerbated by the unexpected circumstances caused by the global pandemic and the urgency of developing new forms of teaching and learning. Therefore, it is important to build a renewed model of vocational training based on new paradigms.

One of such paradigms is the holistic educational approach, which is emphasized in a number

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of normative documents, such as the Concept of the New Ukrainian School [5, 6], the National Strategy for the Development of Education in Ukraine for 2012–2021, the Law of Ukraine "On Higher Education", the Law of Ukraine "On the Concept of National Education information programs'', Education for Sustainable Development Goals: Learning Objectives and others. According to recent research papers on the theory of holistic education, it is considered as a paradigm that provides educators with a system of principles that can be applied in various ways [7, 8, 9]. The central idea of holistic education is the cohesive development of the whole personality of a learner at both the intellectual and emotional levels [10]. It is also emphasized that such a cohesive development should be supported by strong links between personal experience and real-life problems. However, the evidence from real educational practice shows that the productive and important ideas of holistic paradigm are often implemented in a limited way without fully exploiting its potential for providing integrity at the levels of the content, means and forms of education.

In this research, we aim to implement holistic approach in a comprehensive way, covering various aspects of vocational training, such as: (1) designing the educational content based on the integrative approach to structuring the curriculum disciplines; (2) providing multi-code representation of the educational content to stimulate cognitive processes; (3) integrating students' educational practices with innovative ICT applications to real-life challenges through project-based learning. We argue that these aspects are both driven by and complementary to each other, and thus they enable a more holistic understanding and practice of education.

We also contend that the realization of the main principles of holistic theory requires an appropriate system of learning aids that can facilitate the cohesive development of learners' personality. This leads us to develop digital aids based on the functional approach, which is regarded as the most advanced approach to their design.

In this context, it is essential to prepare IT specialists of various directions (including potential IT teachers) for designing and implementing effective didactic aids that are based on the analysis of their functions and that can support holistic learning of different subjects at different levels of education [11, 12, 13]. Therefore, one of the important components of the renewed model of IT specialists' vocational training based on the holistic approach is the students' project-oriented activity on creating digital learning aids.

The aim of this paper is to present the practical aspects and outcomes of applying the functional approach to the development of contemporary digital learning aids in the process of project-based activity of pre-service IT specialists within their holistic vocational training.

2. Theoretical framework

To conduct this research, we employed a combination of theoretical, empirical, and modelling methods. In the proposed model of pre-service IT specialists' training based on the holistic approach, their preparation for designing innovative didactic aids is realized comprehensively through the integration of common and vocational curriculum disciplines and project-oriented activity.

The theoretical background of the research in the field of digital learning tools development consists of two main components: the holistic educational approach (briefly discussed above)

and the functional principles of digital didactic aids design.

The issues of defining didactic functions of learning aids and applying functional approach to their design have recently attracted the attention of researchers and practitioners (e.g., Grinshkun et al. [14], Grinshkun and Usova [15], Gryzun [16, 17], Kraevskii [18, 19, 20], Lerner [21], Kuts and Lavrentieva [22], Lerner [23], Robert et al. [24, 25] and others). This approach is based on a thorough analysis of the didactic functions of the learning aids and the means of their realization. Functional approach to creating learning aids enables to determine the functional load of its structural elements and the connection between the performance of their required functions [16, 17, 21, 26, 27, 28, 29]. These ideas become increasingly relevant nowadays in the context of designing digital multimedia tutorials [30], as they play a vital role in education.

The problem of didactic functions analysis has always been complex and ambiguous. There are various views on their nature and classification. Based on the review of a number of sources that represent a wide range of functions, we could identify certain groups of them that seem to be pertinent for digital aids. Specifically, *the first group* includes functions that enhance learning motivation; *the second group* contains pure didactic functions that provide effective representation of the learning content and its successful assimilation; *the third group* includes functions of optimization of educational process in terms of adaptation to the learners' needs; *the fourth group* consists of meta-functions that foster learners' progress and increase their general educational potential, which creates a basis for further successful learning beyond the knowledge domain covered by this specific digital aid. It is important to note that these groups of functions are general in nature. Depending on the target audience of the digital aid (schoolchildren or students), the type of academic discipline for which the aid is developed, and some other factors, the emphasis and priorities of these groups of functions may vary.

Nevertheless, the functional analysis for a specific digital learning aid provides practical guidelines for developing the structure of e-tutorials that can be used as a theoretical foundation for their design. The design process involves determining the structure of the tutorial that specifies the interrelations of its components, establishes the mechanism of implementation of these links, etc. As mentioned above, the process of contemporary tutorials development must rely on their deep understanding as an object of design. Thus, it is relevant to acknowledge that a digital learning aid in its state-of-the-art sense has been transformed into an integrated learning environment that incorporates functions of a whole set of learning aids. This has happened due to the use of advanced multimedia and cloud-based technologies in its design.

In addition to determining the structure of a digital aid and clarifying the functional load of each of its structural components, the functional approach also helps to formulate specific requirements for the aid and its design features. This makes the process of the aid development more practically oriented, which is very beneficial for the students' project-based activity, as it gives them a clear understanding of the objectives and significance of their work, enhances their motivation to design high-quality aids that meet the requirements derived from the functional analysis.

The above-mentioned theoretical background provided a basis for applying the functional approach to the development of contemporary digital learning aids in the process of project-based activity of pre-service IT specialists within their holistic vocational training.

3. Results and discussion

The practical aspects and experience of this kind of activity are covered below on the examples of the development of different digital learning aids provided by the students of different specialities within their project-oriented activity in the process of their holistic training.

In particular, we would like to represent multimedia tutorial for English learning support which was designed by the pre-service teachers of Computer Science and English in the process of their project-oriented activity, rested on the previous learning of such curriculum subjects as Programming, Computer Graphics, Pedagogy, English (common academic subjects) and Computer-oriented systems of learning, Basics of E-pedagogy, Design of didactic aids (professionally-oriented subjects).

On the initial stage of the project the didactic functions and structure of the multimedia tutorial were specified due to needs and problems of foreign languages mastering at school.

In particular, pre-service teachers revealed basic demands to the tutorial, determined its functional facilities and defined its structure. In such a way, there was concluded that in order to provide the fulfilment of the leading didactic functions, the English multimedia tutorial for 6th grade pupils has to realize the set of facilities that are given below with the reference to the groups of functions (see "Theoretical framework" section).

First of all, it must provide high-quality visualization of educational content and interactive dialogue with a trainee. It will help to realize in proper way informational, transformational, developing didactic functions (the second group of functions), as well as functions of feedback, friendly correction (the first group of functions) and control (the third group). It should also ensure that the acquisition of linguistic competence is enhanced by the complex involvement of many information perception organs, which will provide the implementation of transformational and developing functions.

The tutorial also has to enable working out of various skills of speech training and in such a way to realize systematic and consolidation functions (the second group of functions). It should guarantee the cognitive activity management including game activity for ensuring realization of didactic functions of developing and self-learning (the fourth group). In addition, the tutorial must provide a strong feedback with a teacher and other trainees to obtain consultations, help, assessment etc (the second group of functions).

Finally, the tutorial has to be easily integrated with other e-resources which will guarantee it integrative and coordinative didactic functions (the third group of functions).

Based on the above functions and relying on research [21, 28, 31, 32], it became possible to design the structure of the multimedia tutorial, since it is conditioned by the need to implement its didactic functions. Thus, students concluded that the tutorial should be the complex of interconnected components characterized below.

For high-quality information visualization, the tutorial should include a multimedia illustration library that offers text, graphics, video, and audio materials [33].

To build language competence via the comprehensive involvement of many sense organs, the tutorial contains an interactive video library with didactic support.

To develop a variety of skills, the manual has a bank of interactive exercises with an immediate output of the results of their implementation.

For learning activity management, the tool has a learning activity management component with repetition of the material and involvement of game elements.

To automate the processes of information retrieval and integration with other electronic sources, the manual has a technological component that will provide its online uploading and the ability to be integrated with other resources. To communicate with the teacher and other students, the tutorial has an appropriate component.

Defined and specified didactic functions and structure of the multimedia tutorial became the basis of its design for the students.

Thus, on the subsequent phases of the project the multimedia English tutorial for 6th grade schoolchildren has been developed with the help of the tools of Ourboox environment, whose capabilities were enhanced by the students' programmed elements. It's worth noting that it does not need to be installed or downloaded due to the fact that it is a cloud-based multimedia book called MultiEnglish. It covers the main topic taught in the 6th grade during English lessons: My family, My friends, Shopping, Food, Sport, Traveling, Ukraine, Great Britain, School life (figure 1).

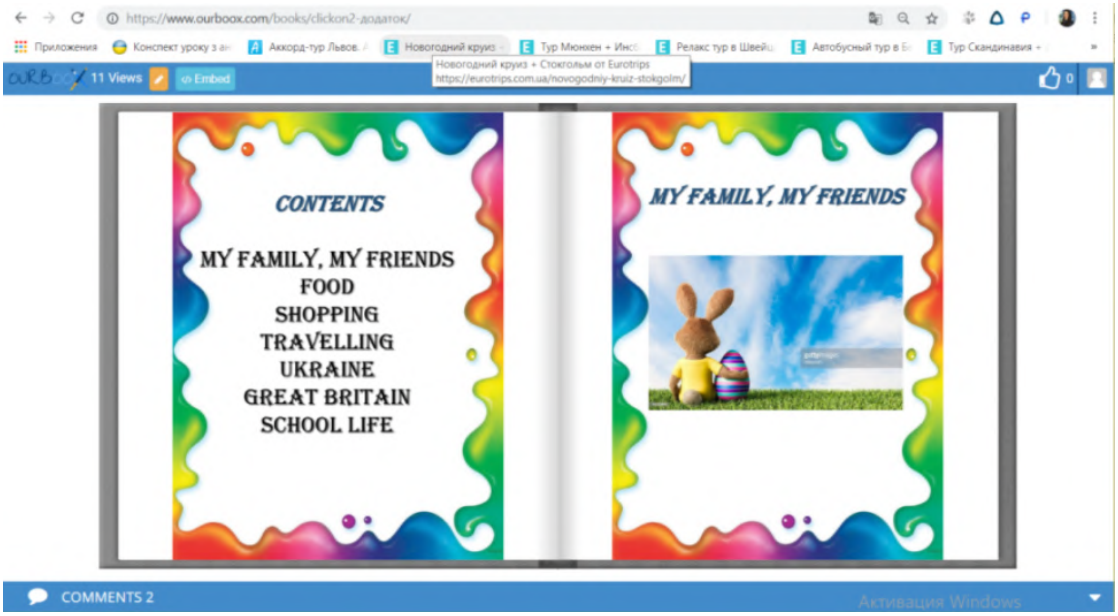

Figure 1: Content of the multimedia tutorial MultiEnglish.

Each topic is represented in four headings (Let's focus on...) that target formation and development of four basic language skills: Let's focus on Vocabulary, Let's focus on Reading, Let's focus on Grammar, Let's focus on Listening and Speaking, Let's focus on Writing (figure 2). The sections contain relevant teaching materials, questions, tasks and various exercises. The demo version of the tutorial is available via the link https://www.ourboox.com/books/multimediaenglish/.

While designing the tutorial, according to its didactic functions and structure, standard features of the Ourboox environment have been significantly extended by HTML markup programming.

Figure 2: Selected categories of the multimedia tutorial MultiEnglish.

Adding appropriate language instructions allowed students to supplement the tutorial with interactive elements of other services that are not provided by the Ourboox environment toolkit. In particular, training exercises, interactive videos, interactive posters, games, static and dynamic illustrations, hyperlinks of a number of services (LearningApps, Quizlet, YouTube, Edpuzzle, Vizia, Gettyimages, ThingLink, ESL Game Plus, Jigsaw Planet, Google Forms) were integrated into the tutorial (figure 3).

In addition, due to editing the HTML code of the tutorial pages, the media content was created. For example, the students-developers could combine text, graphics, video elements and the necessary hyperlinks. Using HTML, it was enhanced Ourboox's capability to format text. For example, it was developed code fragments in HTML with CSS elements to align text and to create numbered lists. In addition, students-developers programmed integration with interactive didactic support into the tutorial. This element allows a trainee to watch the video with a pause at the marked places and do interactive tasks to the video story.

On the whole, thanks to the programmed elements that were added, the multimedia tutorial is able to perform all its didactic functions, defined at the first (theoretical) stage of the students' project.

At the final stage of their project, pre-service Informatics teachers do analysis and reflection of the designed tutorial, revealing its didactic features.

Discussing the didactic capabilities of the MultiEnglish multimedia tutorial, designed on the basis of a functional approach by the pre-service Informatics and English teachers at their project activity, we would emphasize its following features.

The tutorial provides high-quality visualization of educational information and interactive dialogue with the student. A vast library of multimedia illustrations of the application visualizes the necessary elements of the educational content and provides instant feedback. The library contains static and dynamic illustrations of various types, including interactive posters. This type of illustrations enables quick boosting and checking a trainee's vocabulary (figure 4).

This tutorial capacity provides high-quality implementation of informational, transformational, developing didactic functions, as well as the functions of feedback, correction and self-control. In addition, the tutorial enhances the effectiveness of language competencies through the comprehensive involvement of multi-senses activities. In particular, the tutorial allows you to organize the learning activities of the student with interactive video stories, for

Figure 3: An example of an interactive element of a multimedia tutorial that is embedded with HTML programming.

which it has been developed appropriate didactic support. Thus, while viewing the pupil is provided with the tasks that develop their audio skills, replenish their vocabulary, encourage the conscious using of grammar (figure 5).

The multimedia tutorial also has the ability to record a student's speech in order to develop their oral speaking and communication skills (figure 6), which provides realization of the transformational and developing functions.

The developed digital aid encourages training of various skills and can be used as a simulator. The Bank of interactive exercises offers the trainee a variety of exercises of different formats:

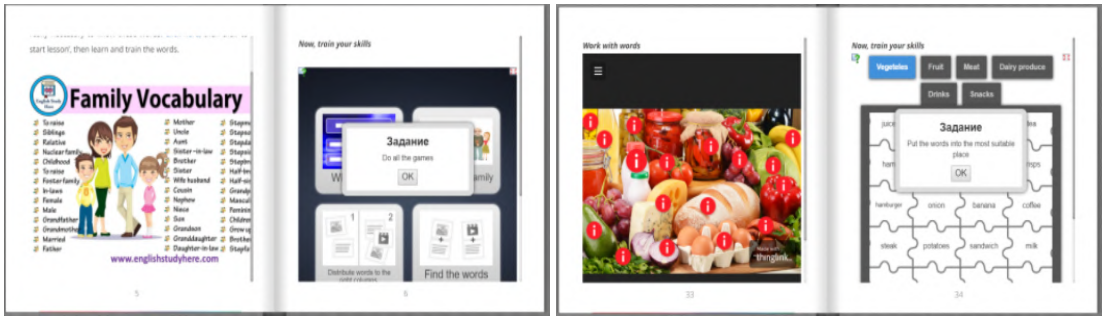

Figure 4: Fragments of work with the multimedia illustration library.

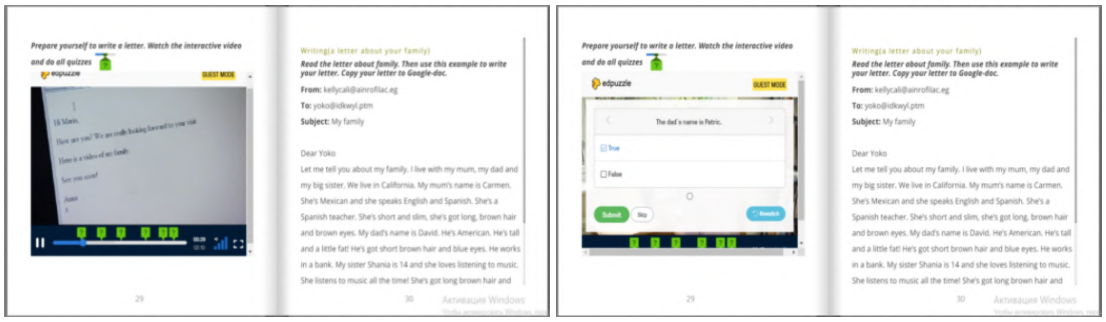

Figure 5: Fragments of the using the interactive video "My Family".

word search, matching, interactive text, puzzle solving, audio and video tasks. In such way, the systematic and anchoring functions are realized. Fragments of different types of training exercises are given in figures 7-9.

The functionality of the developed multimedia tutorial also includes the arrangement of cognitive activities, including game activity. That means that a trainee is able to work at their own pace, both independently and under the guidance of the teacher. In addition, all of the tasks offered to the student can be performed several times to achieve the best results. In order to increase motivation for learning, the tutorial involves pupils into game activities. It offers quizzes, crossword puzzles, cognitive grammar trips, quests etc (figure 10). These kinds of activity provided by the tutorial ensure fulfillment of the developing, systematic and consolidation functions (from the first, second and third groups).

The tutorial expects technological capability of its uploading to other websites and be integrated easily with other electronic sources and environments (figure 11), which facilitates the implementation of integrating and coordinating functions. It is also essential that the tutorial works correctly with all browsers like Google Chrome, Microsoft Edge, Opera, Mozila Firefox.

In addition, the tutorial has the functionality, which helps students to communicate with their teacher. For example, comments element can be used to ask questions, to do the exercise, send a speech to a teacher, or ask for help from other trainees. In such a way, the tutorial implements the didactic feedback function.

Thus, the analysis of the developed multimedia tutorial (provided by the students on the

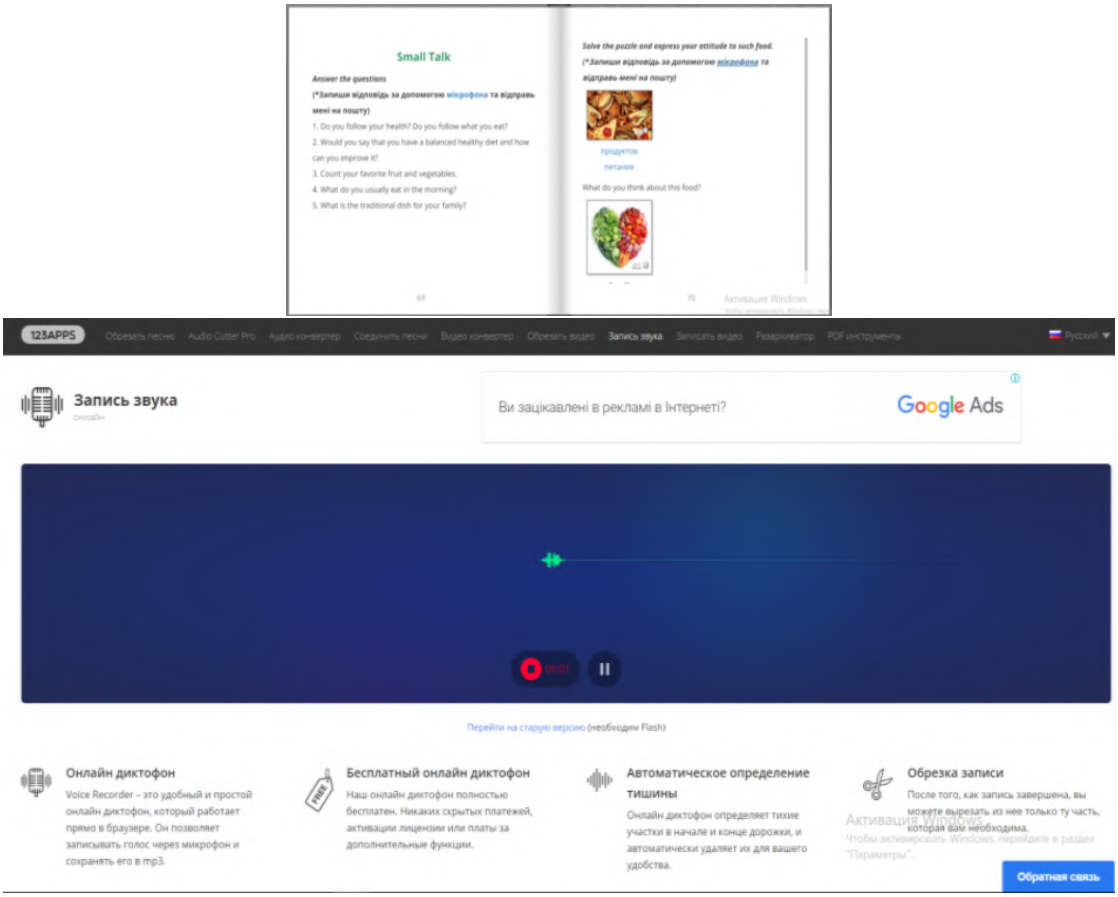

Figure 6: A situation of a student's voice recording while learning the topic "Food".

final stage of the project) testifies that the tutorial designed on the basis of functional approach becomes really innovative, as it creates for a trainee the integral cloud-based cognitive environment oriented on the activity-centred learning. In fact, the tutorial provides pupils with a platform for their independent cognitive activity, for their motivation to learning due to availability of tasks choice and ways of their fulfilling. As a result, it promotes cohesive development of both of students and their potential pupils.

The other example of functional approach applying to the design of innovative digital learning aids is the development of the e-guide on the cryptography fundamentals provided by pre-service IT specialists (unlike the first e-tutorial realized within vocational training of pre-service teachers of Computer Science and English), but also within their project-oriented activity in the process of their holistic training. Including this example, we also aimed to demonstrate main features of the approach realization on the samples of e-guides for completely different target audience (schoolchildren and university students), knowledge domain, forms of potential students' activities etc.

At the first stage of the project activity, the didactic functions and structure of the e-guide

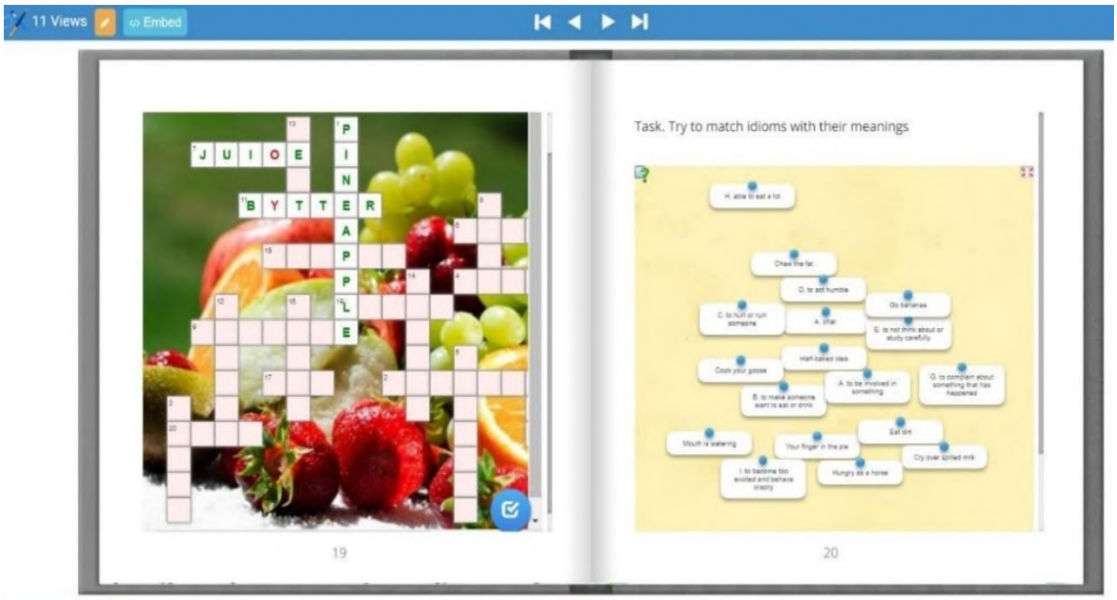

Figure 7: A fragment of matching and interactive crossword puzzles.

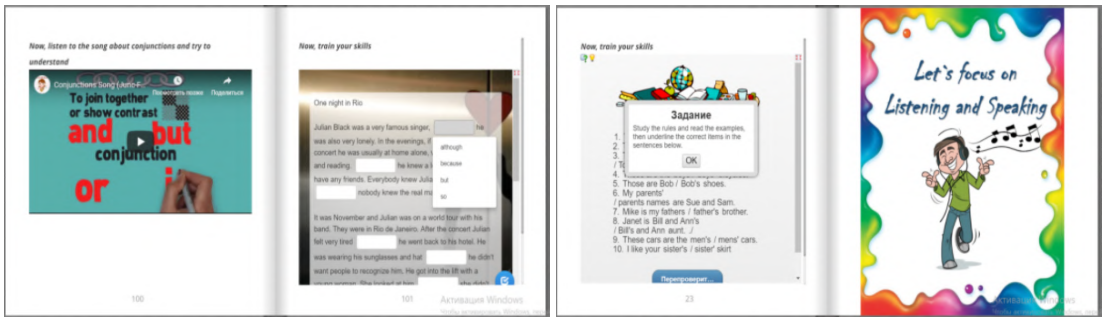

Figure 8: Fragments of work with the interactive text.

were determined due to problems of the course “Information security”, which is a basic one for lots of vocations.

In such a way, resting on the theoretical background on the functional approach (covered above), the students defined proper structural components of the learning aid. In particular, it was determined that the e-guide must contain the textual component organized in hypertext form which presents systematized and didactically processed learning material according to the syllabus of the academic discipline. Here the place of the cryptography fundamentals in the course was determined, and the necessity of coverage in the aid of encryption as one of the means of information protection was established. The learning material was selected and structured on the basis of a number of sources on the basics of cryptography and modern computer encryption systems [34, 35, 36, 37].

It was also determined that the textual component has to provide transition to non-textual

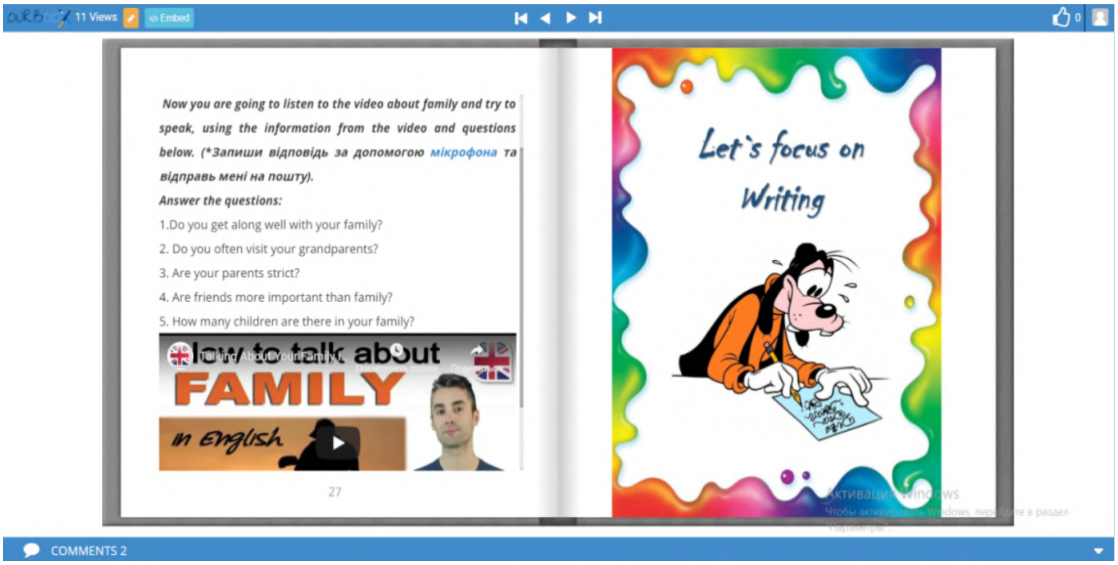

Figure 9: Fragment of work with the video content.

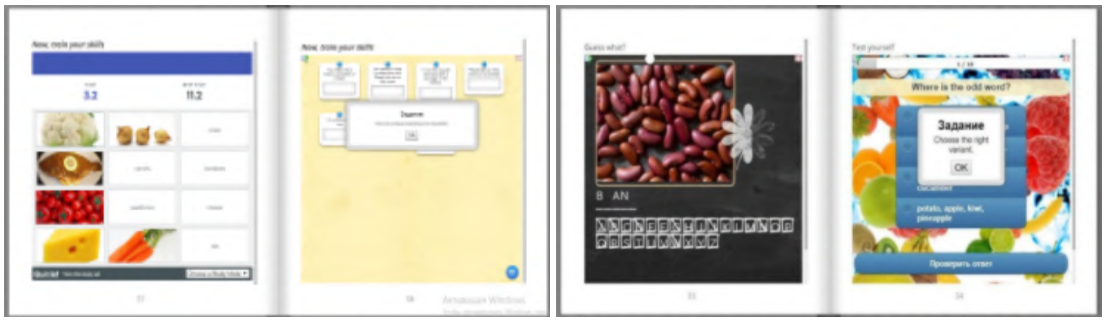

Figure 10: Fragments of the Learning Activity Management component with repeated material and involvement of game elements.

structural components: Illustrative material and Apparatus of the acquisition arrangement.

Illustrative material should contain the static illustrations (technical charts, schemes, photos, pictures etc.) and dynamic ones (animated or video illustrations that demonstrate different methods of information encrypting).

Apparatus of the acquisition arrangement should be represented by a library of learning tasks of different types and a system of self-checking. Among the learning tasks of the e-guide should be distinguished three basic types of the tasks: teaching, training and cognitive-search ones.

At the next stage of the students' project-oriented activity, the e-guide whose functions and structure were specified at the previous stage was developed in the environment of MS Learning Content Development System using its tools and facilities. The developed learning aid covers the following topics on the basics of cryptography: "Basic concepts of information security", "Cryptology as a science", "Classical encryption algorithms", "Computer encryption systems".

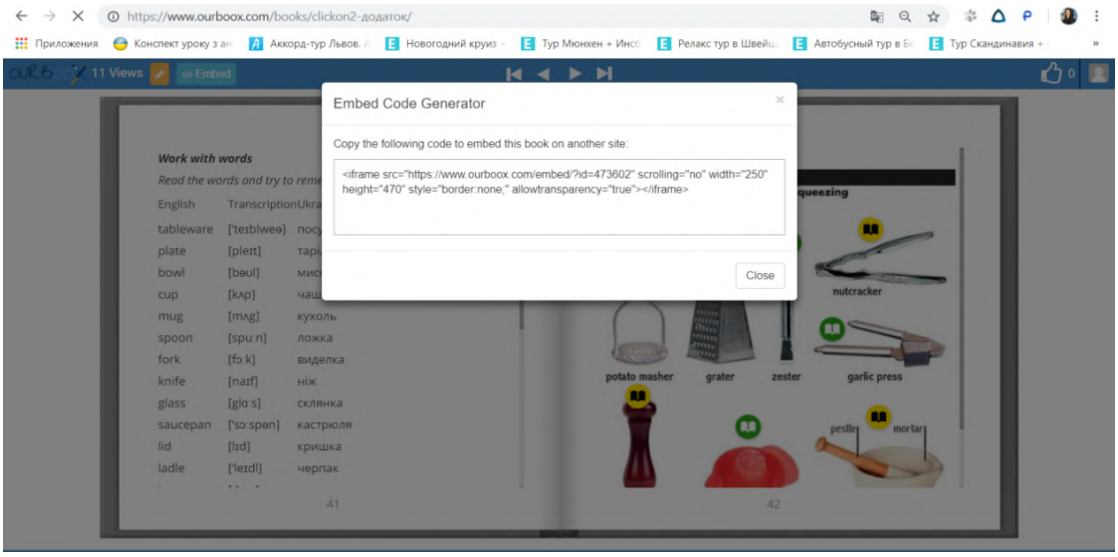

Figure 11: A fragment of the technology component that allows you to embed the author's tutorial on other websites.

As it was planned, the e-guide contains a textual component organized in the form of hypertext, which allows to find quickly necessary learning material on the course, navigate easily the topics and sections, work with illustrations and tasks, refer to external links for other information resources (figure 12).

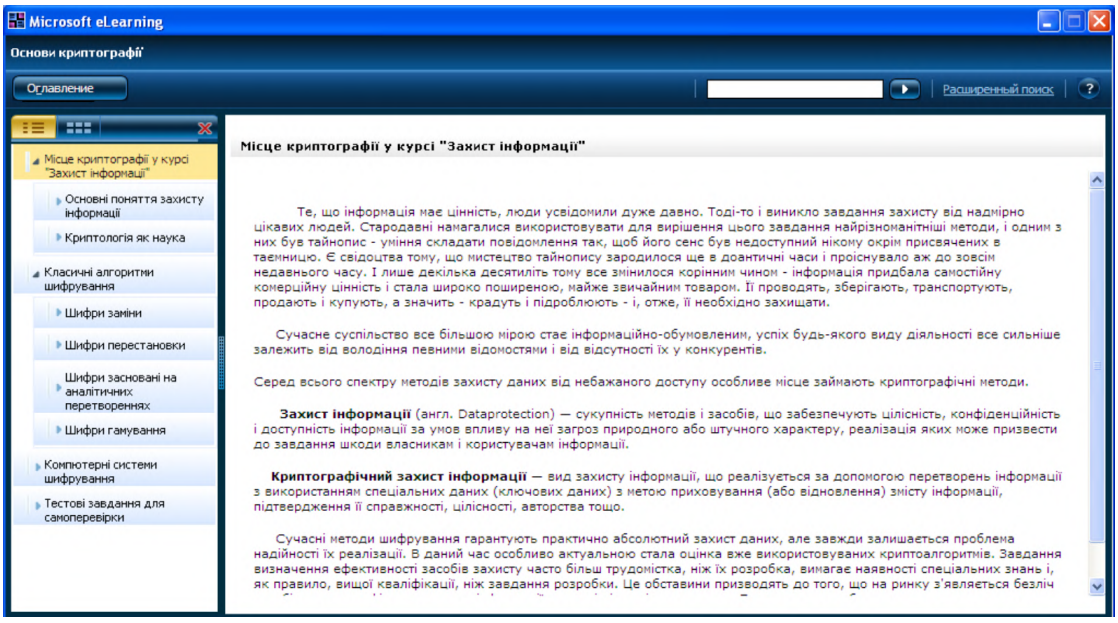

Figure 12: Episodes of work with the hypertextual component of the e-guide.

The textual component is supported by the Illustrative material component which provides a trainee with two types of illustrations. The first type includes static illustrations, such as generalized schemes of computer cryptosystems, the visualization of which facilitates the understanding of educational content (figure 13), contributes to the transformational didactic function and function of visual method use.

The second type of illustrations are dynamic ones which demonstrate the process of data

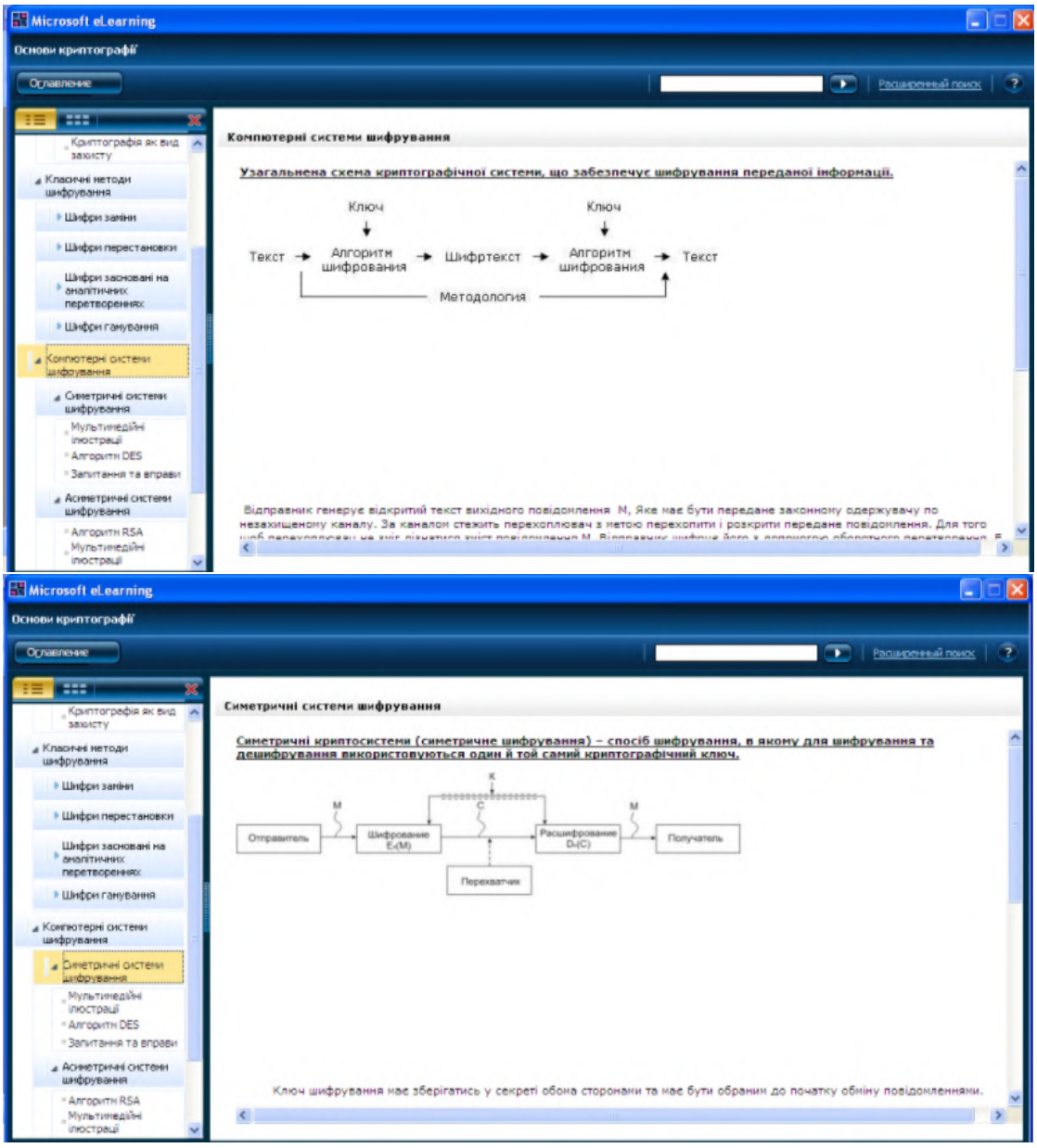

Figure 13: Work with static illustrations on the topics “Computer encryption systems”.

encrypting based on various encryption algorithms; processes that reproduce the sequence of actions in the operation of encryption algorithms, historical information, the essence of some abstract concepts, and so on. This component gives for potentical trainees the opportunity to observe these processes, review them at different speeds and check the assimilation of the content, answering a number of questions to the reviewed dynamic illustrations offered by the e-guide.

Thus, the work provided by the e-guide with its hypertextual component supported by static and dynamic illustrations promotes implementation of informational, transformational and systematizing functions (the second group of functions depicted in the Theoretical framework above).

Apparatus of the acquisition arrangement of the e-guide, as it was planned, is represented by a library of learning tasks of different types that are forcused on the mastering of theoretical content, and a system of self-checking.

The teaching tasks of the developed aid are ready-made programs (realized in different programming environments) that implement a certain encryption algorithm. The e-guide encourages a trainee to work with the program, to find out its purpose and functions, and to analyze the program code. In particular, the teaching tasks allow data encrypting and decrypting based on some classic encryption algorithms. The solution of the teaching task expects trainee's processing, according to a certain scheme proposed by the library of teaching tasks (or by the teacher). Trainees have the opportunity to run them, analyze the operation of algorithms and make conclusions by answering questions. In addition, it is possible to copy fragments of program code and use them to develop trainees'own programs (figures 14-15).

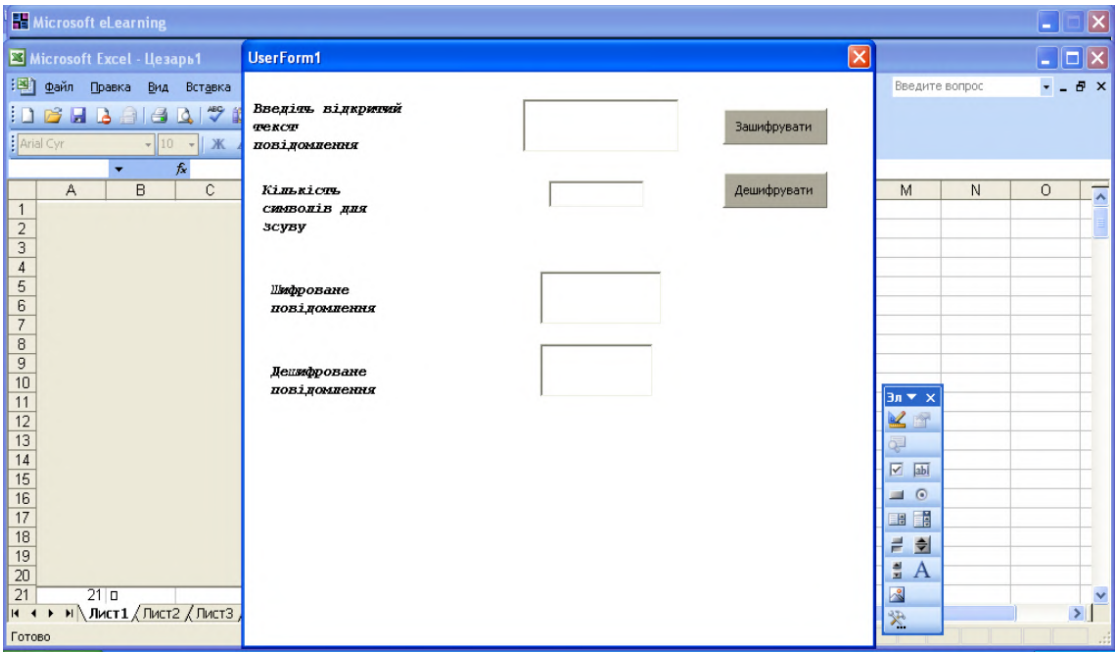

Figure 14: Teaching task for the implementation of the Caesar encryption algorithm.

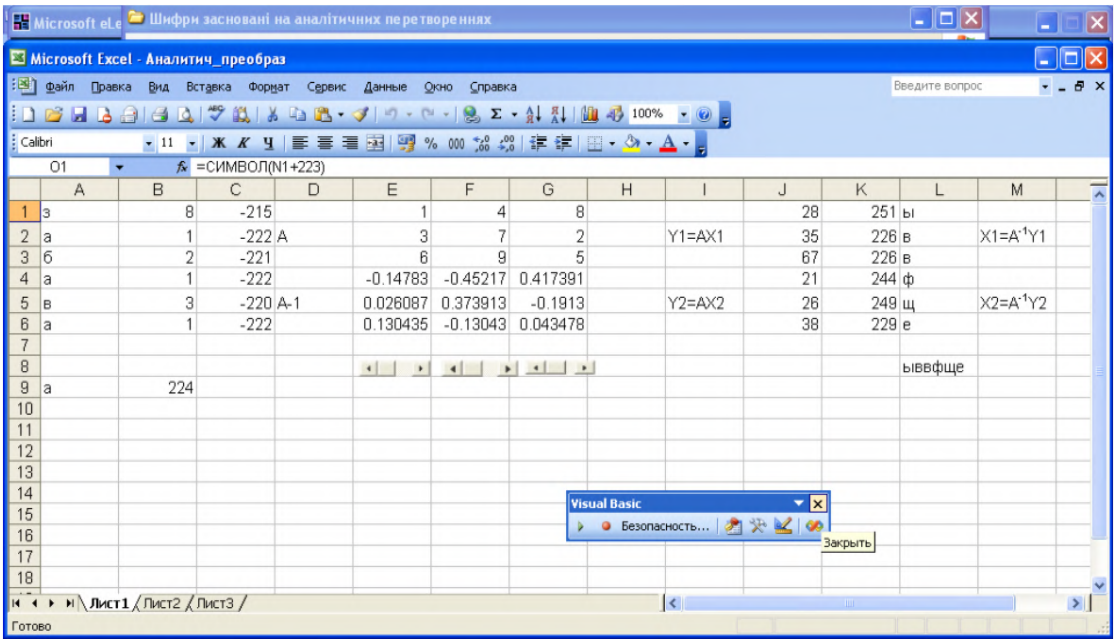

Figure 15: Teaching task for implementation of the encryption algorithm based on analytical transformations.

Training tasks include tasks similar to teaching ones, but students solve them independently, based on theoretical content and program implementation of teaching tasks. For example, working with the code of the learning task, a trainee masters the encryption of a certain algorithm, and then he is offered a training task to implement a decryption program by the same algorithm. Some of the training tasks are focused on working out the skills of using various encryption algorithms via the set of exercises. For example, for the topic "Replacement encryptions" and "Substitution encryptions", the e-guide offers the set of exercises given at the figures 16-17.

Cognitive-search tasks presented by the Apparatus of the acquisition arrangement are aimed at applying knowledge at the creative level. Trainees are offered a number of tasks on each topic: tasks that require significantly transformed knowledge; tasks for independent application of different types of encryption algorithms; research tasks and comparative analysis of different information encryption systems; complex tasks on the composition and those that involve gradual complication etc. Each task has instructions and answer, as well as the references to relevant theoretical material or to the teaching tasks of the manual.

Thus, the developed and filled library of the learning tasks allows to realize at a higher level the functions of consolidation (the second group of functions) and development (the fourth group of functions).

The self-checking system presented in the e-guide is realized with the help of Google Forms (figure 18). The system includes a set of generalized test tasks to check the level of mastery of educational material. The form is connected to the Google spreadsheet and the answers of the respondents are automatically stored in it, which in turn allows the teacher to analyze

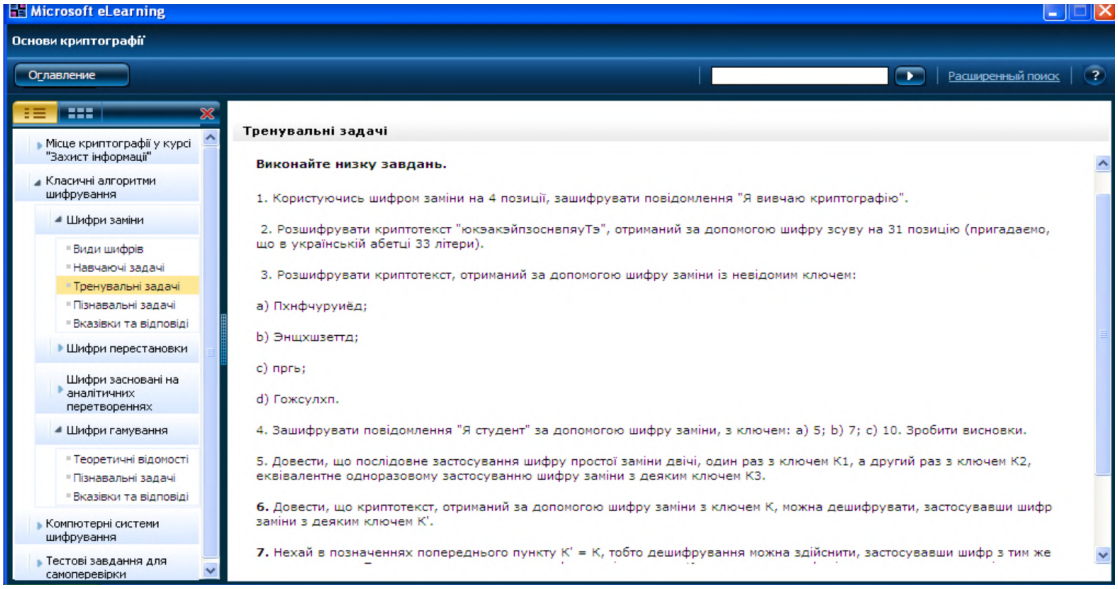

Figure 16: Fragment of work with training tasks on the topic “Replacement encryption”.

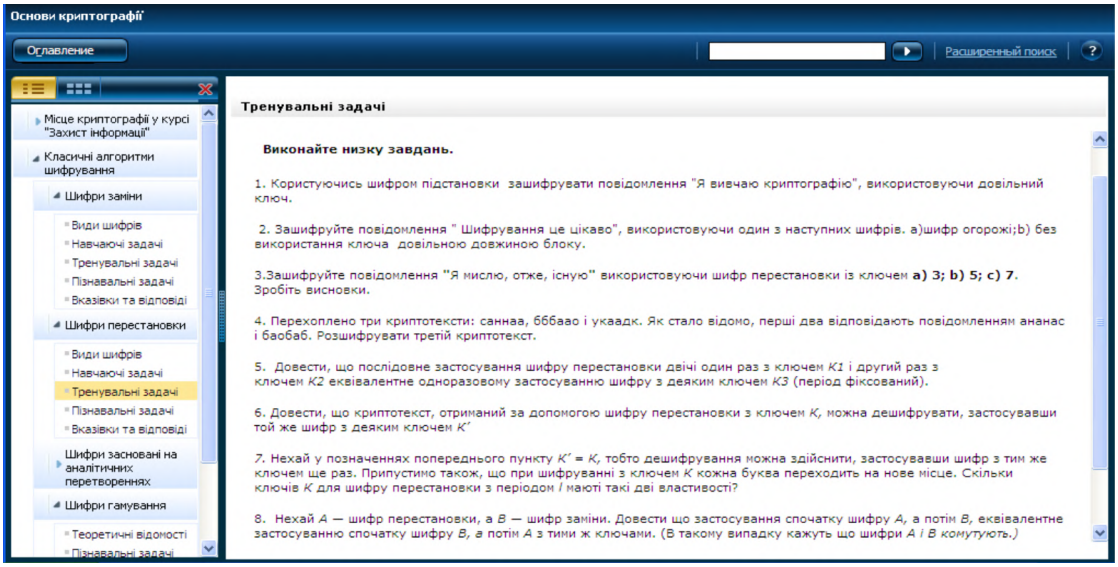

Figure 17: Fragment of work with training tasks on the topic “Substitution encryptions”.

the trainees’achievements. Thus, the implemented system of self-checking contributes to the implementation of such didactic functions as the functions of correction and control (the third group of functions), consolidation (the second group), and developing and educational function (the fourth group).

Thus, the digital learning aid, designed by the students based on the functional approach, makes a whole learning environment suitable for use in the educational process of IT specialists

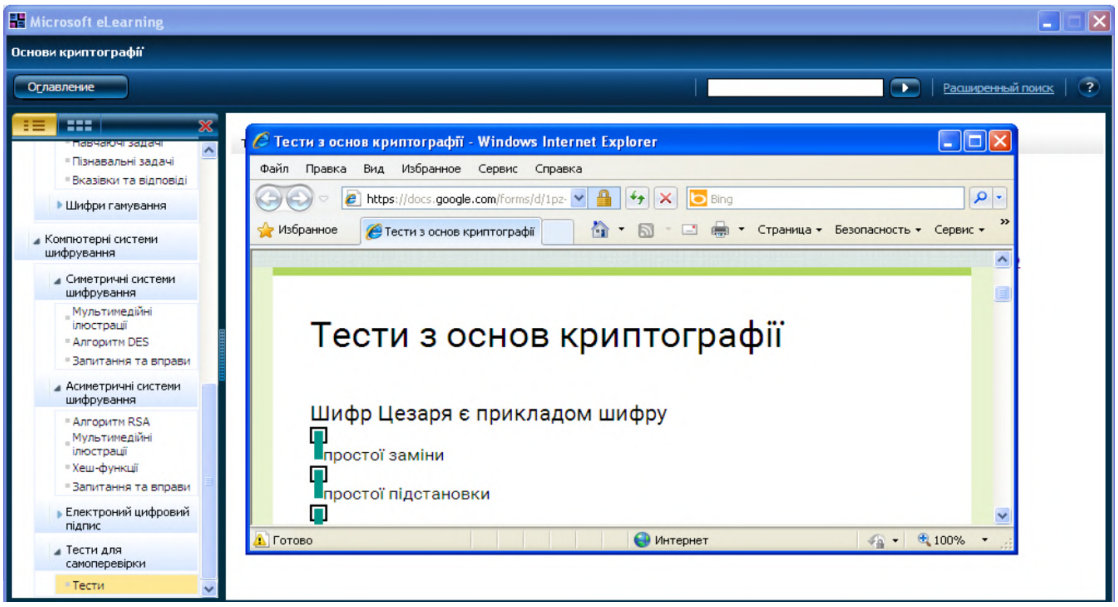

Figure 18: The fragment of work in self-checking system of the e-guide on the fundamentals of cryptography.

training within the course “Information Security” providing its holistic learning.

At the final stage of the students’ project-oriented activity the developed e-guide was tested and elaborated. In addition, there were offered some methodical recommendations as for its using at the educational process of the university in its different forms.

Summing up the depicted experience and specific examples, we would emphasize the following. The functional approach which was applied by the students to the design of the digital learning aids demonstrated its great benefits as for the quality of the aids as the results of the students’project-oriented activity. In particular, the functional approach enabled the students (1) to specify the goals of development; (2) to determine the aid’s structure components, their purposes, and their mutual connections; (3) to clarify the choice of the fulcrums for the purposes achievement; to control the process of the aid development; (4) to provide objective estimation of the results; (5) to promote the demand and practical application of the created digital learning aid. Here, it is important to point out that the result of the academic project-oriented activity had not only learning value, but also obtained essential practical application. Th elaborated digital learning aids were approved in the real educational processes at school and at university during various kinds of practices. The results of the work were also presented during the students conferences and workshops.

It is also worth underlying, that on condition of such an interdisciplinary preparation and project activity, pre-service IT specialists obtain meta-skills on the design of innovative digital learning aids. In the process of this kind of training, potential pre-service IT specialists obtain full understanding and capability for practical embodiment of core ideas of holistic educational approach via their personal experience of development of the learning aids. In addition, the application of the fuctional approach made students’ project activity more practically driven

and motivational.

It seems to be reasonable to predict positive influence of this kind of training on the forming of the students' holistic system of professional knowledge and skills. Elaboration of proper methodology of its diagnosing and estimation is a prospect of our further research.

4. Conclusions

This paper presents the practical aspects and outcomes of applying the functional approach to the development of contemporary digital learning aids in the process of project-based activity of pre-service IT specialists within their holistic vocational training. The paper draws on the theoretical framework of holistic education and the functional principles of digital didactic aids design. The paper illustrates two specific examples of students' project work on creating digital learning aids using the functional approach: (1) a multimedia tutorial for teaching English to schoolchildren (done by pre-service teachers of Computer Science and English) and (2) an e-guide on the basics of cryptography for university students (done by pre-service IT specialists). The paper analyzes the benefits and advantages of such project work from the perspective of holistic and functional approaches. The paper also suggests some directions for future research in this area.

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Developing professional stability of future socionomic specialists using cloud technologies in blended learning

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Abstract

This article explores how cloud technologies can be used to develop the professional stability of future socionomic specialists in blended learning environments. Professional stability is a key factor for the competitiveness and adaptability of graduates in the labor market. The article focuses on the use of cloud services, such as Google Workspace for Education and Moodle, to enhance the ICT competence and the mental capacity of the students. The article also identifies the psychological and pedagogical conditions and the didactic capabilities of cloud services for developing the cognitive, motivational, behavioral, emotional and volitional components of professional stability. The article presents a methodological framework for designing the process of professional stability development based on cloud services. The article reports the results of an empirical study that assessed the level of development of professional stability components and related abilities, such as empathy, emotional self-regulation, vitality, among students in blended learning. The study found significant positive changes in the indicators of professional stability after the implementation of the cloud-based program. The article suggests further research directions for developing a comprehensive program for using cloud technologies in non-formal education and personalizing the process of professional development of future specialists.

Keywords

cloud technologies, blended learning, professional stability, socionomic specialists, higher education

1. Introduction

Higher education is undergoing a transformation, as it adapts to the open and dynamic educational system of the European Union. To achieve this, higher education institutions need to adopt the latest methods that rely on information technologies, and meet the diverse needs, abilities and interests of the learners. The rapid development of information technologies and the challenges posed by the COVID-19 pandemic [1, 2, 3] have increased the demand for

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personalized and individualized education, as well as for competitive and professionally stable specialists [4]. Information technologies are present in all aspects of pedagogical activity, from teaching specific disciplines to managing higher education institutions.

Cloud technologies are one of the most prominent and innovative information technologies that are increasingly used in various sectors, including education [5, 6, 7, 8, 9]. Cloud technologies offer many benefits, such as scalability, flexibility, cost-effectiveness, and accessibility. According to recent statistics, about 77% of companies have already adopted or plan to adopt cloud technologies, and 69% of them consider it a necessary condition for survival in a competitive and changing world. The cloud industry is also constantly evolving and introducing new features and applications. The year 2020 has been marked as "the year of cloud technology'' by the international press, as it witnessed a massive shift to cloud-based solutions due to the coronavirus crisis [10, 11]. Major cloud providers, such as IBM, Amazon and Microsoft, have expanded their cloud services not only in the United States, which is the main country of data hosting, but also in other countries.

Cloud technologies are one of the key factors for improving the quality, individualization and personalization of higher education. They enable the interaction of multiple remote systems that support the learning process, as well as their mobility and cost-effectiveness. Cloud computing provides data resources to end users as an Internet service [12]. The Development of Digital Economy and Society of Ukraine Concept outlines the need for implementing incentives for the digitalization of the economy, public and social sectors. It also addresses the challenges of raising awareness, using tools for digital infrastructure development, and developing digital competence. This Concept also defines the critical areas, identifies the digitization projects, and plans to stimulate the domestic market of production, use and consumption of digital technologies. It emphasizes that the integration of Ukrainian science into the European research space will facilitate the development of advanced scientific ideas, participation in interdisciplinary projects, and focus on promising ideas, technologies and innovations.

One of the important tasks is to formulate a comprehensive national policy of digitalization of education as a priority component of educational reform, and as a key element of the Digital Single Market of Europe and a part of the paradigm "Open Innovation – Open Science – Openness to the World", which is evolving within the European scientific innovation space. There is also a need to develop a European cloud of open science and a European data infrastructure. The implementation of the main postulates of the Concept has been underway for some time, and various scientific research works in this direction have been conducted in Ukraine [13].

The dynamic changes in modern Ukrainian society create a socio-cultural and educational situation that requires enhancing the quality and professionalism of future specialists who can adapt and self-actualize in unstable and changing work conditions. Future professionals need to be aware of the connection between their personal characteristics and the requirements of their profession, and to construct their own personality within the framework of professionalization, which creates conditions for becoming a professional. The issue of students' social mobility, readiness for self-education in the new information field, where integration competence plays an important role, is also urgent for modern Ukrainian student youth. The issue of professional stability is also relevant, as it is a practical aspect of a broader problem – the problem of competitiveness, efficiency and readiness for professional self-actualization in today's uncertain conditions of professional activity. Therefore, it is also very important to find optimal ways to

provide educational services that take into account the individual psychological characteristics of future specialists and the innovative trends of using cloud technologies in their training process.

2. Literature review

The issue of creating cloud services is very popular in today's world, where the priority is a rapid development of information technologies and their use in public spheres. Many analytical companies study the development market, build cloud services and implement them into practice. The main purpose of professional training is to develop such a potential of a specialist, which would ensure not only the quality of his professional duties, but also professional self-improvement. In the conditions of transformation of a society the problem of adaptation of future experts to fast changes both in social and economic, and in cultural and educational spheres of life acquires special sense. Today's dynamic, competitive society requires the training of a new type of professionals, namely those who could be creative, unconventional in decision-making, be mobile and effectively carry out professional activities. Forrester Research has assessed the current dynamics of cloud storage popularization and concluded that by 2020 the cloud computing market will be $ 241 billion [14].

In the world's developed countries, the technology of cloud computing is becoming more and more widespread. In the domestic market, they are also actively penetrating public infrastructure.

Infrastructure as a service (IaaS) is a model of providing on-demand remote access to a common pool of configurable computing resources (cloud infrastructure) with the ability to manage them independently.

The foundations for the creating and rapid development of cloud technologies were:

- technical progress, rapid development of hardware: the ever-increasing power of processors, development of multi-core architecture and increase of the hard disk storage capacity;
- high power Internet channels;
- "large" Internet services, cloud data storage;
- impact of quarantine conditions caused by COVID-19, combined with the need to perform certain activities.

Cloud storage is a model of online storage in which data is stored on numerous networked servers which are provided to customers mostly by a third party. Data is stored and processed in the cloud, which is, from the client's point of view, one large virtual server. It should be noted that the cloud is not the Internet itself, but the whole set of hardware and software that provides processing and execution of customer's requests. There are not many authoritative sources that define the concept of cloud computing. The most comprehensive and fundamental approach to this issue was proposed by Mell and Grance [15]: they define cloud computing as a model of providing convenient on-demand network access to a shared set of parameters, computing resources (e.g., networks, servers, data storages, applications and/or services) which the user can quickly use, when executing their own task, and free up while minimizing the number of

interactions with the service provider or their own management efforts. This model is aimed at the increase of the availability of computing resources and combines five main features, three service models and four deployment models.

Characteristics of cloud computing:

1. Self-service on demand. The consumer, when he or she needs it, can use computing capabilities, such as server time or automatic network storage, without interaction with the staff of the service provider.
2. Wide availability via the network (Internet). Opportunities are available online; they are accessed on the basis of standard mechanisms; it ensures the use of heterogeneous thin and thick client platforms (e.g., mobile phones, laptops, PDAs).
3. Combining the resources into a pool. The provider combines its computing resources into a pool in order to serve a large number of customers using the principle of multitenancy. Different physical and virtual resources are dynamically distributed and redistributed according to the user's needs. There appears a sense of location independence when the customer does not know where the computing resources they use are, but may be able to identify their location on a more abstract level (e.g. country, region or data center). Examples of resources can be data storage, computing power, RAM, bandwidth, virtual machines.
4. Ability for quick adaptation. Computing capabilities can be quickly and flexibly reserved (often automatically) for prompt scaling according to the customer's tasks, and also quickly vacated. From the consumer's point of view, the available options often look unlimited and can be purchased in any quantity and at any time.
5. Measurable service. Cloud systems automatically control and optimize resource utilization by measuring some abstract parameters. The parameters vary depending on the type of service. For example, they may be: data storage size, computation power, bandwidth and/or number of active user's records. Resource use is tracked, controlled; reports are generated. Thus, both the provider and the consumer receive transparent information about the range of services provided (consumed).

Cloud technologies represent a new paradigm that provides a distributed and remote processing, data storage; they lead us to a new concept of using Internet resources in today's educational environment.

The analysis of modern scientific research works has shown that there exists the experience of using cloud platforms and virtualization technologies, including those based on the virtual machines from Microsoft, Amazon, Google, for the organization of universal workplaces for students with unification of system and application software for individual learning. Shevchuk et al. [16] studied the main advantages of cloud software over traditional academic tools used in the educational environment. The authors paid attention to the organization of a virtual workplace in order to increase the effectiveness of learning both in the educational institution and outside the classroom.

Analyzing the possibilities of using cloud technologies as a component of future specialists' professional training, taking into account personal psychological characteristics, Kolesnyk et al. [17] demonstrated a structural model of information and media literacy of university entrants

and the use of cloud technologies in the education for sustainable development. Kolesnyk et al. [17] analyze the levels of formation of such type of entrants' literacy in the process of their sustainable development (cognitive, constructive-exploratory, creative and productive levels). Kolesnyk et al. [17] developed a method of interaction of information and media literacy with cloud technologies in the educational process.

Osadcha et al. [18] research the current state and relevance of the use of adaptive learning systems and cloud technologies as useful tools for the development of an individual learning path leading to the highest level of intellectual development in accordance with natural abilities and inclinations. Taking into account the technological progress and the actualization of STEM education, the priority is the research work done by the Valko et al. [19], they focused on a detailed description of the introduction of cloud sources in the development of robotic systems.

Analyzing the combination of traditional classroom education and distance learning, Petrenko et al. [20] focused on the possibilities of using cloud technologies in the process of organizing distance learning and the implementation of a comprehensive competency-oriented approach.

The practice-oriented research of the staff of the research laboratory "Cloud Technologies in Education" of Kryvyi Rih National University and the Institute of Information Technologies and Textbooks of NAES of Ukraine demonstrates ways to implement models of cloud services SaaS, PaaS, IaaS, which should be used in the process of doing the courses on mathematical, natural cycles while organizing future specialists' professional-practical training in the field of information technology (on the example of software engineering, computer science and computer engineering). Scientists have identified the most significant advantages of using cloud technologies in future specialists' training in information technology, namely the possibility of using modern parallel programming tools as the basis of cloud technologies [21]. Thus, cloud technology is not only a modern trend of effective use of information and communication technologies in professional activities, but also a proven tool of educational activities [22].

Analysis of literature sources has shown that the issue of development and implementation of cloud services in the process of training of competitive future professionals is an important area and it requires additional practice-oriented empirical research in order to expand the possibilities of creating cloud technologies and to implement them successfully not only in the sphere of education but also in other no less important areas of human activity.

3. Research methods

Interdisciplinary research was conducted as part of research work carried out at the expense of the general fund of the state budget: "Adaptive system for individualization and personalization of future professionals' training in the conditions of blended learning", state registration number: 0120U101970. Taking into account the pandemic conditions and social isolation, from 2019 to 2020 on the basis of Bogdan Khmelnitsky Melitopol State Pedagogical University in the context of the program "Development of professional stability of the future specialist in the conditions of information and educational transformations" the implementation of the psycho-correctional program, based on the elements of cloud technologies, was proposed. The following methods were used in the research process: method of theoretical analysis of literature sources on the introduction of cloud technologies in the educational process of higher educational institution

and on the implementation of distance learning based on the principles of adaptive and personalized learning; analysis of modern experience of psychological and pedagogical support of integrative process of future specialist's professional stability development; systematization of practical experience of enhancing the person's working capacity in higher educational institution; analysis of the practical implementation of Google Workspace for Education in the program of the future specialist's professional stability development; a set of psychodiagnostic examinations using Google Forms; experimental study consisting of two stages: ascertaining and formative.

4. Research results

4.1. Theoretical foundations

Modern information and educational environment of the university is analyzed in the context of the electronic display of various aspects of the university activity on the Internet. There are different plans for designing the e-learning environment that take into account the interests of different groups of network users. From the socio-psychological standpoint, the electronic educational environment of the university takes an active part in the improvement of educational technologies, emergence of new aspects of teaching activity, and creation of the conditions of students' self-realization.

Example of modern cloud-based services for educational institutions is Google Workspace for Education. Google's online services for educational institutions have a number of advantages, which makes it possible to use them in any educational environment where there is an Internet connection (figure 1).

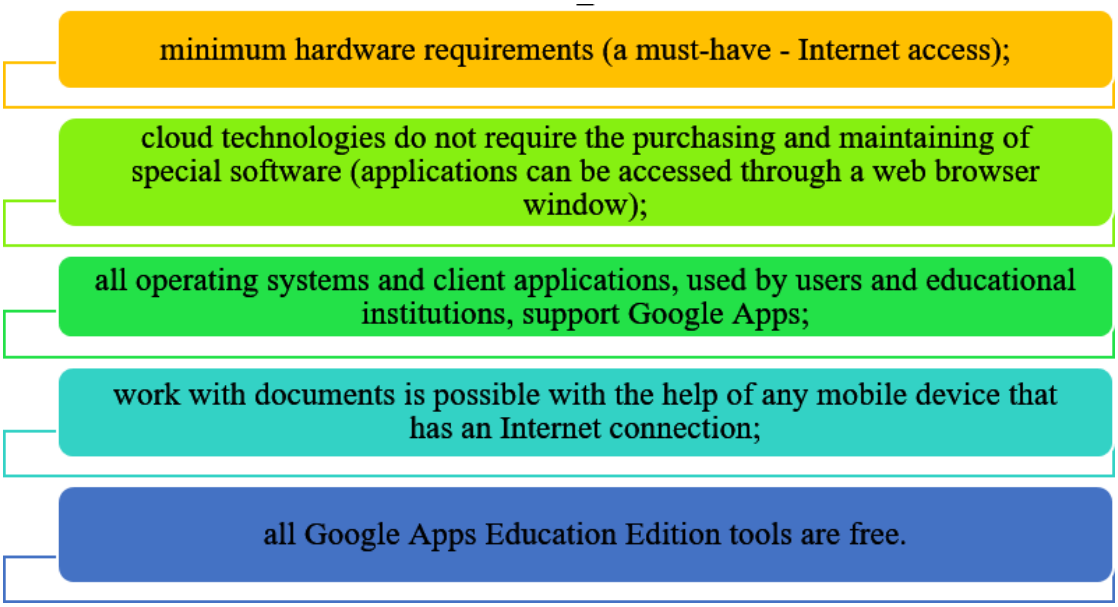

Figure 1: Main features of Google Workspace for Education use in education from the user's point of view.

Modern computer technology allows students, teachers and researchers to use several devices for the communication and work: laptops, computers, smart phones, mobile phones, etc. Google Workspace tools are supported by a variety of devices, so it is a widely available and universal IT technology to work with in the modern educational environment. Google Workspace include more than sixty free services that can be connected to one domain, including video hosting service YouTube, CMS Blogger, Google Analytics, organization chart service Lucid Chart, graphic editor Aviary, etc. They are easy to use, are serviced by Google and do not require downloading, installing or maintaining hardware or software. In addition to its diversity, which meets any needs of the modern teacher, Google applications have such characteristics as accessibility, simplicity, reliability, low cost, stability, variability, quality. The additional arguments in favor of choosing Google services and other services for the educational purposes are the availability of special applications for phones and tablets, centralized data storage, information security and Ukrainian interface. Google Workspace for Education combines a number of useful services, such as:

- Gmail – a free e-mail service;
- Classroom – assistance of learning;
- Drive – file hosting using cloud technologies;
- Calendar – time planning;
- Vault – archiving and management of user's data;
- Docs – a set of tools for working with office files;
- Sheets – processing of data presented in the form of spreadsheets;
- Forms – creating online forms and conducting surveys;
- Slides – creating presentations, regardless of the available device;
- Sites – a platform for hosting and a designer for creating sites;
- Meet – interactive communication and video conferencing tool.

The above mentioned services can be used both separately and in combination, as a complement to each other [23].

Today, one of the most well-known and widely used services for organizing learning of students is Google Classroom (https://classroom.google.com). Its use allows you to organize effective interaction of all participants of the educational process, distribute educational materials and provide the execution of various educational tasks with necessary software, assessment of students' learning outcomes. Google Classroom provides a user-friendly interface for creating and managing training courses. It gives a wide range of opportunities for the organization of the educational process in higher educational institutions. The service has all necessary facilities for the communication, task setting and testing. Also, the use of Google Classroom helps to increase learning motivation; saves time for the preparation; provides clear and interactive information, so it contributes to better assimilation of information. The use of Google Classroom in the process of future professionals' training systematizes the work of all participants of the educational process and takes it to a higher level.

Taking into account the dominant advantages of using Google Classroom in the organization and monitoring of the educational process in the university and certain quarantine restrictions

due to COVID-19 [24, 25], the priority in the context of our study was given to the development, testing and implementation of a comprehensive program "Development of professional stability as a factor of future specialist's psychological security in terms of information and educational transformations". This program was being piloted during 2019–2020 as part of the scientific and practical online course "Modern innovative technologies in education and psychology" [26]. The purpose of this online course is a practice-oriented implementation of the competence-based approach in the process of training future specialists in socionomy. It also aimed at the improvement of future educators and psychologists' professional skills and competencies in order to create better opportunities for the use of modern practice-oriented technologies in the educational process. This online course consists of four modules and is based on the use of Google Classroom. It is 90 hour, 3 ECTS credit online course which includes four modules:

Module 1. Worldview foundations of professional development of specialists of socionomic professions
Content lines:

1. Information part. State strategy of education development. Legislative support of the system of education and professional development of teachers in Ukraine. A healthy and safe environment of an educational institution as a component of professional well-being and development.
2. Practice-oriented part. Value and activity principles of teacher and psychologist's professional development. Specialist's speech competence. Information and media literacy as a key competence of a digitalized society and the main condition for quality education.
3. The part is aimed at developing the professional stability of the individual. Implementation of practical tasks and group training exercises on "Professional resilience as a means of overcoming complex professional tasks and life situations". The main directions of the introduction of innovative psychotechnologies:
   - Styles of overcoming behavior in the decision-making process under conditions of uncertainty while performing professional tasks;
   - Resource components of personality and their development;
   - Social environment as a resource for the development of professional stability. Team building and corporate ethics of interpersonal interaction.

Module 2. Development of modern specialist's psychological and pedagogical competence.
Content lines:

1. Information part. Fundamentals of inclusive education, children with special educational needs: peculiarities of learning and development, psychological and pedagogical conditions for their assistance in the educational process, universal design in education. Establishment of the safe educational environment, prevention of bullying and its overcoming in the educational institution, modern problems of adaptation and socialization of the students; formation of students' social competencies in the process of neuromanagement. Pedagogy of partnership: interaction with teachers, parents, local authorities, and community. Psychological support of talented children.

2. Practice-oriented part. Development of specialists' emotional competence. Specialists' psychological competencies: psychological features of the child's development at different age stages, strategies and tactics of professional and personal burnout prevention, psychology of team building; psychodiagnostics of student's personality, psychodiagnostics of educational management.
3. The part is aimed at developing the professional stability of the individual. In this block, group lessons were implemented aimed at developing the emotional component of professional stability and goal-setting skills:
    - Professional stability and psychological well-being as determinants of the competitiveness of a future specialist;
    - Professional stability as an alternative to learned helplessness;
    - The art of setting and achieving professional goals;
    - Personal formula for professional success

Module 3. Organizational and methodological principles of the development of specialist's professional competencies.
Content lines:

1. Information part. Practical psychologist's educational and preventive work in the educational institution. Counseling as a method of psychological influence. The use of art-therapeutic techniques in the educational process. Conflict prevention and resolution using renewable techniques. Functioning of psychological service in the system of education in the conditions of the New Ukrainian school: legislative base.
2. Practice-oriented part. Development of a practical psychologist's digital competence:
    - protection of personal data on the Internet, safe use of digital technologies and services; legal and ethical requirements for the use of information and communication and digital technologies in professional activities;
    - cloud services in the professional activity of a specialist; streamlining digital educational resources, ensuring accessibility, organizing the interaction of participants in the educational process;
    - use, creation, design and distribution of digital educational resources;
    - use of distance learning technologies; virtual class: an overview of the resources for creating a virtual class; creation and organization of the educational process;
    - preparation of a distance course: selection of a platform for webinars, educational process planning, preparation of a scenario for a webinar; providing interactive distance interaction of participants in the educational process;
    - specialist's digital portfolio; working with documents; creating and compiling a portfolio using a site (blog).
3. The part is aimed at developing the professional stability of the individual. In this block, a personality-oriented approach is implemented in the process of updating the creative potential of future specialists. Students researched and used the mechanism of creativity for the development of resource components of professional sustainability. The following group training sessions were held:

- Creative creativity as a resource for development professional stability;
- Professional and personal potential as the foundation of creative creation.

To achieve an effective result, students are familiar with the "Quest of resilience" methodology to prevent the devaluation of their own achievements in the process of solving practical professional problems.

Module 4. Introduction of innovative technologies into various spheres of psychological and pedagogical activity.

The subject of study – modern practice-oriented technologies and methods of psychological assistance of individuals and groups. The purpose – acquaintance with and internalization of innovative practice-oriented technologies in practical psychologist's activity.

Content lines:

1. Information part. Innovative technologies for working with children with special educational needs. Development of interhemispheric interaction by the method of kinesiology. Innovative coaching technologies in a modern specialist's activities. Innovative art-therapeutic technologies in various spheres of public practice. Case-study technology in a modern specialist's educational work. Supervision in psychological practice: modern realities.
2. Practice-oriented part. Within this block, future specialists developed, implemented and analyzed the effectiveness of the developed training program, focused on solving current social problems. Based on the results of the implementation, students wrote down in online format a qualitative and quantitative analysis of the effectiveness of the implementation of a personal training program.
3. The part is aimed at developing the professional stability of the individual. In this block of the module, group lessons are implemented, focused on the development of the general level of individual resilience:
    - Development of communication skills as an element of "involvement" (according to S. Maddy);
    - Development of teamwork skills, conflict-free communication skills as an element of "involvement" (according to S. Maddy);
    - Development of skills of confident behavior as an element of "involvement" (according to S. Maddy);
    - Development of skills of stress-resistant behavior as an element of "control" (according to S. Maddi);
    - Teaching relaxation skills, self-control emotions as an element of "control" (according to S. Maddy);
    - Development of the ability to set a goal as an element of "control" (according to S. Maddi);
    - Development of self-knowledge as an element of "risk taking" (by S. Maddy);
    - Development of a positive Yconception as an element of "risk taking" (according to S. Maddy)

Due to the practical orientation of this online course, its structure includes a comprehensive training program "Development of professional stability of the future specialist in the conditions of information and educational transformations", which was conducted using Google Classroom cloud technology. In order to provide feedback and stimulate sharing with the participants of the training group, the technical capabilities of Google Meet and the Trapscan application (psychological diary) are used. The application uses one of the main methods of cognitive-behavioral therapy – ABC analysis. The role of thoughts in shaping the mood and well-being of the individual is very significant and it is not the situation that affects what emotions a person feels, but the perception of this situation. The application allows you to keep a diary and analyze personal reactions, work with your thinking, improving the quality of your life. Duration of this training: 18 hours (9 classes of 2 hours each). The duration of each class may slightly vary depending on the degree of participants' interest and the actualization of their problems.

When indentifying the essential characteristics of specialist's professional stability, we took into account the following methodological ideas:

- stability is a qualitative characteristic of any object, system or individual; thus, quality means some certainty of the subject or the individual possessing certain specific features;
- stability is manifested in holistic systems, self-organization of which is impossible without the existence of a hierarchical structure of internal factors;
- stability of the psychologist's personality is formed in the process of self-identification and professional development and is manifested in the work and active self-organization;
- stability is the result of the functioning of mechanisms that actively counteract the negative influencing factors [27].

The developed model of structural components of future specialist's professional stability acts as a theoretical and methodological basis for the development and implementation of this training program (figure 2). As a result of theoretical analysis, we have identified the following components in the structure of the future specialist's professional stability.

Based on the model of development of future specialist's professional stability, as a factor of effective mental capacity of the individual, all structural parts of the training were divided into the following blocks:

- formation of psychological readiness to work in new transformational conditions;
- development of psychological awareness of various aspects of professional activity;
- enhancement of personal efficiency and working capacity;
- development of specialists' personal stress resistance to the growth of mental load and work in the new information conditions;
- formation and development of professionally significant cognitive qualities;
- development and improvement of skills and abilities to establish psychological contact with different categories of citizens;
- formation of skills of role behavior in different situations of professional activity;
- improvement of the ability to apply psychological and pedagogical methods of influence in the complicated conflict situations of communication;

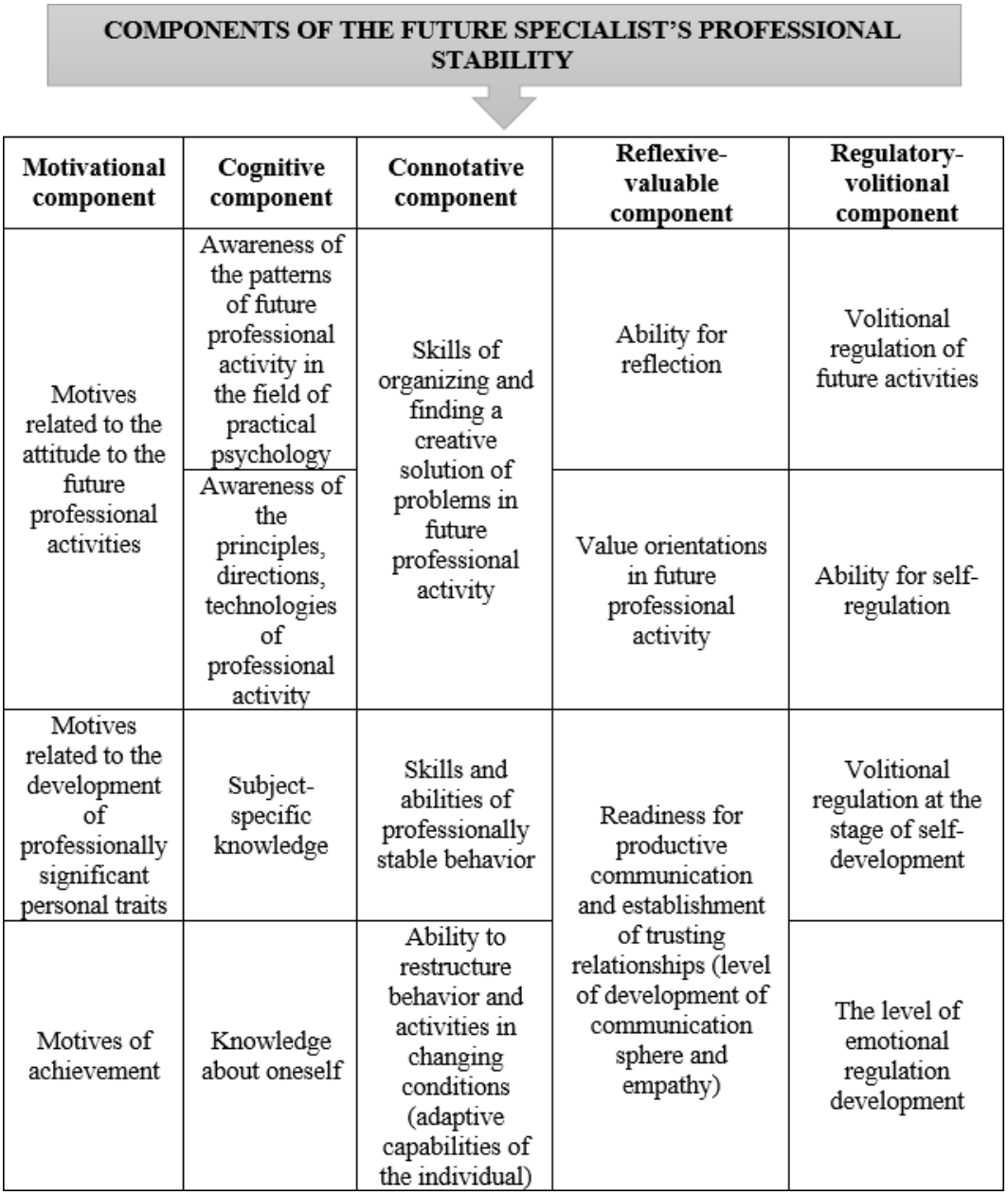

Figure 2: Structural components of future practical psychologist's professional stability.

- formation of the ability of psychological stability in tense situations of professional activity;
- development of personality's positive emotional and volitional qualities, training of specialists in self-regulation and self-management;
- formation of volitional activity and skills of volitional actions;

- development of positive internal motivation to carry out effective professional activity;
- preparation for mental overload at work.

The structure of each unit included three elements: 1) acquaintance with the characteristics of a particular trait that was developed, a metaphorical explanation of the content and objectives of the unit, "warming-up" activities; 2) the main part; 3) reflection on the unit as a whole.

The training program was designed and piloted taking into account the following principles: the principle of purposeful creation of emotionally colored situations (active influence on the individual, creation of appropriate conditions for the perception and assimilation of new knowledge that is emotionally colored and has personal significance); the principle of personal developmental communication (understanding, recognition and perception of personality); the principle of using empathy as a psychological mechanism in the education of personality (includes two cognitive components – the ability to distinguish and name the emotions experienced by other people and take another person's position; and the emotional component – the ability to respond emotionally); the principle of systematic analysis of one's own actions and the actions of others (it contributes to the formation of the ability to predict the above mentioned results and has a positive effect on the development of behavioral skills of overcoming instantaneous aspirations, states, desires).

The program is created in accordance with the principles of the Accelerated Learning Theory and implies all the latest advances in the field of methodology of teaching adults.

4.2. Experimental results of research

While conducting a formative experiment based on the piloting of a comprehensive training program "Development of professional stability of the future specialist in the conditions of information and educational transformations" we introduced the practical online course "Modern innovative technologies in education and psychology" in order to identify the effective psychological and pedagogical conditions for the development of professional stability, as a factor the specialist's mental capacity. After conducting the formative experiment we compared the results of two psychodiagnostic assessments. The sample was randomized and consisted of 58 people who did practical online course "Modern innovative technologies in education and psychology" – 30 people, future professionals in psychology, who participated in the training program and 28 people, future professionals, who didn't take part in the training program. The psychodiagnostic unit of the study included a survey using Google Forms.

According to the analyzed structural components of professional stability of the personality in the psychodiagnostic block the following techniques were carried out:

- For successful higher education and maintaining the optimal level of professional stability of students, it is important to have a valuable motivation to study. For this purpose, we used the method of "Motivation to study at university";
- Methodology "Questionnaire to determine the level of socio-psychological stress", aimed at identifying the level of manifestation of socio-psychological stress in future professionals at different stages of professional genesis, which affects the indicators of their overall level of professional stability;

- Methodology "Coping behavior in stressful situations", aimed at identifying the dominant coping stressful behavioral strategies in students. Obtaining these data allows a more thorough study of the psychological conditions for the development of their professional stability, because only a constructive coping response to stress, aimed at rational analysis of the problem and solve a complex stressful situation, allows future professionals to overcome difficulties and successfully solve professional problems without reducing performance.
- "Questionnaire DORS – Differentiated assessment of states of reduced efficiency (fatigue-monotony-oversaturation-stress)", which is aimed at determining the degree of manifestation of each of the physiological states of personality stability (fatigue-monotony-saturation-stress). The development of these states leads not only to a decrease in resistance, but also affects the qualitative characteristics of behavior and emotional coloring of experiences, which provokes significant changes in the motivational sphere of personality.

The analysis of the results of piloting the system of psychological and pedagogical measures showed the significant differences between the control and experimental groups in terms of indicators of professional stability and the development of its psychological and pedagogical conditions. Significant changes in the indicators have been traced according to all the methods used. In order to identify the significance of the changes that occurred after the correction work, we used the G-criterion [28]. The G-criterion is used for the establishment of the general direction of sign shift under research. We put forward the hypotheses:

H_0: The predominance of the typical direction of shift between the obtained data is accidental.

H_1: The predominance of the typical direction of shift between the obtained data is not accidental.

This work contributed to the effective formation of experimental group specialists' value motivation for learning (table 1).

Table 1
Learning motives of the experimental group ($n = 30$) control group ($n = 28$) specialists according to the formative experiment results.

Learning motives	Experimental group		Control group	
	before	after	before	after
Knowledge acquisition	33.36 (10)	36.67(11)	28.57 (8)	28.57 (8)
Mastering the profession	10.00 (3)	26.66 (8)	7.14 (2)	10.71 (3)
Getting the diploma	56.66 (17)	36.67 (11)	64.29 (18)	60.71 (17)

As we can see from table 1, in the experimental group there was an increase by 16.66% in the number of people wishing to master the profession (from 10.00% to 26.66%). It means that they rethought themselves as future professionals; they started demonstrating the desire to develop professionally important qualities, to become an educated person and a high-caliber professional. In addition, the number of people, who are focused on the acquisition of certain professional knowledge, showing curiosity, purposefulness and independence in the process

of knowledge acquisition, has slightly increased (from 33.36% to 36.67%). Due to this, there was a decrease by 20.01% in the number of respondents who considered getting a diploma or professional certification as a priority of learning. That is, it can be stated that after conducting some activities the motivation for learning of the experimental group respondents has become more valuable. Having analyzed the indicators of the control group, we saw only a few changes. There was a shift of only 3.57% in motives of mastering the profession and getting a diploma. Also, according to the results of correlation analysis it was found out: with $n = 108$, typical shift is positive. Negative shifts – 32.

$$G_{contr} = \begin{cases} 45\ (p \leqslant 0.05) \\ 42\ (p \leqslant 0.01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 32, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

It is also necessary to note significant changes in the manifestations of the level of socio-psychological stress of the experimental group students (table 2).

Table 2
Quantitative indicators (%) of levels of social-psychological stress of experimental ($n = 30$) and control ($n = 28$) groups students after the formative experiment.

Level of social-psychological stress	Experimental group		Control group	
	before	after	before	after
Low level	33.33 (10)	46.67(14)	39.29 (11)	42.86 (12)
Medium level	63.33 (19)	53.33 (16)	57.14 (16)	53.57 (15)
High level	3.34 (1)	0 (0)	2.57 (1)	3.57 (1)

As we can see from table 2, after the introduction of the training program, in the experimental group there was an increase by 13.34% (from 33.33% to 46.67%) in the number of people with a low level of stress and there were no people with a high level of this indicator. Future professionals have stopped perceiving the process of adaptation to the introduction of information, cloud technologies in the educational space as that associated with stress. There was a slight decrease of the medium level of this indicator (from 63.3% to 53.33%), which proves the effectiveness of the development of the experimental group students' personal stress resistance, their ability to tolerate stress. There are only a few changes in the control group. Having used the G-criterion, we found out that the changes were due to the implementation of the correction program, but not thanks to the external artifacts that threaten the internal and external validity of the experiment. With $n = 115$, the typical shift is positive. Negative shifts – 38.

$$G_{contr} = \begin{cases} 45\ (p \leqslant 0.05) \\ 42\ (p \leqslant 0.01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 38, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

The formation of the effective individual behavioral styles to overcome stressors after conducting experimental activities is confirmed by the following data (table 3).

Table 3
Features of coping reactions to stress in experimental ($n = 30$) and control ($n = 28$) groups according to the results of the formative experiment.

Coping-behaviour in stressful situations	Experimental group		Control group	
	before	after	before	after
Coping oriented for the solution of the problem	23.33 (7)	36.66 (11)	28.57 (11)	32.14 (9)
Coping oriented for the emotions	6.67 (2)	13.34 (4)	7.14 (2)	7.14 (2)
Coping oriented for the avoidance	70.00 (21)	50.00 (15)	64.29 (18)	60.72 (17)

The table 3 shows the increase in the percentage of participants of the experimental group (from 23.33% to 36.66%) who choose coping, focused on solving the problem, and a significant decrease (from 70.00% to 50.00%) in the number of people who prefer to avoid coping in stressful situation. That is, thanks to the work done, future specialists in situations of stress and uncertainty have become more focused on rational analysis of the problem, its constructive solution, they try to create and implement a plan to solve a complex stressful situation, rather than just blindly avoid their problems applying protective mechanisms or compensating for problems as before. In addition, in the experimental group, the number of people, who prefer not to think about problems at all, involving others in their experiences, trying to forget in a dream or compensate for negative emotions with food, decreased by 6.67%. Analyzing the changes in the control group, we can state in general the same indicators. With $n = 58$ typical shift is positive. No negative changes were identified.

$$G_{contr} = \begin{cases} 13\ (p \leqslant 0.05) \\ 10\ (p \leqslant 0.01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 0, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

The introduction of the training program based on the cloud technologies has had a positive impact on all states of the reduced capacity, in particular among the experimental group participants.

Thus, there was an increase of 10.00% (from 10.00% to 20.00%) in the number of people with a low level of fatigue, which indicates that future professionals perform mental work online without exhaustion and significant errors. Due to this, the number of respondents with medium indicators of this state decreased by 3.33% (from 83.33% to 80.00%). Future specialists gained skills of rational organization of mental activity, which allowed them to get rid of high-level indicators on this parameter (from 6.66% to 0), which proves the ability of students to perform mental activities and tasks without deterioration of the working capacity. Analyzing the indicators of this state manifestation in the control group, only partial shifts were noted (a number of people with a high level decreased by 3.57% and a number of people with a medium level of fatigue increased accordingly). With $n = 58$ typical shift is positive. Negative shifts – 37.

$$G_{contr} = \begin{cases} 50\ (p \leqslant 0.05) \\ 46\ (p \leqslant 0.01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 37, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

Accordingly, the work, which was carried out, also affected the indicators of monotony. It has to be noted that significant changes are noticeable in the experimental group. Therefore, the indicator of a high level of monotony decreased by 6.66% (from 10.00% to 3.34%). The participants demonstrated an increase of attention and the general ability to strong-willed efforts, they showed their general inclusion in innovative mental work. It should be noted that the number of people with a medium level decreased by 3.33% (from 76.66% to 73.33%) and the number of students with a low level of monotony decreased by 9.99% (from 13.34% to 23.33%). By developing the ability to gradually approach the perception and performance of intellectual actions, gradual mobilization and appropriate adjustment of the body to more effective execution of these actions, students learned to adaptively perceive the latest online intellectual activity, while maintaining a high level of working capacity. Assessing the indicators of this state manifestation in the control group, we noted only partial changes (there was a decrease in the high level by 3.58% and, accordingly, an increase in the medium level of manifestation of monotony). With $n = 40$ typical shift is positive. There were no negative shifts identified.

$$G_{contr} = \begin{cases} 14\ (p \leqslant 0.05) \\ 12\ (p \leqslant 0.01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 0, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

According to the indicator of mental oversaturation, it was found out that due to the introduction of highly efficient cloud technologies in the development of professional stability (namely, diversification and emotional saturation of mental activity in the process of performing practice-oriented tasks), low level of this state increased by 13.33% (from 26.67% to 40.00%), so future professionals have learned to perceive mental activity without a wish to stop it. Accordingly, the indicators of the medium level of oversaturation decreased by 13.33% (from 73.33% to 60.00%), indicating the formation of respondents' ability to accept subjectively uninteresting activities without changing the stereotype of performing reasonable actions. In the control group the oversaturation indicator remained unchanged. With $n = 58$ typical shifts are positive. Negative sifts – 37.

$$G_{contr} = \begin{cases} 50\ (p \leqslant 0.05) \\ 46\ (p \leqslant 0.01) \end{cases}$$

G_{emp} – a number of untypical shifts, so $G_{emp} = 37, G_{emp} < G_{contr}$. It means that H_0 is not proved, but H_1 is accepted.

Thanks to this work done, it was possible to increase by 16.67% the number of people with a low level of stress (from 20.00% to 36.67%), which indicates an increase in their stress resistance and the formation of skills of self-regulation of their own psychophysiological state. Due to this, the number of people with a medium level of this state decreased by 16.67% (80.00% to

63.33%), they have an experience of overcoming a difficult stressful situation. In the control group the indicators of stress remained almost unchanged.

The training work helped to increase students' neuro-psychological stability. According to the formative experiment results, there was an increase in the level of neuro-emotional stability in both experimental and control groups. But more significant changes took place in the experimental group. In particular, the number of people with a low level of neuro-emotional stability decreased by 10% (from 66.66% to 56.66%) and the number of people with a high level of this indicator increased by 10%. This states that the respondents have become more optimistic about the reality when doing the educational activities in the online format under quarantine restrictions. They adequately perceive new transformational innovative requirements of the intellectual and educational environment. These shifts in the control group were shown only partially (there was a decrease by 3.57% in the number of people with a low level and, accordingly, there was an increase in the number of people with a high level of neuro-emotional stability).

Thus, the results of statistical processing of empirical data proved the effectiveness of the training program, based on cloud technologies, in the process of developing the future specialists' professional stability in the modern educational environment. The corresponding program, in contrast to the traditional training, has certain advantages, which were identified according to the feedback, received from the participants:

- personal orientation and personification;
- possibility of in-depth study of personal problems;
- psychological and emotional security;
- free timing and autonomy in performing practice-oriented tasks; selection of the tasks depending on personal requests, etc.

5. Conclusions and future work

Cloud services are emerging as a powerful tool for enhancing the quality and efficiency of education, especially in the context of quarantine and social isolation. They enable the creation of learner-centered information environments that support personalization, individualization, collaboration, and networking. They also facilitate the development of professional competencies and information literacy among future specialists. However, the use of cloud services in education also poses new challenges and requires new skills and strategies from both educators and learners. Therefore, we propose a model for developing future specialists' professional stability with the help of cloud services, which aims to foster their adaptability, creativity, and self-regulation in the face of changing demands and opportunities in the modern world. Our model is based on the integration of cloud technologies in formal and informal education, as well as on the monitoring and evaluation of the individualized and personalized learning outcomes.

Our future work will focus on designing and implementing technologies for applying our model in various educational settings, taking into account the individual characteristics of learners in online learning. We will also explore the possibilities and limitations of cloud technologies for supporting different types of learning activities and interactions, as well as for enhancing the quality and accessibility of education.

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Inquiry-based learning for enhancing students' interest in mathematical research: a case study on approximation theory and Fourier series

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Abstract

This paper investigates how to develop students' interest in mathematical research by using inquiry-based learning (IBL) as a pedagogical approach. We conducted a case study on the application of IBL to the teaching of approximation theory and Fourier series, which are important topics in mathematics and computer science. We surveyed the students who participated in the IBL workshops and measured their emotional state using the Differential Emotion Scale (DES) by Izard. The results showed that the IBL environment reduced the students' negative emotions and increased their positive emotions, which in turn enhanced their engagement and motivation in the mathematical research activities. We conclude that IBL is an effective method for fostering students' interest in mathematical research and suggest some implications for future practice and research.

Keywords

inquiry-based learning, mathematical research, approximation theory, Fourier series, emotional state, differential emotion scale

1. Introduction

Higher education aims to develop scientific competencies in future professionals and academics, which are essential for their successful career advancement. Research activities are one of the mechanisms to foster such competencies, as they enable students to create new methods, ideas, and approaches that meet the changing demands of the modern world [1, 2, 3]. This is especially relevant for mathematical education, where research activities can enhance students'

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performance and creativity in their professional or academic endeavors [4, 5, 6, 7, 8]. Therefore, the issue of organizing research activities in Mathematics remains a topical challenge in pedagogical studies.

However, traditional teacher-centered methods do not facilitate active student involvement in research activities [9]. According to the reports of the European Association for Quality Assurance in Higher Education, the European University Association, and the Higher School Teachers European Society [10], the effectiveness of developing students' research skills depends on the choice of learning strategy that prioritizes student-centered methods. This is related to the diversity and increasing expectations of higher education, which require fundamental changes in its delivery and focus on flexible ways of engaging students in research activities. One of the methods that implements such an approach is inquiry-based learning, which has been widely adopted in many countries [11, 12, 13]. Inquiry-based learning is based on the student-centered paradigm, where students construct their learning and knowledge acquisition in a similar way as scientists do [14]. In Mathematics, this is emphasized by Sandoval and Reiser [15], Jahnke et al. [4], Artigue and Blomhøj [16], Dorier and Maass [17], who argue that inquiry is one of the most important contexts for learning mathematics. Thus, the issue of organizing research activities in Mathematics through inquiry-based learning aligns with the current trends and demands of higher education.

Many researchers have highlighted the need to support active student research activities. Lithner [18] noted that an international trend in Mathematics education is to acquire mathematical knowledge not only in terms of context but also in terms of developing skills related to conducting mathematical research. Bonwell and Eison [19], cited in [20], stated that students should do more than just listen. They should read, discuss, and investigate problems. Jones et al. [21] affirmed that it is necessary to foster creative thinking and investigative skills in students at every level of their university education. Scholars stress that engaging students in research activities during their studies promotes the development of research competence, which is vital for solving practical problems and for adapting quickly to the changing conditions of the modern era and enhancing their skills continuously. We also considered the views of Dreyfus et al. [22], who regarded research activities during Mathematics learning as a natural part of the educational process, which aims to develop research competence among students.

According to Yore [9], the formation of interest in research activities is the first stage during the development of research competencies while learning Mathematics. This idea is consistent with the conclusions by Hernandez-Martinez and Vos [23], who have described the critical state of the matter to form students' interest in research activities. Scientists emphasized the importance of organizing students' activities, the formation of their positive attitude to research projects, and the use of inquiry-based learning as a pedagogical approach.

Inquiry-based learning is a student-centered method that involves posing questions, problems, or scenarios and encouraging students to explore them using their own prior knowledge and scientific facts. Inquiry-based learning also requires students to restructure their previous ideas about the scientific concept by adding new studied information, take into account each other, monitor and evaluate their own learning, and transfer new knowledge into a real context [24].

Approximation theory is a branch of mathematics that deals with finding simple functions that approximate complex or unknown functions. It has many applications in various fields such as computer science, engineering, physics, biology, and economics. For example, approximation

theory can be used to compress data, model natural phenomena, optimize systems, and solve differential equations [25, 26, 27].

In order to organize practice-focused research activities using approximation theory, scientists offer to use special courses dedicated to special scientific researches in the priority areas of modern Mathematics. This fact is evidenced by the opinion of Yarullin et al. [28], Biza et al. [29], Telegina et al. [30] about the significant potential in the researches on forming a positive attitude to students' research activities using the materials of different mathematical branches. In scientists' opinion, the use of interesting mathematical theories encourages students to get a more meaningful education of theoretical materials, facts, and methods of solving mathematical problems and it allows getting particular experience. We can also meet the confirmation of this opinion in the works by Matejko and Ansari [31], Sevinc and Lesh [32], who investigated the organization of research activities related to particular branches of Mathematics.

The idea caught on, that is why guided by the conclusions made by the above-mentioned scientific researches we decided to research the formation of students' interest in research activities on Mathematics through the implementation of practice on approximation theory following inquiry-based learning. The choice of this branch results from its extensive use in practice. This is explained by the fact that the modern stage of science and technology development is characterized by the use of a considerable amount of information. As experience shows this tendency will only enhance in the future – the development of computer science, telecommunication, and registration equipment lead to steady growth of the data amount. Therefore, the tools and methods of their processing and analysis are growing. The creation of a single methodical approach based on general mathematical principles is actual for several tasks such as to get, model, register, and process data. The series finds a mass use as a tool to represent a considerable class of functions, carrying out analytical transformations, approximate calculations in many applied tasks. Algorithmic and computer software that is created on their basis is characterized by high universality and is included in computer and hardware-computer complexes of different purposes.

The research is aimed at investigating the effects of inquiry-based learning and approximation theory on students' interest in research activities on mathematics, as measured by a self-report questionnaire and a performance-based assessment.

2. Method

At the first stage of the research, we used a survey method to assess students' interest in Mathematics research activities. We used the Differential Emotions Scale by Izard [33] to survey students. The relevance of involving this methodology to assess students' interest in research activities is proven by the researches where the direct dependency between the subject's interest in cognitive activities and their emotional state during its implementation is emphasized. Since the feeling is a dynamic component of the emotion (Panksepp [34]) and two psychobiological processes are connected with it – fascination and individuation (Langer [35]), motivating, managing, and informative functions of feelings allow them to capture or simplify and organize the thing that can become (especially in difficult situations) a great number of impulses in concentrated cognitive processes. During 2015–2019 we surveyed master's degree

students of Physics-Mathematics departments of Kryvyi Rih State Pedagogical University and Berdyansk State Pedagogical University. 49 master's students took part in the survey (17 male students and 32 female students aged from 20 to 28). The use of the online survey, first through Google form, posted on the Internet, and then, moved to the forum of the platform "Higher School Mathematics Teacher" [36] had an advantage in comparison to the survey on paper as it encouraged the respondents' frankness and prevented missed questions.

According to the chosen methodology, we selected the Likert scale to assess each of the basic emotions where 1 – "feeling is completely absent"; 2 – "feeling is slightly expressed"; 3 – "feeling is moderately expressed"; 4 – "feeling is strongly expressed"; 5 – "feeling is fully expressed". At the beginning of the research, the most significant (> 9 points) positive emotion related to the experience of Mathematics research activities was "interest", negative – "shame" and "fear". Students usually face the last two emotions while learning Mathematics.

Students believe that the key problem of learning mathematical theory is the absence of the connection between theory and practice and the abstract character of the subject.

At the second stage of the research, we determined the structure of practice regarding Approximation theory and the main aspects of the content that ensure its correspondence to inquiry-based learning. While selecting resources for the analysis of possibilities to use inquiry-based learning we were focused on those that represent the efficiency of its use during the education. Among them, we can name TeachThought [37], Lesley University [38], The National Academies Board on Science Education [39], Alberta Education [40] (table 1).

Table 1
The analysis of the resources that represent the efficiency of using inquiry-based learning.

Resources	Used while learning a subject	Features	What are the efficiency grounds
Teach Though	Biochemistry and Molecular Biology Education, Mathematics	Joint activities	The solid knowledge foundation through an active part
Lesley University	Mathematics, Life sciences	Constructing knowledge based on experience	Possibility for the full cycle of education
The National Academies Board on Science Education	Biological sciences	Structure and sequence of education are directed at creating a challenging situation	Integration of learning activity with laboratory experience
Alberta Education	Librarianship, work with information	Student's involvement in metacognition; encouragement of critical and creative thinking	Focus on achieving defined learning outcomes in different subjects

We also found out what the purpose of using inquiry-based learning by other scientists was. Cheng et al. [41] noted the efficiency of using the approach to increase the motivation of students' learning. Duran and Duran [42] describe the use of inquiry-based learning in

programs of professional development in education. Supasorn and Promarak [43] see the use of inquiry-based learning as an efficient method of improving students' understanding of natural processes.

In conclusions of scientific researches done by Bybee et al. [44], Abdi [45], Ong et al. [46] we also find the confirmation of the efficiency to use the above-mentioned approach to improve students' achievements in science. Considering it, we believe that inquiry-based learning will encourage the alignment of teaching processes with the formation of better students' understanding of scientific knowledge and skills during practice.

The practice program consists of six classes.

1. The history of the development of approximation theory and Fourier series.
2. The ways of periodic function classification.
3. Approximation methods that are based on matrix series summing.
4. Main tasks of approximation theory: approximation of individual function, class approximation, precise, and asymptomatically precise ratio.
5. Examples of researches by subject.
6. Examples of using approximate aggregates in computer complexes of broad purpose.

The practice was aimed at the formation of students' interest in research activities through their implementation in the real process of using series in applied tasks.

The practice was held for a group of 7–8 students twice a month for three months. Every class included two hours of classwork and three hours of extracurricular work. The classes were held by the prominent teachers of Mathematics departments who took part in the development of the practice and looked for the method, the implementation of which would encourage the formation of students' interest in research activities during the practice.

During the organization of practice classes, we developed recommendations for every practice stage that have to encourage the increase in students' interest in mathematics research activities.

At the first stage, the teacher has to determine what students already know regarding the concept that is considered and what kind of knowledge they still need. In order to master new educational material, it is necessary to help students to revise Mathematics sections such as Algebra, Mathematical Analysis, Functional Analysis, and Function Theory. Moreover, at this stage, the teacher is only a consultant who helps students to prepare short reports encouraging students' interest and motivation. For this purpose, the teacher presents the actuality of the researches dedicated to learning approximate features of approximation methods that are generated by certain transformations of partial sums of Fourier series and allow building the sequence of trigonometric polynomials that would equally coincide for any function (table 2).

Table 2
Recommendation for the teacher on the organization of the first stage.

Appropriate	Inappropriate
encourage students to raise their questions	read the lecture
offer to compare their ideas with others	give definitions to terms
	explain or give tasks

The second stage is aimed at strengthening students' activities regarding knowledge and skills. At this stage, students can revise the tasks that use the methods of Approximation theory on special subjects that they learn. As a rule, students cite examples of tasks on periodic signal approximation in the theory of control engineering, pattern recognition, nondestructive testing, etc. Students can discuss and write down approximation methods in every particular case. The teacher is only a consultant who offers students such research methods as observation, hypothesis generation, forecasting. Students' communication and work in groups without the direct teacher's involvement are encouraged to equally coincide for any function (table 3).

Table 3
Recommendation for the teacher on the organization of the second stage.

Appropriate	Inappropriate
encouragement of search for several ways to solve the problems comparison of ideas self and mutual survey	use of traditional explanation implementation and involvement of a great amount of terminology

At the next stage, students can describe their point of view regarding the search for solving extreme problems of approximation theory. After this, the teacher has to introduce common terminology and acquaint the students with the general scheme of researching integral images of trigonometric polynomial variations that are generated by linear methods of summing Fourier series, from periodic functions. Generating students' new ideas on methods of approximation improvement, their comparison with the ideas of the previous stage is possible. At this stage, the teacher also has to prevent possible mistakes while explaining misconceptions that could arise at the stage of engagement and exploration. During the classes of this stage, the teacher involves interactive methods and presentations for mathematical modeling of periodic processes (table 4).

After getting an explanation about the research main scheme regarding integrated images of trigonometric polynomial variations during the classes of periodic functions it is important to involve students in further research activities. Further work includes significant analytical calculations connected with exact and approximate methods. Starting from the integral image students can learn asymptotic behavior of exact upper bounds of deviations of trigonometric polynomials from periodic functions to infinity. The stage is aimed at helping students to develop a deeper understanding of general methods of mathematical analysis and the use of approximation processes in practical tasks. Students can carry out additional researches, develop new approximation methods, exchange ideas, and use acquired research experience to integrate Approximation theory in practice (table 5).

The practice of working in small groups is important at this stage. The lessons include planning and preparation of students' proper development on using the considered approximation methods from every group of students. It is possible to create an algorithmic and program-algorithmic product based on the created methods. As the simplest and at the same time the most natural example of a linear process of approximation of continuous periodic functions of the real variable can be the approximation of these functions using the sequence

Table 4
Recommendation for the teacher on the organization of the third stage.

Appropriate	Inappropriate
teacher's explanation	forming a great amount of terminology
expression of the ideas using generally accepted terms	focus on independent work
idea review and formation of new ones	

Table 5
Recommendation for the teacher on the organization of the fourth stage.

Appropriate	Inappropriate
enhancement of understanding through strengthening the ideas acquired by experience	development of the ideas that are not connected with previous experience
use of algorithms that are close to new situations	generating a great number of ideas without deepening in the essence of the theory
grounds for conclusions	
support of forming student's proper ideas	

elements of partial sums of Fourier series, the greater majority of students have a basic idea about the techniques of using these methods while creating an algorithmic product. But, as it is well known, the sequences of partial sums of Fourier series $S_n(f;x)$ are not equally similar for the entire class of continuous periodic functions. Thus, a considerable number of students' developments in this area are directly dedicated to the learning of approximate features of other approximation methods that are generated by particular transformations of partial sums of its Fourier series for this function and allow building the sequence of trigonometric polynomials that would be completely similar for every function [47]. Fejer sums $\sigma_n(f;x)$ are arithmetic averages for the first n of partial Fourier sums for this function and, as it is known, the sequence of polynomials $\sigma_n(f;x)$ equally coincides with its function. Sums of de la Vallee Poussin $V_{n,p}(f;x)$ are a synthesis of sums $\sigma_n(f;x)$ and have approximate features that depend a lot on the parameter p. Trigonometric polynomials $V_{n,p_1,p_2}(f;x)$ that are generated by the repeated use of de la Vallee Poussin summation method are the further synthesis of classical Fourier methods, de la Vallee Poussin and Fejer [48]. Choosing particular parameters p_1 and p_2 these polynomials coincide with the sums $S_n(f;x)$, $V_{n,p}(f;x)$, $\sigma_n(f;x)$. The works of practice participants should be dedicated to the learning of approximate features of such approximation methods showing graphically the advantages of its use (figure 1, 2). For the visualization, students can be recommended a system of computer mathematics Maple that includes developed graphic means.

The demonstration of the efficiency of the selected approximation methods can be done by comparing the results of numerical experiments held simultaneously for the operators $S_n(f;x)$, $V_{n,p}(f;x)$ and $V_{n,p_1,p_2}(f;x)$. Meanwhile, it is necessary to pay students' attention to the fact that the aggregate of all the harmonicas that are used to build the operators $S_n(f;x)$;

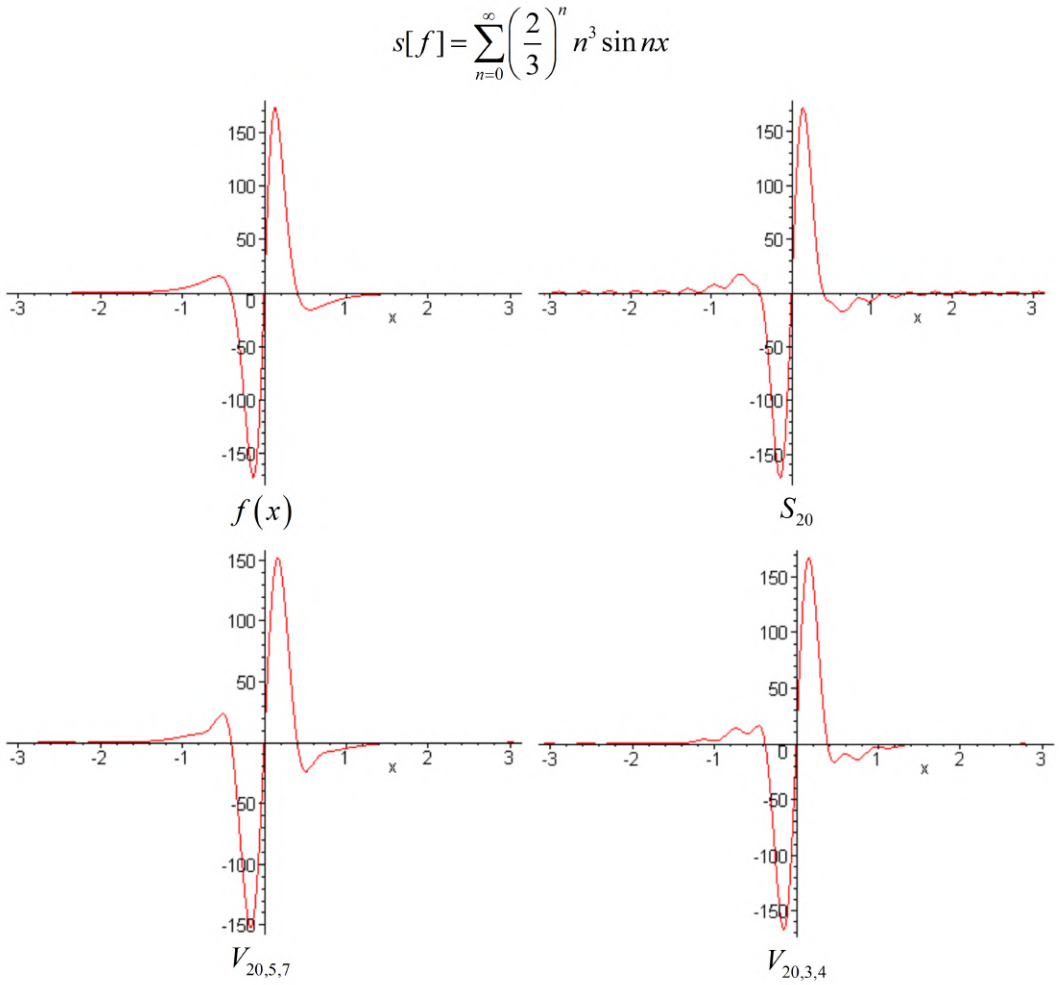
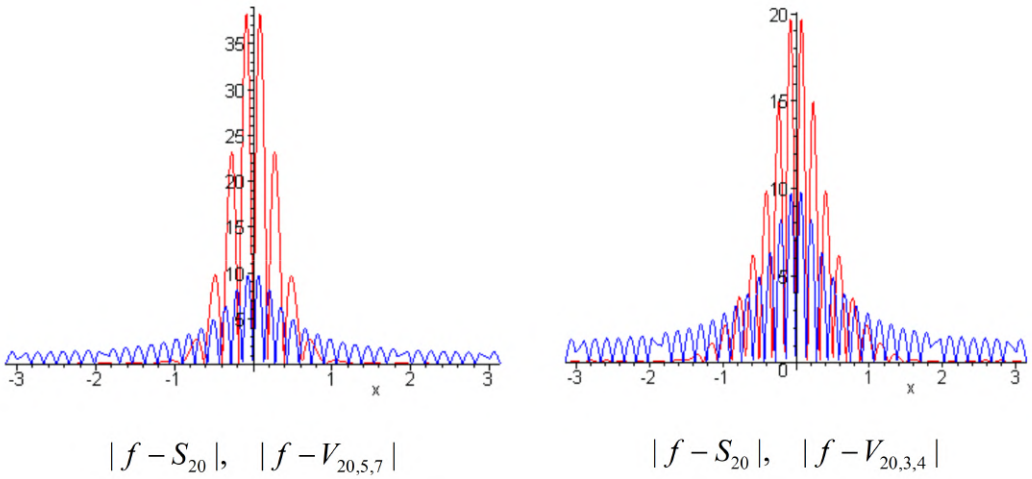


Figure 1: Visualization of functions and trigonometric sums that are generated in different methods of summarizing Fourier series in the system of computer mathematics Maple.

$V_{n,p}(f;x)$ coincides with a similar aggregate for the operator $V_{n,p_1,p_2}(f;x)$. At the same time, the program for the numeric implementation of the values $S_n(f;x)$, $V_{n,p}(f;x)$ and $V_{n,p_1,p_2}(f;x)$ can be developed using Python. This tool is easy to use for students–non-programmers and is suitable for easy calculations.

The final stage of practice is dedicated to evaluation. Evaluation is considered to be a permanent process during which the teacher only observes the students and supports them during report presentations, idea introduction, and question tasks. The use of peer assessment is relevant. Such a form of evaluation can be complemented by students' self-assessment of their level. During the classes of this stage, the teacher involves interactive methods and presentations for mathematical modeling of periodic processes (table 6).

The use of inquiry-based learning does not oblige the teacher to strictly follow the indicated stages. If necessary, it is possible to repeat them several times (Bybee and Landes [49]). This



$|f - S_{20}|, \quad |f - V_{20,5,7}|$ $\qquad$ $|f - S_{20}|, \quad |f - V_{20,3,4}|$

Figure 2: Visualization of deviation of Fourier series and repeated de la Vallee Poussin repeated series from the function $f(x)$ in the system of computer mathematics Maple.

Table 6
Recommendation for the organization of the final stage.

Appropriate	Inappropriate
evaluate the progress in general in comparison to the initial level	evaluate single facts and separate elements of approximation theory
evaluate the ability to use approximate methods to solve complex problems	offer a survey in a test form
give students feedback regarding the feasibility of their ideas	
encourage questions that enhance a deeper understanding of the influence of individual function features on the approximation order	

fact proves the flexibility of using this approach for the implementation of scientific practice.

3. Results

During the preparation stage, we selected the target type as a selection strategy, because the selection had to include the students who have a high achievement level in mathematical branches. By high level, we understand the absence of the final mark "satisfactory" and lower following the national 4–level scale "unsatisfactory", "satisfactory", "good", "excellent" for each of the subjects "Algebra", "Mathematical analysis", "Functional analysis" and "Function theory". The target selected analysis provided us with a sample size n=49 of students that represents 23% of the general number of master's degree students of the first year during 2015–2019. At the stage of organizing data collection, we used the tool of express-evaluation of positive and

negative emotional states called the Differential Emotion Scale (Izard [33]), which ensures diagnostics of a wide range of emotional states. Each of the ten basic emotions (x_i, $i = 1, 2, ..., 10$) is represented by three independent changeable 5–character scales for factors that describe emotional states. The points on every scale correspond to the level of emotional feedback and can be in total from 3 to 15 points. The stage of data analysis of every profile implies the selection of significant (>9 points) emotions, creation of "emotion profile", determination of the dominant emotional state.

At the beginning of the research, the most significant positive emotions regarding the experience of research activities are "interest", negative – "shame" and "fear" (table 7).

Table 7
Distribution of significant emotions at the beginning of the research.

Emotion	Number of students who have this emotion as dominant (>9 points)	Comparison with the general number of students
Interest	32	65.3%
Fear	45	91.8%
Shame	27	55.1%

While processing every profile we defined the indexes of emotional states that characterize the level of subjective students' emotional attitude to the present experience of research activities. The Index of positive emotions and Index of critically negative emotions could range from 9 to 45 points, the Index of anxious–depressive emotions ranged from 12 to 60 points. We defined that the positive emotional state turned out to be dominant among 69.4% of students; a strong level (> 36 points) of expressing a positive emotional state was marked only among 6.1% of respondents. Also, a distinct (from 29 to 36 points) level of positive emotional state was fixed among 10.2% of students. Other students (53.1%) showed moderate (from 20 to 28 points) and weak (< 20 points) level. So, most students' attitude to the research process can be mainly characterized as positive. However, this positive attitude is weakly expressed, unstable, and cannot ensure the proper motivation in overcoming difficulties that inevitably arise during research activities. This fact plays an important (if not the most important) role in the failure of attempts to involve an unprepared student in research activities in any area, including Mathematics.

The dominant critically negative emotional state regarding the present experience of research activities was fixed among 12.2% of respondents, half of whom had a strong (>32 points) or distinct (from 25 to 32 points) level. It is important that among all the students who had the critically negative state as dominant, the factor "Dull" took no less than 4 points, and, accordingly, made the greatest contribution to the calculation. It testifies a stereotype regarding the complexity and absence of interest in research activities among young people. We considered this aspect while searching for methods of practice implementation.

As mentioned above, the emotions "fear" and "shame" were detected as significant among 91.8% and 55.1% of respondents. These emotions are included in the third group of emotions that determine the anxious–negative emotional state of the subject regarding the experience of research activities. Despite this fact, the given state is dominant only among 18.4% of students. It demonstrates that these two emotions influence the formation. 4.1% of respondents have

strong (> 30 points) level of emotional state, distinct (from 21 to 30 points) – 10.2%, moderate (from 12 to 20 points) and 4.1% of respondents – weak (< 12 points). Such a noticeable selection of two emotions in the general image of the emotional state confirms the idea that fear and shame prevent students from implementing their interest in the research process and take an active position while conducting research.

The repetitive survey was carried out after finishing the practice. The distribution of significant emotions after taking practice is represented (table 8).

Table 8
Distribution of significant emotions after taking practice.

Emotion	Number of students who have this emotion as dominant (>9 points)	Comparison with the general number of students
Interest	44	89.7%
Surprise	18	36.7%
Fear	39	79.5%
Shame	5	10.2%

Interest turned out to be a significant positive emotion among 44 students. We can note that the number decrease in students who had shame as a significant negative emotion is well seen – 17 respondents. At the same time, the number decrease of students who had fear as a significant emotion is minor – 6 students (figure 3).

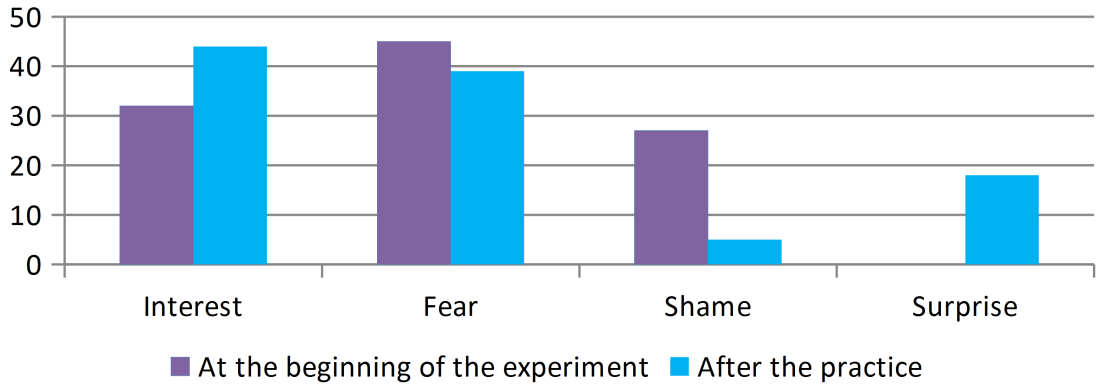


Figure 3: Distribution of a significant emotion.

Despite this fact it is impossible to claim that this emotion in the context of the given research is badly adapted. The profile analysis of respondents' emotions shows the decrease of fear expression to varying degrees among 77.5% of students. The presence of surprise among the significant emotions, as well as interest, which is included in the positive group, is predictable.

More detailed analysis of the feasibility of implementing practice that was carried out using the index calculations of students' emotional states. We detected the increase of students with the dominant positive emotional state up to 81.7%, where 63.2% of respondents had a strong and distinct level. At the beginning of the practice, the same indicator was 16.3%. Thus, we

managed to form a stable positive attitude to research activities among more than half of the practice participants.

The number of students who have a critically negative emotional state as dominant remained at the level of 12.2%, though the qualitative structure of this subgroup changed. In our opinion, it is connected with a greater amount of working practice in small groups during classes in comparison to individual work. As teachers pointed out certain students perceived such a format negatively.

The dominant anxious–negative subject's attitude to experience of research activities after taking a practice was fixed among 6.1% of students. Among them 4% of respondents have moderate and 2.1% – weakly expressed level of emotional state. The comparative analysis of the students' number regarding dominant emotional states is displayed (figure 4).

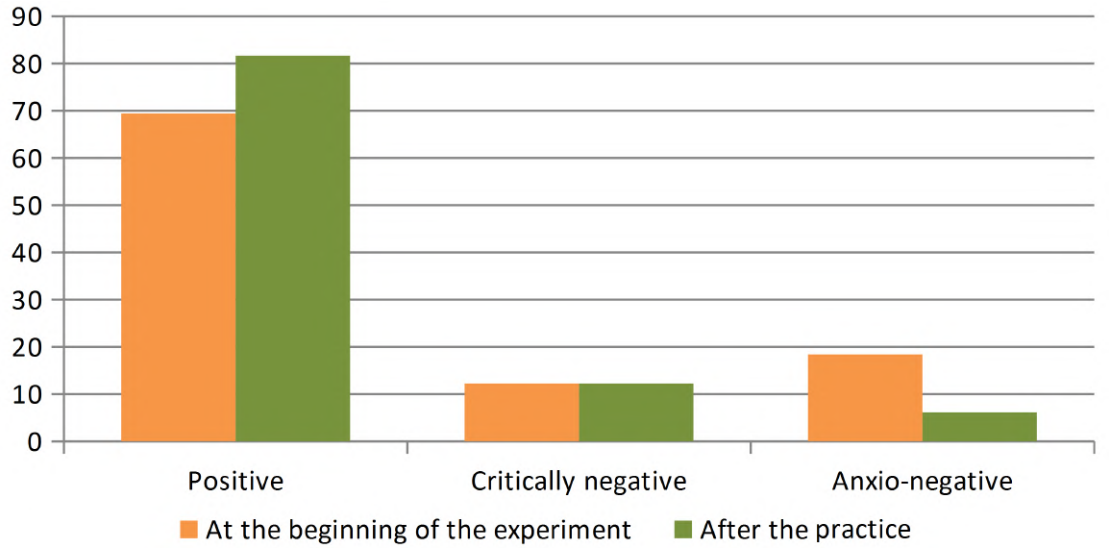


Figure 4: Distribution of dominant states.

The analysis of the results proved that creating the environment based on inquiry-based learning during the scientific practice where students did not feel negative emotions to research activities encouraged the increase of their interest in research activities.

4. Discussion

Searching for ways of forming students' interest in research activities on mathematics we faced the researches done by Sandoval and Reiser [15], Rocard et al. [12]. The scientists point out that in order to form students' impression of the real world it is necessary to show them how to organize their activities as real scientists do during the process of learning and knowledge grounding. Fallon et al. [20] offered to seek the possibilities to organize students' research activities through the method selection and forms of a learning organization that influences active students' involvement.

Traditional educational methods, which are focused on the teacher, don't provide an active students' involvement in research activities [9, 50, 51]. The scientists emphasize the importance of searching for educational models that encourage the strengthening of students' learning activities. The Deductive Content Analysis Method helped us to choose inquiry-based learning as the foundation of developing a scientific environment for students' education.

The efficiency of inquiry-based learning to encourage students' research activities is proved by Duran and Duran [42], Bybee and Landes [49], Supasorn and Promarak [43], Cheng et al. [41]. Also, we support the opinion by Vlasenko et al. [51, 52, 53, 54], who believe that learning has to be built so that students can research, explain, extend and estimate their progress, and the introduction of ideas assumes students' awareness of the reason or necessity of their use. The indicated aims are fully agreed with the content of inquiry-based learning.

Alshehri [55] believes that while organizing research activities it is necessary to direct students to the main models of subject matters. One of the key subject matters of Mathematics is Approximation theory, its broad influence on the modern state of innovation and technology development is widely known. The research is aimed at searching for ways of implementing a practice on Approximation theory to form students' interest in Mathematics research activities. The main research result testifies that the use of the approach inquiry-based learning influenced efficiently the formation of students' positive attitude towards research activities. Within this approach, the involvement of the practice on Approximation theory encouraged the increase of the level of expressing students' positive emotional state (particularly interest, surprise increase) and decrease of anxiety level. These results are agreed with the conclusions by Chin and Lin [56], Abdi [45], Jung et al. [57], Ong et al. [46], who studied the connection between interest growth and a person's emotional state. This justifies the use of methodology Differential Emotions Scale by Izard [33] during the experiment.

5. Conclusion

In this paper, we have explored the use of inquiry-based learning and approximation theory as a way to foster students' interest in research activities on mathematics. We have developed and implemented a practice on approximation theory that follows the principles of inquiry-based learning. We have also measured the effects of this practice on students' emotional states and attitudes towards research activities.

Our results show that inquiry-based learning and approximation theory can create a positive and engaging learning environment that enhances students' interest in research activities. This can help students develop their research competence, which is a key component of professional competence in mathematics and related fields.

However, our research has some limitations that need to be addressed in future work. For instance, we only focused on one branch of mathematics and one type of inquiry-based learning. We also did not compare our practice with other methods or assess its long-term effects on students' performance and motivation. Therefore, future research could extend our work by exploring other branches of mathematics, other forms of inquiry-based learning, and other outcomes of interest.

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Developing digital and ICT literacy skills for future foreign language teachers: a comparative and action research approach

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Abstract

Digital and ICT literacy skills are essential for effective learning and teaching in the 21st century, especially for foreign language teachers who need to use various technologies to enhance their pedagogical practices and students' outcomes. However, the current state of pre-service teacher training programmes in different countries may not adequately prepare future foreign language teachers for the challenges and opportunities of integrating digital and ICT tools in their classrooms. This paper reports on an action research project that aimed to investigate and improve the digital and ICT literacy skills of future foreign language teachers in Ukraine, and to compare them with those of their counterparts in the USA. The project involved three surveys of students and teachers, as well as the implementation of several interventions based on the courses of Methodology of foreign language teaching and Practical course of foreign language. The paper also describes the positive practices and projects that contributed to the development of digital and ICT literacy skills among the participants. The paper discusses the findings and implications of the action research project, as well as the challenges and limitations posed by the pandemic situation. The paper concludes with some recommendations for further research and practice in this area.

Keywords

digital literacy, ICT literacy, foreign language teaching, pre-service teacher training, action research

1. Introduction

Teaching is a dynamic and complex profession that requires constant adaptation and innovation to meet the diverse and changing needs of learners. This is especially true for foreign language teachers, who face the challenge of integrating various digital and ICT tools into their pedagogical practices to enhance language learning outcomes and intercultural communication

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[1, 2, 3, 4, 5]. However, the rapid development and evolution of digital technologies also poses a problem for pre-service teacher training programmes, which may not be able to keep up with the current trends and demands of the profession. Therefore, future foreign language teachers need to develop their own digital and ICT literacy skills, as well as their ability to engage in continuous professional development, in order to be prepared for the realities and opportunities of the 21st century classroom [6, 7, 8].

Digital and ICT literacy skills are among the key competencies for lifelong learning and employability in the knowledge society, as recognized by various international organizations and initiatives. For example, the Decree of the President of Ukraine "On the Aims of Sustainable Development of Ukraine within the Period till 2030" states that one of the goals is to provide diverse and equitable quality education and opportunities for life-long learning for all Ukrainian people [9]. Similarly, UNESCO has been promoting the use of digital and ICT tools for educational reform and innovation, as well as for fostering intercultural dialogue and social inclusion [10]. However, the terminology and definitions of digital and ICT literacy skills have also changed over time, reflecting the complexity and diversity of this concept. According to the EU Skills Panorama, digital competences or ICT skills/digital competences refer to "confident and critical use of information society technology (ICT) in the general population and provide the necessary context (i.e. the knowledge, skills and attitudes) for working, living and learning in the knowledge society. Digital competences are defined as the ability to access digital media and ICT, to understand and critically evaluate different aspects of digital media and media contents and to communicate effectively in a variety of ICT influenced contexts" [11].

Daily digital discoveries and inventions, combined with the necessity of education adaptation to pandemic conditions, promoted blended and distance learning/teaching, favoured to learners' and teachers' deep diving into digital reality [12, 13, 14]. The educational institutions of all levels developed their own strategies of making education accessible to their learners. In higher pedagogical education it is important to develop the strategies of effective university learning / teaching under the new conditions as well as training future teachers for being ready to act professionally in a changeable pedagogical environment, containing unpredictable or force-major situations.

The *aims* of this paper are to study the opportunities for digital and ICT literacy skills development while pre-service teacher training. The focus is on the experience of Ukrainian universities and their educational programmes for future foreign language teachers.

2. Methods

The methodology of our research is presented with the procedure of action research.

The action research contained several stages according to the procedure of Chen [15]:

- identifying problem of meaning (starting point, kick off, notice, find interesting area, etc.);
- developing questions and examine assumptions (reflect and formulate questions);
- planning (choosing enquiry strategies, ways of gathering data, planning interventions);
- taking action (intervening);
- gathering data (wider evidence);

- analysing data (reflecting on wider evidence, qualitative analysis);
- interpreting data (assessing impact on teaching and learning);
- reporting (formulating recommendations);
- taking action (wider scale intervention).

Besides of the mentioned above stages and their specifications we added comparative analysis of the data and before taking an action we planned implementing new elements into educational process. After having taken the action we compared the expected programme results formation with the previous ones.

The issues of future foreign language teachers' pre-service training are rather well-studied, though there still are the aspects which have not been paid enough attention. Such an issue is the one associated with skills of handling with information and communication technologies. So, we have studied Ukrainian and foreign experience of the future foreign language teachers' digital and ICT literacy skills development.

The next stage of our research was the study which helped us to collect the data about Ukrainian and foreign university educational programmes for bachelors and identifying their potential as for digital and ICT literacy skills formation.

This study was aimed at answering the research question:

1. What are the programme opportunities for the formation of students' digital and ICT literacy skills?
2. How do these components contribute to future teachers' digital and ICT literacy skills development?
3. What are the most effective ways to train digitally and ICT aware teacher of foreign language?

Our analysis comprised the analysis of all components of educational programmes giving the necessary information and qualitative data of the competences to be developed and the expected results as well as educational components contributing to their achievement. Ukrainian and American programmes were compared with the educational programme for future teachers of English implemented in Bogdan Khmelnitsky Melitopol State Pedagogical University.

The stage of interpreting data was realised by means of assessing impact of the educational programme content on teaching and learning. It was studied as the dynamic system of educational components, extracurricular activities, continuing process of amending and renovation of the content, methods, forms, means, modes and approaches to teaching and learning. The results of the tailor-made course "Information and Communication Technologies in Learning and Teaching" implementing were analysed together with other components of the educational programme. This course was especially valuable as a part of the course "Methodology of English Language Teaching", which proved to have the effective combination of content, modes of interaction, motivation and outcomes.

Taking action, in this case is sharing the results of all the previous stages of our action research as the positive practice of creating the student-centred educational environment with the focus on development of future teachers' 21st century skills. To prove that the educational programme under consideration could really enhance the technologies impact in the classroom taught by its graduates, we analysed and interpreted the data gained from its content and from responses of students, teachers and graduates about learning and teaching within its functioning.

3. Results and discussion

Each year university education becomes less accessible as the requirements for the matriculation are changing and becoming stricter. The quality of university education is now under profound renovation as, on the one hand, the Ministry of Science and Education emphasizes on high quality specialists' training based on modern demands and world standards; on the other hand, the National Agency for Higher Education Quality Assurance crucially has changed the procedure of accreditation of educational programmes and subsequently the criteria for their evaluation. Besides of quite reasonable and expected conditions for continuing change of higher education, there is one more unpredictable and sudden factor challenging its functioning such as the pandemic.

Nowadays most of educational programmes in Ukraine are renovated annually. The head of educational programme together with its staff have to analyse all stakeholders' needs and improve it in accordance with them. The authors of the article while being the heads of educational programmes for future teachers of foreign languages have decided to study the opportunities for digital and ICT literacy skills development while pre-service teacher training within their educational programmes. The comparative analysis with the focus on the experience of Ukrainian and foreign universities and their educational programmes has been realized.

It goes without saying that the study of existing experience and positive practices was based not on the educational programmes content only, but also on its dissemination in scientific and methodological resources. During our work with relevant researches we have discovered that in spite of the numerous works revealing the importance of digital and ICT literacy skills for any teacher, great advantages of ICT used in the process of learning and teaching foreign languages, the issue of digital and ICT literacy skills development as one of the key components in future foreign language teachers training have not been thoroughly investigated yet.

Diving into the topic of our study it would be relevant to mention Gavin Dudeney's recollections of his being a student in 1970s-1980s and understanding of literacy and numeracy as the 'three Rs' (reading, (w)riting and (a)rithmetic). He states that "times have changed, and the notion of 'literacy' in the wired world of 2014 is a completely different beast" [16]. The researcher with co-authors Nicky Hockly and Mark Pegrum have created a taxonomy of the new digital literacies "by breaking them down into four main areas: those with a focus on language, on connections, on information, and on (re)design" [16]. A focus on language is specified with print and texting literacies, mobile, gaming, hypertext, code; a focus on connections – with personal, participatory, network and intercultural literacies; a focus on information – with search, information and tagging literacies; a focus on (re)design is associated with remix literacy. Speaking about incorporating a focus on both digital literacy and 21st century skills into a language class, Dudeney [17] emphasises ensuring the learners acquire an integrated level of proficiency with technology, digital literacy and 21st century skills, which should be of benefit both in further study, and in professional contexts.

Houcine [18] presented a "language training centre" in an Algerian university where ICTs are an integral part of the teaching practices and described its positive effect on learning and teaching foreign languages with such benefits:

- students develop better listening skills due to regular exposure to audio materials (audio

and video recordings – authentic and software, podcasts, pronunciation software);
- selection of updated articles from the Internet contributes to learners' awareness of the language (grammar skills, coherence in committing ideas, syntax...) and of the specific scientific editing/presentation (scientific texts, reports);
- teachers reported on their learners being engaged, motivated and attentive;
- ICT impacted positively on students' proficiency. A majority of students got better scores in their fields after attending language courses at the MLC;
- students increased their ability to take notes effectively; i.e., they were more likely to listen to the teacher and grasp the message, select the appropriate information and take notes that will be further exploited;
- the enhancement of linguistic competence combined with motivation and challenge led to more autonomy and initiative (to do research on the Web, to propose links, to use online dictionaries and encyclopaedias).

The research presented by Hadef [19] describes the survey conducted in the department of foreign languages with 30 students whose age ranges between 18–22 years old and 4 university teachers to assess the application of ICTs in the teaching and learning process. Students' and teachers' attitudes to ICTs application were studied and the following recommendations articulated: "University/school have to prepare to a digital society; develop a policy based on its own vision; make use of more digital tools; provide sufficient material; provide an academic training for teachers on how to use ICT's in teaching; prepare an equipped rooms; use video Conferences to present lectures" [19].

One of the most relevant studies of the issue is revealed by Guillén-Gámez et al. [20] whose work has demonstrated that "future foreign language teachers have a medium-low development of pedagogical digital competence. The result of this is that technologies are still not being used today for pedagogical purposes. The lack of pedagogical use may be due to the fact that the teaching staff do not have a solid initial pedagogical training with regard to the development of digital competence, which implies their limited use of ICT, as well as their tendency to only use the best known tools on the market" [20]. The researchers discovered that future teachers have an adequate motivation to use ICT, though there is still a lack of pedagogical consistency in their use, so they recommend educational institutions to motivate teachers by revealing benefits of using ICT.

Sevcikova [21] explored her students' responses to digital technology and its practical use for teaching purposes while TEFL training. Her action research took place in Saudi Arabia. The teacher-researcher discovered that her students believed that "technology is essential for the future; it enhances learning and teaching, supports collaboration and motivation. They also pointed out some limitations such as IT literacy, the time-consuming nature of technology, and the lack of access to free internet learning/teaching resources" [21].

It's crucial that there are specially designed courses for practising classroom teachers which can be used for future teachers. Such course is presented with Nik Peachey – the Blended Learning in ELT course. It is aimed at "developing teachers' understanding of the potential of blended learning for the development of English language skills" [22]. In spite of the fact that this course is tutored online the researcher's recommendations are of great use while improving university educational programmes for future teachers.

One more practical and useful research has been elaborated by Courts and Tucker [23] as they suggest multimedia items that can be easily implemented in the college classroom such as animation, slideshows, blogging, instant messaging, podcasting, and video on demand. The researchers state: "As new technologies emerge, both students and educators are often eager to find methods of assimilating these technologies in their college classroom experience" [23]. Integrating multimedia in the classroom can allow students to apply real-world skills, learn effective collaboration techniques, learn creative ways of expressing their ideas, and synthesize complex content [24]. Though the research dates back to 2012 its results can be used and positively influence learning and teaching in Ukraine even now.

Simultaneously with the analysis revealed in theoretical sources we paid our attention to the content of educational programmes for future teachers of foreign languages in Ukraine and in the US. So, under our consideration there were the educational programmes of Ball State University (USA), New York University (USA), Miami University (USA), Stony Brook University (USA), Izmail State University of Humanities (Ukraine), Volodymyr Hnatiuk Ternopil National Pedagogic University (Ukraine), Pavlo Tychyna Uman State Pedagogic University (Ukraine), Vasyl Stephanyk Pre-Carpathian National University (Ukraine) and Bogdan Khmelnitsky Melitopol State Pedagogical University (Ukraine).

The objects of our investigation within educational programmes were competences and results of learning correlated with educational components as for their potential for digital and ICT literacy skills development.

We found out that there are essential differences between Ukrainian and American programmes as the approaches to developing the programmes content differ. In Ukraine the focus is usually on the ICT issues closely related to core subjects, i.e. to Pedagogy and Methodology of foreign language teaching. In American programmes besides of the same educational components there could be found much more variety of subjects.

In Ukrainian programmes the expected results are associated with the creation of educational-methodological means and equipment and application; search, systematising, analysis and check of the information; creation of educational environment.

American programmes for future teachers of foreign languages contain components which help them to master technological approaches and meet the challenge of integrating technology with the teaching of foreign languages as well as allow them to get much deeper knowledge of ICT and dive into the digital world. There are such subjects as Introduction to Business with Integrated Computer Applications, Computer Apps for Design, Computer Applications in Graphic Arts, Technical Design Graphics, Computers and Society, Learning and Teaching with Emerging Technologies, Software Engineering (service), Space and Place in Human Communication, The Internet and Contemporary Art, etc. As we can see, there is no limitation associated with the future professional skills necessary in foreign language classrooms only. Foreign language teachers can freely choose the subjects which will significantly broaden their worldview and the system of competences.

The need for changes in the system of Ukrainian higher education launched the projects aimed at its modernisation and quality improvement. As Ukraine tries to be in line with European and world standards, international organisations help it to reform all levels of educational system. Recently the reform of pre-school education has just began, the UK Government and British Good Governance Fund support it; New Ukrainian School Concept is based on [25]; Ministry of

Foreign Affairs of Finland supports this reform financially; The Lego Foundation contributes to the development of Ukrainian primary school.

As for higher education it is actively supported with the British Council and the British Embassy, America House, IREX and the US Embassy, Goethe-Institute and the Germany Embassy. For the last five years the most crucial in the sphere of teacher training were two projects implemented by British Council and Goethe-Institute.

Goethe-Institute project "Deutsch Lehren Lernen" [26] presents a series of continuing programme of learning based on innovative didactic approach of action research and corresponds to the world quality standards of teacher training. The project system comprises the integration of methodology of language teaching and foreign language learning as two inseparable components of a future teacher's professional competence.

"Deutsch Lehren Lernen" suggests the tasks on systematic observation and reflection on pedagogical activity by means of German language video-lessons from three continents. As the follow-up activities, the students can participate in one-week on-line course moderated by mentors. On accomplishing the course the students are to do the planning and elaborate their own action research project.

The project activity is based on blended learning and combines traditional language learning with digital learning, i.e. doing on-line tasks, new words and patterns revision and use, virtual collaboration with group-mates, virtual class learning, Adobe Connect webinars for both students and teachers with the system of completed tasks monitoring.

There are such effective learning tools as Page Player-App, E-book, introductory on-line test (Einstufungstest online), media-pack, help-test (Testhelf), application for the work with vocabulary (Vokabeltrainer – App), supplementary on-line materials, bilingual glossary. The advantage of the project course is obvious as it promotes and motivates students' learning and helps teachers to deliver their teaching taking into consideration all challenges of modern education and information and communication technologies development.

The project "New Generation School Teacher" [27] was initiated by British Council Ukraine and the Ministry of Education and Science of Ukraine in 2013. It aimed at introducing change to the initial teacher education system in Ukraine. The project resulted with the PRESETT curriculum in Methodology and the network of Ukrainian universities implementing it and proving its effectiveness. The project outcomes were presented with such learning ones as:

- student-teachers' and newly-qualified teachers' English proficiency is improved;
- their classroom skills and confidence are enhanced;
- their digital and social media skills are developed.

On the level of action outcomes the newly-qualified teachers:

- teach more effectively and confidently;
- engage with colleagues;
- join networks and meet colleagues overseas;
- can integrate ICT in/outside the classroom;
- are committed to CPD.

As it can be seen the ICT skills were paid special attention and there was designed a separate unit of the new Methodology course "ICT in Learning and Teaching". Its objectives are to form the students' awareness of the advantages and disadvantages of doing activities on a computer and other electronic devices as opposed to similar paper-based activities; the criteria for evaluating and selecting online resources for language teaching purposes; and to develop their skills to use different software (e.g. Microsoft Word, PowerPoint) for language learning and teaching purposes; make use of social networking sites, blogs, wikis, etc. in language teaching; evaluate the potential of online audio and video for language teaching purposes; assess possible risks of using the Internet with young learners and develop a set of rules for cyber safety; explore current trends in mobile learning and be able to use mobile phones for teaching and learning reference.

The whole project represents the large-scale research which comprised 8 university at its beginning, and 13 universities and colleges within the period of its piloting. Our small-scale research was based in its results but was elaborated on the content prepared and piloted in Bogdan Khmelnitsky Melitopol State Pedagogical University only.

Besides of "New Generation School Teacher" project results we used the experience of our participation in the joint project of International Research and Exchanges Board, Academy of Ukrainian Press and Ministry of Education and Science of Ukraine "Learn to Discern: Info-Media Literacy" as its realisation is concerned around integrating info-media focused modules or courses into pre-service teacher training syllabus. In spite of the fact that the project is mostly oriented at the training of teachers of Ukrainian Language and Literature, History and Arts, we have implemented its element in our courses for future teachers of foreign languages.

The amended and modernised curricula of Methodology of Foreign Language Teaching and The First Foreign Language develop teacher profile specialty-based competences as well as critical thinking skills, implement interactive methods of learning and teaching, dialogue modes of interaction, and the ample use of online tools.

While identifying the issue for doing our action research we studied the experience presented in scientific-methodological resources and found out the challenges and opportunities for our learning and teaching context.

The role of information and communication technologies in higher education has been being studied since the very beginning of their appearance and application in this branch. The issue has its diachronic and space aspects, i.e. in different periods we observe the studies of various technologies and the context of national systems of education, types of educational institutions, technical and financial capability, and other numerous factors have an impact on the ICT use and their role.

It is obviously that the ICT use in higher education provides for both personal professional development and the world's information-digital-literate society. Modern education should be available for all people always and everywhere. That is why "life-long learning has become the driving force to sustain in the contemporary competitive environment. Therefore to strengthen and / or advance this knowledge-driven growth, new technologies, skills and capabilities are needed" [28].

The first overview of the issue helped with the starting point of our research and finding the relevant area. Still we had to specify the narrow aspects for elaborating and implementing. This was a cause for doing the survey. Our respondents were university students and school teachers.

The questions asked were about their attitude to the use of ICT in class, their confidence in this practice, and their skills in handling with cyber well-being, websites and learning platforms choice, online resources use, social networking, blogs, wikis application, flipped teaching, proper use of various devices such as mobile phones, tablets, laptops, interactive whiteboards. There were 200 students and 30 teachers who took part in the survey.

In 10 months we repeated the survey of the same students and teachers. There were the crucial differences in educational environment between two surveys as the pandemic influenced greatly the role of ICT in classroom when each university teacher and student faced the challenge of completely distance education. In our case, one more factor made its impact on learning and teaching – it was participation in two projects "Learn to Discern: Information and Media Literacy" (continuing) and "Teaching Excellence Programme" by British Council, Advance HE, Institute of Higher Education NAES of Ukraine in partnership with Ministry of Education and Science of Ukraine and National Agency for Higher Education Quality Assurance in Ukraine (started in May, 2020), and participation in the Training for Teachers by Progresylni (August, 2020).

The project "Learn to Discern: Information and Media Literacy" contributed to the development of skills to work with information by means of various online tools and resources. The team of teachers and students of Bogdan Khmelnitsky Melitopol State Pedagogical University won the grant for the creation of the Hub of Infomedia-Literate Citizens. The team consisted of people who took part in both surveys and they surely demonstrated new results. Due to involving at least 300 people improved their handling with information online and Zoom platform for education and communication.

Application for participation in Teaching Excellence Programme was based on creation of Hub for Teaching Excellence Development. It has been created in 2020 and several workshops for university teachers were delivered. Two of them were devoted to the use of ICT for student-centred education. Sharing the experience of participation in the Programme was of great value for the development of digital and ICT literacy skills of both teachers and students. The trainers from Advance Education (Great Britain) Kathy Wright and Caroline Brennan combined such issues as influences on learning, conceptions of learning, learning theories, outcomes led teaching, planning for learning, making teaching interactive, principles of assessment, types of assessment, giving and receiving feedback, reflective practice, action research, interdisciplinary and other issues with the advanced use of various modern technologies, resources and tools (Edmodo, Socrative, Thinglink, ClassDojo, Storybird, Animoto, Kahoot!, Scretch, Quizlet, Trello, Edpuzzle, Jamboard, TurnItIn, Canva, Schoology, AnswerGarden, Nearpod, Flipgrid and many others).

Besides of demonstrating and explaining all those technologies and resources, the trainers used the loop input, involving participants into activities realised by means of all those tools. Most of them were multifunctional and catered for achieving several educational purposes, while some of them helped to create rapport and demonstrated good sense of trainers' humour. Such simple use of Zoom as filters turned the trainer into a master, then deer and later on helped to create holiday frame. All those workshops-webinars made participants discover numerous ICT uses for education promotion under any circumstances.

The first survey allowed us to see the so-called "digital divide" as only two of teachers (6.7%) answered that they are completely confident as for ICT use in classroom. Completely confident

students were 49%. Though, the questions about cyber well-being, websites and learning platforms choice, blogs and wikis application, understanding of flipped teaching demonstrated that there were some gaps in their information literacy and digital safety skills.

For teachers who took part in our survey we prepared a series of workshops to help them in ICT application in foreign language classrooms.

For students, on the basis of our baseline study we elaborated the unit "Information and Communication Technology (ICT) in Learning and Teaching English" [29] which was based on blended learning and included the following items:

- Modern learning technologies and their relevance for the educational process.
- Cyber well-being: keeping children safe on the Internet.
- Selecting and evaluating websites for teaching and learning purposes.
- The use of learning platforms (e.g. Moodle) for teaching purposes.
- Using online audio and video resources for language learning and teaching purposes.
- Exploration of opportunities offered by social networking sites, blogs, wikis to language learning and teaching.
- The notion of a 'flipped' classroom and its benefits; traditional vs. flipped teaching.
- The main uses of IWBs (interactive whiteboards). and their benefits as opposed to traditional whiteboards.
- Exploration of opportunities offered by mobile devices (e.g. smartphone) in language learning.
- The use of different software and online tools for teaching and learning purposes.
- Power Point making rules.
- Effective ways of information search, finding the primary sources. Accumulating and generalising the information.
- The notions of copyright and plagiarism. Following the copyright. How to avoid plagiarism.
- Teacher's skills in photo, logo, symbols, posters, emoticons, memes, infographics use.

There were no traditional lectures within delivering this unit. The main modes of interaction were presented with games, jigsaw learning, buzz groups, socratic technique, role play, workshop, simulation, cross-over groups, guided reading, lecturette, brainstorming, speaking corners and others. Of all methodology units this one was of the greatest interest for students and positively influenced their motivation to learning. It was confirmed at each session which ended with taking students' feedback.

Each session began with studying the experience on the topic of it. Starting where the students are helped us to choose between possible variables and contributed to making the unit content and methodology of its deliverance more flexible.

Here there are some examples of organising the learning within the unit. In the session devoted to cyber-well-being, after getting acquainted with its principles, watching several videos and brainstorming all ideas about safe use of the Internet, the students make a list of rules for communicating in the world web. They work in groups and find the examples to each rule from the Internet. Each group creates a document on a Google Drive and then works with

all lists created by other groups. They add other suggestions or comment on other groups' products. After discussing the rules of netiquette, one student takes a responsibility to make an accumulated netiquette code and shares it with all students.

One more example of work in teams is presented with evaluating the sites. Before doing this evaluation, the students learn the following criteria essence:

1. Audience
2. Credibility
3. Accuracy
4. Objectivity
5. Coverage
6. Currency
7. Aesthetic or visual appeal
8. Navigation
9. Accessibility

After that their teams work with different educational websites and evaluate the possibilities for their use in the narrow context, i.e. they are informed on the age of learners and their level of English.

When one team presents their findings the representatives of other ones ask questions and give comments. The activity is summarised with formulating tips for the work with websites.

The work with online courses was a little more time-consuming for students as they had to begin some courses (according to their learning interests) on various learning platforms such as https://futurelearn.com or https://openlearning.com. After diving into their courses and getting access to all platform tools, students analysed the content management, curriculum mapping and planning, ways of communication and management of the platform. On the stage of discussing the platforms the students are asked to reflect on their possible moderating such courses, strengths and weaknesses of them.

The use of social networks in learning and teaching arouse the most interest of students. This topic was studied with simultaneous revision of keeping children safe on the Internet. The students suggested the ways of possible algorithms of social media use for educational purposes. This way of ICT use was studied in micro-teaching as students prepared 1-2 activities for their group-mates playing the roles of school students. Through the prepared activities a student-teacher taught English or German to his/her school students. After each microteaching there was a feedback session aimed at finding positive features and methodological mistakes so that avoid them in real classroom.

Especially valuable for students was the work with wikis and blogs as they promote online writing which is rather important for teachers-philologists. In this case we asked students to create their own blogs. They worked in small groups and had one task per a group. To make use of the task they created the blogs of newly-qualified teachers so that they could use them while having their school experience (practice).

All above-mentioned examples were used in methodology class, though sometimes we applied activities of the same typology in our language classes. We give just one example of a task in the class where German is taught as the second foreign language.

So, the students got a set of QR-codes with the help of which they had to find the endings of the statements beginnings of which were given. Then they had to match parts of statements according to the logic approach

In practical language classes especially often were used mobile phones applications as they helped to work with vocabulary and grammar (visualising, training, revision, test control), listening. Writing skills were monitored on the level of messaging. Still for larger pieces of writing we used standard e-mail writing which helped students to learn to write various types of letters. Before writing such letters they searched the information necessary for that very kind of a letter.

While gathering data on our action research we looked for wider evidence of the unit effectiveness. That is why the same survey was conducted for the second time. It confirmed that most of students (87%) began to feel more confident as for ICT use in class. Besides, they were acquainted with a wide range of software, online tools, applications and other methodologically valuable ICT items. While speaking about students completely confident with ICT we discovered 67%. There were still a lot of students quite confident with the use of Instagram or TikTok and very unaware of how to use digital opportunities in their future professional activity.

The ICT use in learning and teaching unit was a very dynamic and useful for future teachers. Its importance and relevance was confirmed by students and teachers. It is the call of the time to make the classroom blended and to transfer a part of learning to virtual reality which so important for "digital native" school students. Besides, modern university students are ready to implement the ICT innovations.

The students had a good opportunity to train in using ICT in hands-on activities when they had their school experience (practice). So, their reflective journals they wrote while practice contained the same feedback as in the end of each methodology session: the ICT is a powerful methodological tool and the factor which favours learning and teaching stay effective.

After the third survey we discovered that the situation changed to the better as 6 teachers grew confident with ICT use in classroom (20%). They explained that fact with the need for vast ICT application during the pandemic and the direct dependence of their teaching on technological decisions. Participation in project events and workshops stimulated their progress as well.

The students stated their progress as well. The number of completely confident students grew up to 75%. The most frequent explanation for the progress was the same as the teachers' one – the emerging need for ICT use as the only way for their learning. Students shared their new experience as "up-scaling their digital worldview".

The comparative analysis of the contents of Ukrainian and American educational programmes demonstrated that the American ones give the students much better possibilities for the development of digital and ICT literacy skills, including both for their future teaching foreign languages and more advanced use. However, among Ukrainian programmes there were several under our consideration which proved to be rather progressive in this direction. They were the programmes of Ternopil, Uman and Melitopol universities. These three programmes were greatly influenced with participation in the project "New Generation School Teacher", so the educational components for digital and ICT literacy skills of future teachers of foreign languages appeared to be well represented. While having such positive experience of specific professional training there is the need for implementing some educational components aimed at advanced ICT use.

The application of ICT in both teacher training and those teachers' future professional activity can be considered unlimited as the technology is rapidly developing and changing the world around us as well as the educational opportunities. Virtual reality contains the enormous potential for improving the quality of learning and teaching foreign languages. This issue have been studied Symonenko et al. [30] who emphasized that "the practice of immersion into virtual environment in foreign language learning will enable students to feel themselves an integral part of the professionally oriented situation which is designed specifically to prepare the course participants for communication within" [30]. Researchers point that virtual reality tasks help students to get used to "psychological challenges and apply existing speaking skills in a foreign language", "encourage spontaneity" and increases students' motivation to "achieve better results in a training course" [30]. Virtual reality is especially valuable for teaching languages in the conditions of natural language speech environment. Besides of demonstrating "situational models of possible daily life circumstances for foreign language communication" [30], virtual reality based tasks surely promote the development of future teachers' information literacy and digital skills.

4. Conclusions

This paper has presented the results of an action research project and a comparative analysis of American and Ukrainian educational programmes for future foreign language teachers, focusing on their digital and ICT literacy skills development. The main findings and implications of the paper are as follows:

1. The action research project demonstrated the importance and effectiveness of developing future foreign language teachers' information literacy and digital safety skills during their pre-service teacher training process. The project involved the design and implementation of a unit based on the courses of Methodology of foreign language teaching and Practical course of foreign language, which aimed to enhance the participants' awareness and skills in various aspects of ICT use in language teaching and learning, such as evaluating and selecting online resources and tools, creating and communicating digital content, assessing potential risks and ensuring cyber safety, and using various electronic devices for pedagogical purposes. The project also involved three surveys of students and teachers, which showed that the participants improved their digital and ICT literacy skills as a result of the project interventions, as well as due to the increased use of ICT in the pandemic situation.
2. The comparative analysis of American and Ukrainian educational programmes revealed that the American programmes offer more opportunities and flexibility for future foreign language teachers to develop their digital and ICT literacy skills in relation to their specific professional activity and needs. The analysis also identified some positive practices and projects in Ukrainian universities that contribute to the innovation and quality of higher education, such as the participation in international projects, the implementation of Teaching Excellence Programme, and the integration of information and media literacy components. However, the analysis also indicated that there is still room for improvement and revision of the Ukrainian educational programmes, especially in terms of adding

more components and courses that aim to develop advanced digital and ICT literacy skills for future foreign language teachers.

3. The paper contributes to the existing literature and practice on digital and ICT literacy skills development for future foreign language teachers by providing a novel action research approach and a cross-cultural perspective on this topic. The paper also addresses a timely and relevant issue in the context of the pandemic situation, which has posed new challenges and opportunities for education in general, and for foreign language teaching in particular. The paper offers some recommendations for further research and practice in this area, such as exploring more effective ways of producing digital content, handling virtual reality, fostering intercultural communication, and ensuring inclusive and equitable quality education through ICT.

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Exploring the potential of immersive technologies in university education worldwide

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Abstract

This paper explores the potential of immersive technologies in university education worldwide. We analyze the advantages and disadvantages of using immersive technologies and highlight their use in professional training for archaeologists, architects, engineers, pilots, rescuers, and physicians. We also emphasize the use of immersive technologies in creating inclusive learning environments for students with special educational needs. Our analysis of global experiences with immersive technologies in university education reveals their use in distance learning, empathy training for social issues such as homelessness, and environmental education on topics such as ocean oxidation and coral reefs. We conclude that immersive technologies are used not only for professional training but also for gaining social and emotional experiences and raising awareness of environmental issues.

Keywords

immersive technologies, university education, professional training, inclusive learning, distance learning, empathy training, environmental education

1. Introduction

In today's digital age, there is increasing pressure on educational systems worldwide to integrate new information and communication technologies into their curricula to equip students with the knowledge and skills required for the 21st century. This necessitates the transformation of the educational process and the adoption of new learning technologies [1]. In our view, the use of immersive teaching methods represents a natural progression in the evolution of education.

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Previous research has examined the use of immersive learning technologies, including AR and VR, as teaching methods and tools, as well as their application in education [2, 3, 4, 5, 6]. Other studies [7, 8, 9, 10, 11, 12] have focused on defining key concepts, exploring aspects of VR technology theory and methodology, and investigating the use of immersive technologies as a factor in educational development.

The questions of peculiarities of the use of immersive technologies have been studied by Khvilon and Patru [1] in order to study information and communication technologies in teacher training, by Bockholt [13] to determine the essence and features of virtual reality (VR), augmented reality (AR), mixed reality (MR). Biggs [14] focuses on using the potential of VR technology to help memorize learning material. Calvert and Abadia [15] investigated the influence of immersion of university students and high school students in educational narratives using virtual reality technologies.

Our analysis reveals that some research (e.g., Kamal et al. [16]) has investigated the use of immersive technologies at specific universities, including the University of British Columbia, Central Pacific Institute in Hawaii, Punahou International University, and Malaysian universities. However, these studies have not yet comprehensively examined the global experience of using immersive learning technologies in university education.

The aim of this paper is to analyze the theoretical aspects and practical implementation of immersive technologies in universities worldwide. To achieve this goal, we will examine the forms, methods, and means of using immersive technologies in leading countries, as well as analyze positive and negative experiences in their implementation at leading universities.

2. Methods

Interrelated and complementary research methods have been used to achieve the aim of the scientific intelligence. Thus, to collect scientific material in the article the method of studying scientific sources, analysis of the results of surveys conducted by international companies has been used. In particular, a survey conducted by the global law firm Perkins Coie LLP and XR Association in 2019, which identified specific areas of use of immersive learning technologies in the training of professionals in the world's leading universities [17]. The results of the survey conducted by the company Sony in July 2019 on the use of video in higher education institutions were studied [18]. The results of this survey give us the idea of how video is currently used in the educational space of universities, and what the use of video in the educational process may look like in the future; questionnaires and surveys conducted among researchers and students of Lviv Ivan Franko University, Volodymyr Hnatiuk Ternopil National Pedagogical University and Khmelnytskyi Humanitarian-Pedagogical Academy allowed to determine that respondents are familiar with virtual and augmented reality technologies in the context of their use for entertainment, games, but a clear definition of what is immersive learning technology could give only research and teaching staff, students answered that they do not know how to define such a concept, or difficult to answer; special linguistic methods allowed to make correct editing and translation of information from English.

3. Results

The introduction of new innovative technologies in the educational process of universities is an integral part of improving the quality of education around the world. In connection with the global pandemic [19, 20], although distance learning has been introduced in universities [21, 22], teaching is carried out mainly by traditional methods, which include providing material in the form of text documents, its processing by students and testing of knowledge [23, p. 159]. Therefore, in this research we will summarize the world experience of using immersive learning technologies in the educational space of universities.

Let's consider the problem of development of immersive technologies. The idea of creating a virtual world originated in the 1930s and belongs to Stanley Grauman Weinbaum, who described a similar world in the story "Pygmalion's Spectacles" [24]. It was then that VR technologies began to develop, but due to technical limitations and high costs of ample opportunities, they were not actively introduced [7, p. 17].

With the development of immersive technologies, educational processes become more complex and a grainy picture of reality emerges. There is a whole spectrum where the digital and real worlds are mixed and mixed reality is used, which is becoming increasingly important [25, p. 2].

A new impetus for the development of immersive technologies occurred in 2014, when Facebook acquired the startup Oculus VR – a pioneer of digital technology. An updated model of the virtual reality helmet was released, which caused a real sensation in the technology market. Nowadays, VR is gaining momentum and refers to the so-called immersive technologies – the generalized name of all technologies that include human interaction with space, information, content. They blur the boundaries between real and fictional worlds, allow to interact and immerse oneself in information and information product [26].

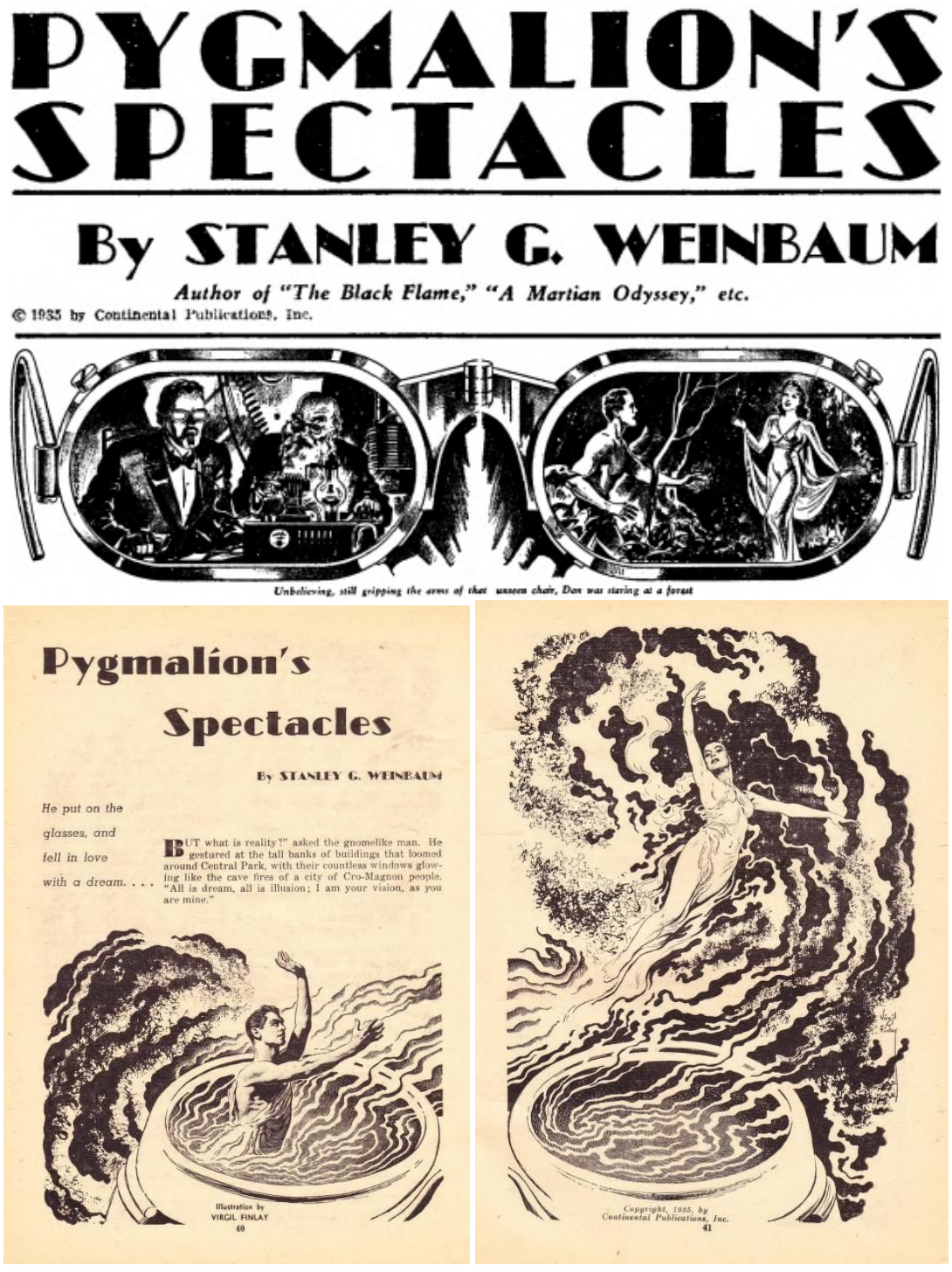
According to a survey conducted by the global law firm Perkins Coie LLP and the XR Association in 2019, by 2025, immersive technologies, including augmented reality, will be as necessary as mobile phones. This is the opinion of almost 9 out of 10 respondents who took part in the survey [17, p. 2].

The use of immersive learning technologies in the educational space of higher education institutions provide the effect of full or partial presence in the alternative space and thus change the user experience in different fields and in different specialties.

The components of immersive learning technologies are virtual and augmented reality technologies, as well as 360 video [27, 28, 29]. In our research it is necessary to clarify the meaning of immersive technologies and to show the difference between virtual and augmented reality technologies.

We are going to consider in more detail what lies behind the basic concepts of our research. Virtual reality is often used to denote an experience that completely immerses the user in the environment created by the computer, and largely "disables" his or her physical environment. Augmented reality, contrary, imposes digital elements on real objects and backgrounds.

Virtual reality is an ideal educational environment. Perception of the virtual model with a high degree of reliability allows to qualitatively and quickly train professionals in various specialties: aviation, process control, medicine, remote control of technical means and more. Over the last decade, virtual reality has become a leading technological trend in the development



PYGMALION'S SPECTACLES

By STANLEY G. WEINBAUM

Author of "The Black Flame," "A Martian Odyssey," etc.

Unbelieving, still gripping the arms of that unseen chair, Don was staring at a forest

Pygmalion's Spectacles

By STANLEY G. WEINBAUM

He put on the glasses, and fell in love with a dream. . . .

BUT what is reality?" asked the gnomelike man. He gestured at the tall banks of buildings that loomed around Central Park, with their countless windows glowing like the cave fires of a city of Cro-Magnon people. "All is dream, all is illusion; I am your vision, as you are mine."

Illustration by VIRGIL FINLAY

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Figure 1: "Pygmalion's Spectacles" by Stanley G. Weinbaum (illustrated by Virgil Finlay).

of educational technologies. This is due to the powerful investments of technology companies that improve VR systems, while increasing consumer access and interest in these technologies [30]. Professional reality training allows to visually conduct lectures and seminars, workshops, demonstrate to learners all aspects of the real object or process, which in general gives a huge effect, improves the quality and speed of educational processes and reduces their cost [31, p. 313].

This is, first of all, visual and sound content, sound in this case of key importance – it complements the virtuality and creates the effect of presence in an unreal location by simulating the reflection and directions of sound waves. One can get into alternative, virtual reality, for example, wearing special glasses, dividing the picture in front of the eyes into two parts, they create a stereoscopic effect. In the presence of tracking for body positions, the virtual space will also take into account the movements of the head and torso.

There are other ways to get into virtual reality: a smartphone with a special VR application, tracking systems, special gloves, mobile VR helmets and more [8, 13]. We are going to consider them in more detail.

Smartphone with a special VR application, which is inserted into the case with lenses – Google Cardboard.

Tracking systems allow moving the user into the virtual space, and the costumes that convey feelings from virtual reality are also being worked out.

Special gloves instead of the usual joystick, so that human hands naturally interact with the virtual world.

Mobile VR helmets with built-in monitors (HTC Vive, Oculus Go and others), optimized devices with high-quality graphics, integrated sound and joystick for control.

Standalone VR helmets (like Oculus Rift), graphics to which are transmitted via wires from a gaming computer with a powerful video card, communication with a PC creates restrictions on use, but VR helmets have better graphics and more potential purposes for users.

Trekking cameras capture the position of the joystick and the position of the person, immersing him or her in virtual reality more realistically, complete with helmets are controllers.

Augmented reality is the result of entering into the field of perception of any sensory data in order to supplement them about the environment and improve the perception of information.

The term “augmented reality” was proposed by company Boeing researchers (Tom Caudell) in 1990 [32]. The concept of 1994 by Milgram and Kishino [33] defines augmented reality as part of a mixed reality, also called a hybrid reality. But since 2016, Microsoft has been actively using the term “mixed reality” to market its HoloLens product. And now some experts (and equipment suppliers) define the terms as follows:

Augmented Reality – projecting any digital information (images, videos, text, graphics, etc.) on top of the screen of any device. As a result, the real world is supplemented by artificial elements and new information. It can be implemented using applications for ordinary smartphones and tablets, augmented reality glasses, stationary screens, projection devices and other technologies [34].

Augmented Reality technologies can create digital information (images, videos, text, graphics) on device screens and combine virtual objects with the real environment. For example, the game Pokemon GO is a prime example of AR technology [35].

Panoramic and 360° photos or videos. These are sequential sets of pictures sewn by means of algorithms, it is possible to make them both by one camera, and special 360° cameras. Cameras which take pictures of surrounding space then the received videos are sewn up in special programs. There are also seamless solutions, but they are more expensive, sometimes additional graphics are added to the finished video. Nowadays, "panoramic" online broadcasts are also common, when you have several points with a panoramic view, which give the viewer the opportunity to "be present in the moment" [8].

Virtual reality, using a 360-degree image, carries a person into the artificial world, where the environment is completely changed. We can get acquainted with augmented reality only with the help of a smartphone, but to dive into the virtual space you need to have a special helmet or goggles.

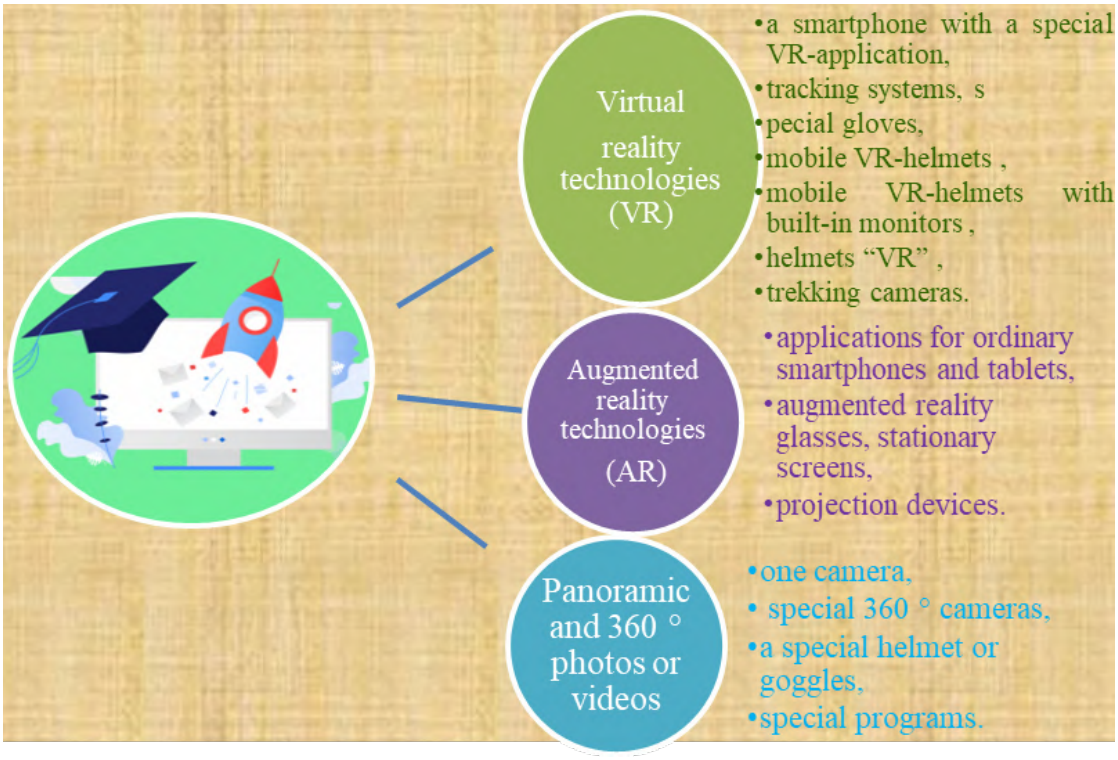

Figure 2: Components of immersive learning technologies.

Thus, the use of immersive learning technologies today can become an effective tool in learning and revolutionize the training of the future professionals [36].

The use of immersive learning technologies in higher education involves taking into account a number of key points on which the principle of visualization in education is implemented. Thus, this principle does not deny, but on the contrary expands and complements the acquired knowledge, taking into account current trends in the development of modern information and communication educational technologies and scientific-technological progress. Immersive technologies in education enhance the importance of visualization in the process of learning due

to deep immersion in the virtual environment, the role of which is very important – enriching students with complex sensory cognitive experience necessary to master abstract concepts. The human sensory system as the first degree of cognition must be strengthened through deeper immersion, the impact on the senses, which contributes to the acquisition of knowledge in the form of concepts, rules, laws, which are laid down at the next stage. Providing knowledge with objectively existing reality should continuously accompany the learning process based on feelings. To increase the effectiveness of learning, the principle of immersion requires, above all, the use of immersion tools, based on visual modality. The principle of complexity in the immersive approach involves the impact on all human senses to the perception of educational material.

The effectiveness of the principle of visualization in the use of immersive technologies is confirmed by the fact that of the five organs of human perception today it is possible to use three – sight, hearing, touch.

Let us consider the experience of using immersive learning technologies in the world's leading universities. Interesting for our research is a survey conducted by the company Sony in July 2019 on the use of video in higher education institutions [18]. In total, the survey was conducted in 13 European countries, in which 123 educators took part. The study showed that the demand for virtual reality is growing today, and several respondents stressed on the benefits of using VR in education: with AR/VR, the potential is further enhanced by the ability to create more interactive and autonomous learning systems. VR allows teachers to create interesting life and interesting learning experiences when students can interact with 3D objects and environments. Students can take virtual tours of artists' exhibitions, explore space or explore the internal organs of a human [18].

Today, VR is actively used in the health care training system to provide medical students with an overview of surgical procedures with their own eyes without being in the operating room. Teachers can simulate the situation and ask students to perform exercises that they could not safely perform in reality, or interact with artifacts that would not otherwise be available [37, 38].

The researches have shown that in a socio-constructivist approach to learning, the most effective educational activity is the experience gained, which involves the acquisition of authentic knowledge in the context of a personally realistic situation. Therefore, the use of immersive technologies is particularly suitable for providing practical experience. Modeling allows students not only to reproduce and practice routine situations, but also to have access to experiences that would be unattainable – due to difficulties, costs, dangers or simply the impossibility of obtaining it in the real educational process. However, their effectiveness depends on the ability to create an environment where the learner feels truly immersed in the environment and the story, going through the real experience.

The positive side of using immersive learning technologies in the process of training the future professionals at the university is to make the learning process exciting and more efficient.

The use of immersive learning technologies provides a deep understanding of the material by the student with the possibility of its further application in real life [39].

Immersive learning technologies should be used to attract the intellectual abilities of students to a more effective learning process. They provide a safe and realistic environment for involving students in learning and practice, where they learn these methods and use them effectively in

the training of the future professionals in various fields. For example, in the training of the future archaeologists to perform work on archaeological excavations; in the training of the future pilots, to guide the landing of aircraft on the aircraft carrier or in the training of the future doctors for surgery. The advantage of using these methods is that the computer system can track the progress of student learning and report any errors [39].

Researchers at the University of Maryland have found that people remember information better when it is presented in VR than a two-dimensional personal computer. It means that VR education is more effective than learning with the use of tablets or computers. Researchers at the university conducted a study in which they asked two groups of people to remember the location of certain images. During the experiment, one of the groups used virtual reality helmets, the other – ordinary computers. The group that studied the image with VR helmets showed a result 10 % higher than the participants of the other group [14].

Universities and colleges have always been at the forefront of introducing new technologies, driving progress and training the next generation of scientists, developers and entrepreneurs [40]. Therefore, let's consider the experience of using immersive learning technologies on specific examples.

During the global pandemic, immersive learning technologies are actively used in distance learning in the world's leading universities, which allows, in particular during video conferencing to improve the effectiveness of learning. For example, professors at the University of British Columbia are already lecturing using immersive teaching methods [40].

For example, at the Central Pacific Institute in Hawaii, students who spent a few minutes using immersive technology for social education regarding the prospects of a homeless person noticed how they realized how easily they could find themselves in the same situation. "Becoming Homeless" is a project developed by Stanford University's Virtual Human Interaction Laboratory (VHIL) to determine the level of empathy for the problem of homelessness, but despite the feelings of discomfort and inconvenience received by students' own practical experience. Students and teachers usually report the consequences of the project implementation as "positive" [25, p. 7].

Another VHIL project that demonstrated the effects of ocean oxidation on coral reefs was conducted at Punahou International University.

So after the application of immersive technologies, in particular, using elements of the game, students gained some interactive experience. They ran their hands through bubbles coming out of coral reefs, causing students to have negative emotions about the environmental problem. The students noted that they are very disappointed that human activities can harm a beautiful and pristine ecosystem [25, p. 7].

Thus, analysing the world experience of implementing immersive technologies in the educational space of universities, we can identify the positive aspects of their use:

- *Visualization.* In the virtual space, a person can view any process or object in detail without obstacles. For example, for medical students through the application Anatomyuo [41] (3D application that teaches human anatomy for minimally invasive procedures, a person can study the structure of the body in the smallest detail), and for students of natural sciences it is advisable to offer the application Operation Apex [42] which can demonstrate with the help of the adventure game all the riches of the underwater world.

It is worth noting that the demand for exciting and interactive experiences continues to grow not only in the sphere of education but also in other areas.

- *Concentration and effectiveness.* Concentration is focusing on educational material. In the virtual environment, students are not distracted by external irritants.
- *Effectiveness.* Students who have used virtual reality technologies to study the learning material show better learning outcomes. Thus, Wu et al. [43] during an experimental study confirmed the effectiveness of the use of virtual technologies to improve student learning outcomes. Scientists conclude that immersive learning technologies can improve both students' knowledge and develop practical skills by supporting the effect of "real-time learning" [43].
- *Maximum involvement.* Immersive technologies provide the ability to fully control and change the scenario of events. Students at history faculties can witness historical events, students at physics and chemistry faculties can conduct their own physics or chemistry experiments, and math students can solve a problem in a playful and understandable form. Art students can attend a virtual tour, exhibition or concert.
  However, it should be noted that research and teaching staff are increasingly choosing the means of immersive learning technologies due to the potential pedagogical benefits. Immersive technologies, when used correctly and strategically, can provide a basis for increasing student engagement, immersion, interaction, enjoyment, and thorough deeper learning process. However, due to the development of understanding of the potential of immersive technologies teachers should begin to develop the quality content of education, rather than using technology as a fashion trend or end in itself [44].
- *Security.* With the help of immersive technologies a person can work as a lifeguard in a fire, for architects, engineers for computer simulation of any complex project, to conduct a complex operation, control military equipment, space shuttle, to conduct an experiment with hazardous chemicals without harming oneself or environment.
- *Reducing the financial costs* of training tools in training specialists, because software or virtual training tools are cheaper than real machines and equipment used in training the future professionals (using a smartphone or tablet a person can get a virtual endoscope, tomograph, model airplane, tank etc. [23, 45].

Immersive technologies play the important role in educating students with special educational needs. After all, with the help of immersive technologies, one can create an inclusive learning environment, taking into account the needs and capabilities of each. This can be one of the important steps in democratizing knowledge.

By studying the experience of using immersive technologies in the world's leading universities, we can determine how they can affect the results of training of the future professionals – for example, reduced cognitive knowledge, brain load, allowing to gain real experience through the visualization of complex ideas and structures. This not only dramatically increases the involvement of students, but also allows students to absorb complex information more effectively and retain it longer. Perhaps most importantly is the fact that this is achieved in the holistic context that significantly increases the transfer rate (i.e. the ability to successfully adapt and apply what is learned in different real-life scenarios) [25, p. 2].

At the same time, with all the positive aspects of their use in the educational space of higher education institutions, their capabilities should not be overestimated. After all, immersive learning technologies cannot completely replace a highly qualified teacher in the educational institution. For example, a team of scientists studying the problem of implementing immersive and interactive educational technologies (Education 5.0 and Industry 4.0) in Malaysian universities identified the following disadvantages of their use: insufficient logistical infrastructure and high financial costs for the development of the content [16].

Today, scientists often note a negative trend, when the use of information technology has priority over the traditional educational process, i.e. educational decisions are implemented without proper consideration and study of the pedagogical context in which they will be applied. This can be seen in education in particular, where success is invariably associated with the effective interaction of the student with the teacher and building feedback with the student, which gives priority to the learning outcome.

4. Discussion

We studied the problems of implementation of immersive technologies in higher education institutions of Ukraine. In order to determine the level of awareness of students and research-teaching staff of Ukrainian educational institutions with the use of immersive learning technologies, we conducted anonymous survey at Lviv Ivan Franko National University, Volodymyr Hnatiuk Ternopil National Pedagogical University, Khmelnytskyi Humanitarian-Pedagogical Academy. Teachers and students (a total of 112 people) were asked a number of questions. The list of questions and answers are given in table 1.

Let us analyze the answers of respondents. To the question: "Do you use virtual or augmented reality technologies in your classes?" 75 respondents said they had never used it, 37 respondents said they had used augmented reality technology and only 2 said they had "written augmented reality software".

To the question "Do you know that today a person can plunge into virtual reality even with a regular smartphone?" 102 people said yes, but there was also the answer: "And yesterday a person could plunge into virtual reality with the help of an ordinary book".

To the question "Do you know which virtual or augmented reality technologies are supported in other higher education institutions?" only 30 respondents answered yes and only 1 respondent stated that such technologies are used in Tech StartUp School of Lviv Polytechnic.

During the survey, 64 respondents (all students) answered that they like to use a smartphone, tablet, augmented reality glasses for games. However, only 56 respondents answered that they visited museum exhibitions, art galleries, and virtual reality concerts, as there were no other options in 2020.

It is interesting that 108 respondents who took part in the survey said that they actively use computers, tablets, smartphones and other gadgets, which improve the quality of education, while 6 people stated that they do not use any technical teaching aids during their classes.

Based on the analysis of the answers to the question "Are you familiar with the term "immersive technology"? What do you think it is?" we concluded that the essence of this word is clear to 100 % of teachers, but a small percentage of students. However, in individual conversations

Table 1
The results of a survey of teachers and students.

Question	The number of positive responses / % of the total quantity	The number of negative responses / % of the total quantity	Note
1. Are you familiar with the term "immersive technology"? What do you think it is?	35 / 48.2 %	54 / 47.4 %	5 / 4.4 % answered inaccurately, incompletely
2. Do you use virtual or augmented reality technologies in your classes?	37 / 32.4 %	75 / 65.8 %	2 / 1.8 % respondents answered that they wrote software for AR
3. Do you know which virtual or augmented reality technologies are supported in other higher education institutions?	30 / 26.3 %	84 / 73.3 %	
4. How do you use computers, tablets, smartphones and other gadgets in your classes?	108 / 94.7 %	6 / 5.3 %	All interviewed teachers answered that they actively use gadgets for distance learning
5. In your opinion, is it possible to safely gain practical experience with the help of virtual and augmented reality technologies?	92 / 80.7 %	18 / 15.8 %	4 / 3.5 % of the respondents found it difficult to answer, 2 answered "maybe"
6. Do you know that today a person can plunge into virtual reality even with a regular smartphone?	102 / 89.5 %	12 / 10.5 %	
7. Have you visited museum exhibitions, an art gallery, a concert in virtual reality?	56 / 49.1 %	58 / 50.9 %	
8. Have you used a smartphone, tablet, augmented reality glasses for games?	64 / 56.1 %	50 / 43.9 %	

we found that teachers and students are interested in learning more about the features of the use of immersive technologies and there is a need for a deeper critical analysis of the use of immersive technologies in the educational process of higher education on the example of other universities.

Thus, having analyzed the answers, in particular a large number of negative answers to the first, second, third and sixth questions, we consider a promising area of improving the educational process of Ukrainian universities, studying world experience of using immersive learning technologies for their implementation in the future, creating opportunities for digital learning.

During the research in order to determine the level of awareness of students and research-teaching staff of national educational institutions on the use of immersive learning technologies,

we conducted the anonymous survey at Lviv Ivan Franko National University, Volodymyr Hnatiuk Ternopil National Pedagogical University, Khmelnytskyi Humanitarian-Pedagogical Academy. After analyzing the answers of research-teaching staff and students, we came to the conclusion that today a promising area for improving the educational process in Ukrainian universities is to study world experience in the use of immersive learning technologies for their implementation in the future.

5. Conclusions and future work

Our study of the use of immersive technologies in university education has revealed their application in training future archaeologists, architects, engineers, pilots, rescuers, and physicians. We also found that immersive technologies play an important role in creating inclusive learning environments for students with special educational needs.

Our analysis of global experiences with immersive technologies in university education has uncovered their use in unexpected ways, including distance learning, empathy training for social issues such as homelessness, and environmental education on topics such as ocean oxidation and coral reefs.

We conclude that immersive technologies are used not only for professional training but also for gaining social and emotional experiences and raising awareness of environmental issues. However, our research does not cover all aspects of the use of immersive learning technologies in university education. Further research is needed to explore this promising area and to facilitate the adoption of immersive technologies in higher education institutions worldwide, taking into account positive global experiences.

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Designing a cloud-oriented methodological system for training science and mathematics teachers in scientific lyceums

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Abstract

This paper presents an analysis of the results of a pedagogical experiment on designing a cloud-oriented methodological system for training teachers of natural and mathematical subjects to work in a scientific lyceum. Our review of recent research reveals that while the problem of reforming teacher training has been well studied, there is currently no cloud-based system specifically designed to prepare science and mathematics teachers to work in a scientific lyceum. Our survey of teachers' use of open science services, readiness to conduct research, and awareness of the functions and requirements of scientific lyceums indicates a need for such a system. We conclude that further development and implementation of a cloud-based methodological system that supports the integration of open science systems and services into teacher training and education is necessary.

Keywords

cloud-oriented methodological system, teacher training, natural and mathematical subjects, scientific lyceum, open science services

1. Introduction

In today's rapidly evolving technological landscape, science and mathematics teachers are expected to possess not only subject mastery but also the ability to effectively teach and engage students using modern tools and techniques [1, 2]. This requires a commitment to lifelong learning and a willingness to embrace new information technologies to enhance the delivery of educational content [3, 4].

In 2020, the COVID-19 pandemic necessitated the widespread adoption of distance learning technologies in Ukraine, as mandated by the Cabinet of Ministers of Ukraine and the Ministry of Education and Science of Ukraine. This highlighted the need for teachers to be prepared to organize and implement effective distance learning for their students [5, 6, 7].

The use of cloud services in education offers numerous advantages, including resource savings, collaborative online work, flexible access from any device or location, and the ability to organize distance learning [8, 9, 10, 11, 12]. However, the integration of cloud-based open

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science systems into teacher training remains an underexplored area that warrants further investigation.

1.1. Literature overview

The system of forms of teacher training in accordance with the requirements of the New Ukrainian School were described by Marchenko [13]. It was identified that the basis of modern teachers' training courses is the development of creativity, creativity, professional abilities and skills. The cloud technologies are briefly reviewed as a means to be familiar with certain topics of the subject area and perform individual practical tasks.

Krutova [14] studied the problem of using information and communication technologies in the system of professional development of teachers. Krutova [14], in particular, provides a list of Ukrainian and foreign platforms (distance learning courses) for teacher training.

Yevtushenko [15] identified the goals and objectives of advanced training of teachers of natural sciences and mathematics in terms of reforming education in Ukraine. In another study Yevtushenko [16] examines the problem of teachers' information culture, which he considers as the ability to perceive and learn something new.

Shyshkina [17], studied the problem of designing a cloud-based educational and scientific environment of higher education. The main problem outlined by Shyshkina [17] are: the considering of methodological principles of creation and development of educational and scientific environment of higher education institution based on cloud technologies, determination of criteria for its formation and evaluation.

The research by Lytvynova [18] is devoted to the cloud-based learning environments as a tool for solving problems related to the learning mobility of all participants in the learning process. Vakaliuk [19] defines the meaning of the concept of "cloud-based learning environment for bachelors of computer science" and provides a description of the structural model of cloud-based learning environment for bachelors of computer science.

Kuzminska [20] researched theoretical and methodical bases of designing and application of digital educational environment of scientific communication of masters-researchers.

Mayer [21] studied the problems of open science, e.g, the terminological apparatus and areas of use of open science.

Marilyn and Edrick [22] considered using the Science-Forums.net platform for scientific collaboration.

Researchers have considered the problem of teachers' training in accordance with the basic provisions of the New Ukrainian School Conception and put forward the idea that the program of teachers' training courses should include the study of cloud technologies. However, this is not a comprehensive study for the further use of the system of cloud services that will help teachers in preparing for work in the scientific lyceum. There are also some studies on the use of ICT in the educational process, the features of ICT and their shortcomings. However, the problem is very widely disclosed, it is not specified and is not focused on a specific target group. Also, some studies have considered the issue of updating advanced training courses for teachers of natural sciences and mathematics in connection with the reform of education in Ukraine.

Scientists have sufficiently considered various models of organization of the educational process using information and communication technologies (ICT). In addition, scientists have

developed models of cloud-based environment, in particular for the training of relevant profiles. However, the problem of designing a cloud-oriented methodological system for preparing teachers of science and mathematics to work in a scientific lyceum remains insufficiently studied.

The current state of preparation of teachers of natural sciences and mathematics for work in the scientific lyceum requires additional research and analysis. In particular, the skills of the use of the relevant ICT tools or cloud services at each stage of research should be considered. These prerequisites caused the need to launch a scientific and pedagogical experiment "Designing a cloud-oriented methodological system for training teachers of science and mathematics to work in a scientific lyceum" in 2019.

1.2. Research objective

The main objective of this research is to analyze and interpret the results of the ascertaining stage of a pedagogical experiment on designing a cloud-oriented methodological system for training teachers of natural and mathematical subjects to work in a scientific lyceum. The goal is to assess the readiness of Ukrainian teachers to use cloud-based open science systems in their educational practice. This will provide valuable insights into the current state of teacher training and the potential for integrating cloud-based technologies into the educational process.

2. Method

In a previous study [23] outlines the term "adaptive cloud-based system of open science": "it is a cloud-based system (based on a cloud platform), which in its parameters can be automatically adjusted by the goals and objectives of the scientific cooperation process, different individual features and educational and scientific needs of the participants of the virtual research team" [23]. Since this study is not about adaptability, we can say that the technology of cloud-based systems of open science means purposeful, specially organized sets of information processes using cloud-based systems that meet all the principles of open science.

The pedagogical experiment on "Designing a cloud-oriented methodological system for training teachers of natural sciences and mathematics to work in a scientific lyceum" was launched in 2019 as part of the planned research "Adaptive cloud-based system of training and professional development of teachers of general secondary education" (DR No. 0118U003161, 20182020), conducted at the Institute for Digitalisation of Education of the National Academy of Educational Sciences of Ukraine. Research work is carried out on the basis of 6 institutions of higher education of Kherson State University, Kryvyi Rih State Pedagogical University, Ternopil Volodymyr Hnatiuk National Pedagogical University, Rivne Regional Institute of Postgraduate Pedagogical Education, Bogdan Khmelnitsky Melitopol State Pedagogical University and Zhytomyr Polytechnic State University. Experimental work on the design and use of a cloud-based system of traing and professional development of teachers of scientific lyceums is planned as a natural, cross-pedagogical experiment, which consists of the following stages: preparatory and research. Thus, the research stage is divided into: ascertaining, forming and control.

The *purpose* of the experiment is to design and verify experimentally the cloud-based methodological system of training teachers of natural sciences and mathematics to work in a scientific

lyceum.

The use of cloud technologies and cloud services in the educational process is a promising trend of modern Ukrainian and foreign research. The methodological principles of the cloud-based learning and research environment design are well investigated by the Ukrainian scientiests in the recent years [19, 18, 17]. At the same time, the cloud services are purposfully used both the educational process of institutions of higher education and general secondary education institutions. Cloud-oriented learning environments have some advantages for educational institutions in the organization of the educational process and the use of learning technologies.

The cloud-based system can provide services such as remote access to learning tools for higher education institutions to save on local and public funding in a cost-effective way. Students can access classes on a laptop, tablet, or phone from anywhere and use them freely. At the same time, the student can ask and answer questions and share what has been learned to help others. Access to analysis and user data means that such a system can be adapted to ensure maximum efficiency for both users and the education system. But most importantly, it helps young people access to access to learning anywhere, anytime, from any experienced teacher.

It turns out that most teachers of pedagogical schools are familiar with cloud services and express their intention to use cloud-based systems in the educational process. It was found that teachers who use a particular cloud service in the learning process fully involve all its possible tools. However, due to the lack of methodological developments, the use of cloud-oriented systems calls into question the effectiveness of their pedagogical use.

The purpose of the *ascertaining stage* of the pedagogical experiment is: to find out the current state of use of services by teachers of natural and mathematical subjects during the preparation of educational materials; to find out the readiness of teachers to perform personally and teach students to conduct research; to determine the state of awareness of teachers about the functions and requirements in scientific lyceums.

At the ascertaining stage, the experimental work was conducted in cooperation with Rivne Regional Institute of Postgraduate Pedagogical Education (2019) and Zhytomyr Polytechnic State University (2020). The following methods were used: questionnaires, interviews and observations. At the stage when the experimental sites were identified, two questionnaires were developed for each institution separately. The primary quantitative analysis of the experimental data is provided and the obtained results are summarized by means of distribution diagrams, tables and their interpretation is fulfilled. The quantitative analysis is to describe the current state of this problem. The reliability of the results is confirmed by the involvement of teachers from all regions of Ukraine.

3. Results

3.1. Rivne Regional Institute of Postgraduate Pedagogical Education

The questionnaire, developed for students of two groups of mathematics teachers of Rivne Regional Institute of Postgraduate Pedagogical Education, consisted of 13 closed questions (2 dichotomous and 11 alternative multivariate) and one open, short. At the beginning of the questionnaire, the respondent indicates in which city he / she works (teachers were from

different cities of Rivne region, in order to determine the territorial distribution) and his / her educational institution. The next point is to indicate which subjects the respondent reads, because at school a mathematics teacher can additionally teach other subjects. Thus, out of 45 respondents, not only mathematics teachers, but also 2 methodologists and 4 teachers were among the respondents. The aim was to find out the knowledge of mathematics teachers about the basic provisions and conditions of work in the scientific lyceum, how much teachers are interested in conducting research (one of the main requirements of work in the scientific lyceum) and involving students in research.

One of the key questions was to determine whether respondents understand how important is it for a science high school teacher to ne engaged into research, as this is a basic requirement. It was found that the majority of teachers (43 respondents out of 45 respondents, which is 96%) believe that a teacher of a science lyceum should be engaged in scientific activities. At the same time, teachers who took part in the survey, in particular, submit articles to professional publications in Ukraine only for certification – 34 respondents (76%).

Only 10 teachers (22%) submit an article to a professional publication at least once a year. This is evidence that teachers are reluctant to publish their own research or do not have enough time to do so. Another possible reason is that teachers underestimate the necessary to be engaged in scientific research. These reasons were established during the interviews and clarification of certain issues related to the survey.

In the content of the cloud-oriented methodological system of training teachers of natural and mathematical subjects to work in the scientific lyceum there is a need to use English-language resources and services (specialized and general purpose). Therefore, the goal was to determine whether teachers were able to use English-language resources (not necessarily cloud-based). However, the results were not comforting enough: 35 respondents (78%) do not use any English-language resources or services. This is the evidence that in order to test and further implement a cloud-based methodological system of training teachers of science and mathematics to work in the scientific lyceum should develop detailed organizational instructions using certain tools and services (including English).

If the teacher uses only printed resources in English, some research may be needed to determine the level of skills in using cloud services. During the interview, it was found that teachers want to work with English-language services, however, they first need to master the skills of working with an online translator or installing plug-ins and applications to speed up the work and make it more comfortable. Such preparatory moments will not distract from the learning process and save time and effort (the teacher does not need to translate each menu or button with a printed dictionary, because, unfortunately, there are such situations). In order to find out the skills and abilities of conducting research work, the respondents answered the following questions: research of the state of the scientific problem, participation in scientific activity and implementation of the obtained research results.

A rather interesting result was that respondents are familiar with open science services (21 people, which is 47%). 22 respondents (49%) answered that they rely on their own experience to formulate and study the state of a scientific problem, but this is not enough, because in this case the scientific problem will not be fully investigated. Questionnaire answer options were designed to cover every aspect of the problem and to consider as many possible life options as possible.

The most common ways for teachers to participate in scientific activities were: participation in conferences (24 respondents, 53%) and individual scientific activities (21 respondents, 47%). Perhaps this will be enough for the secondary school (at least participation in conferences), however, if a teacher plans to work in a scientific lyceum, then cooperation with higher education institutions and project activities will play a significant role. Individual scientific activity, without combination with other ways of participation in scientific activity, will generally give a rather weak result, because in this case there are no discussions, exchange of experience and constructive criticism (discussion of existing methods, establishing new connections).

Among the ways of implementation and use of the obtained research results the most common are: publication of methodical materials (selected by 22 respondents, 49%) and self-implementation (selected by 19 respondents, 42%).

At the same time, self-implementation is not a very effective way, because one teacher will not be able to cover a geographically large enough number of participants. Therefore, this implementation will be local and available only to a narrow circle of participants (especially if the teacher does not sufficiently publish the results of their work, showing previous survey results).

3.2. Zhytomyr Polytechnic State University

The questionnaire "Skills of working with cloud services", developed for four groups of students of the distance course of educators on the basis of Zhytomyr Polytechnic State University, consisted of 13 closed questions (3 dichotomous and 10 alternative multivariate) and one open, short. Some questions of the questionnaire are duplicated with those that were in the questionnaire for mathematics teachers of Rivne Regional Institute of Postgraduate Pedagogical Education. As in the previous survey, the respondent indicates in which city he works (educators from all regions of Ukraine took part in the survey) and his educational institution. Mandatory field to fill in – it is necessary to indicate which subjects the respondent reads (it was necessary to cover not only mathematics teachers, as the target group is teachers of natural sciences and mathematics). Thus, among the 824 respondents surveyed were teachers of computer science, mathematics, Ukrainian language and literature, English, history, biology, physics, foreign literature, geography, chemistry.

If you analyze the questions that are present in both questionnaires, you can trace certain patterns. The majority of respondents (789 people) believe that a teacher of a scientific lyceum should be engaged in scientific activity (95.8%). If we evaluate the use of English-language resources (services) by teachers, we can say that 66.9% (551 respondents) do not use, 31.8% (262 respondents) use such resources and 1.3% (11 people) use only printed English resources.

One of the main issues during the ascertaining stage of the pedagogical experiment is to determine the most common services among teachers that they use in preparation for the lesson. This issue is extremely important, because for the further implementation of a cloud-based methodological system, you need to have at least basic knowledge for the use of cloud services and their principles of operation. As can be seen from the results of the survey, only 548 respondents use cloud services in preparation for the lesson (66.5%). 574 (69.7%) – still used a local ICT tools. That is, teachers can not even assess the benefits of cloud services and their use in organizing group work of students.

The next stage of research was to assess the skills and abilities of teachers to use individual resources and services at different stages of research. After all, if the teacher has sufficient skills to work with services, he will later be able to teach this and his students by offering them as an alternative, such as spreadsheets. What resources are used by teachers to search for scientific (educational and methodological) literature are shown in Fig. 1. Among the answer options, the most common services were chosen, those that are available to teachers. Also, the list included open science services, as they can act as separate components of the cloud-oriented methodological system of training teachers of natural sciences and mathematics to work in the scientific lyceum.

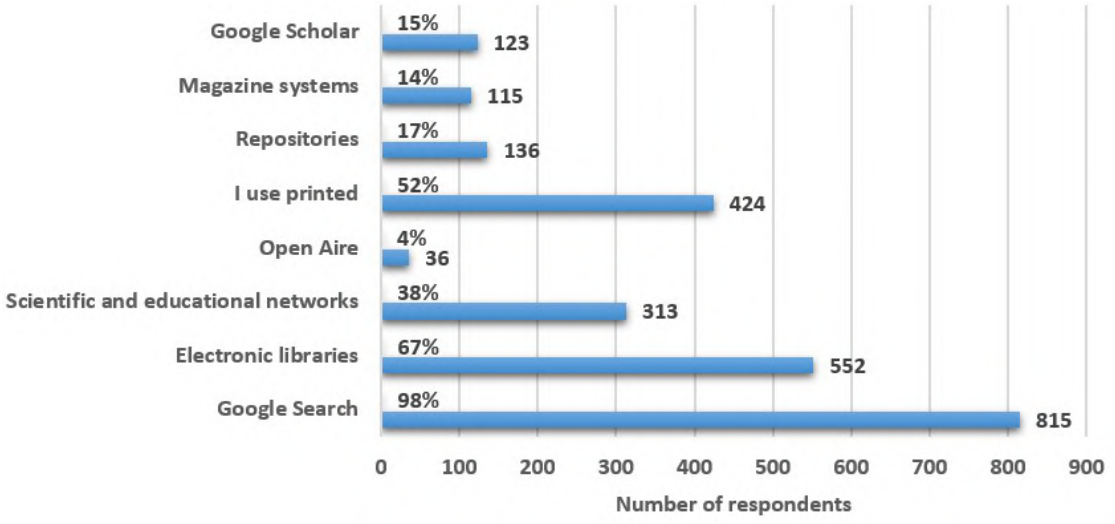

Figure 1: Teachers use services to search for literature.

As can be seen from the chart, 98.9% of respondents (815 respondents) use Google search. Almost half of the respondents (424 people, which is 51.5%) use printed materials to find the right material. At the same time, repositories (16.5%), journal systems (14%) and Google Scholar (14.9%) remain almost unnoticed. It is clear that a rather small number of teachers use open science services (4.4%), as a quarter (only 26.8%) of respondents are familiar with the concept of open science. This is 221 respondents (26.8%) out of 824.

Even fewer respondents know about the European Open Science Cloud – 191 (out of 824 respondents), which is 23.2%. These questions were necessary to clarify the state of awareness of teachers with the latest scientific trends. After all, the use of individual components of the European Open Science Cloud can be quite useful for preparing teachers to work in a scientific lyceum. In addition, the European Open Science Cloud contains about 220 cloud services that teachers can successfully use in the learning process (the main advantage is free and open access). But this is possible only with the appropriate techniques.

Teachers of scientific lyceums must not only bring the scientific component into the educational process, but also be able to organize each stage of research work of students using modern ICT tools. Apparently, one of the leading services can be considered cloud services, because they are focused on the use of anywhere and anytime (on any device) and do not restrict students

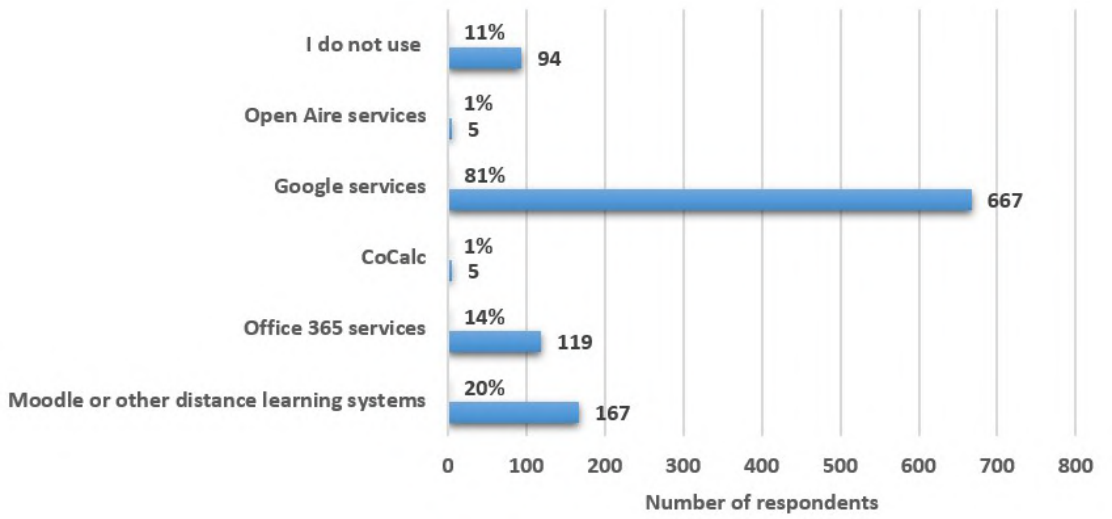

Figure 2: The use of services by teachers to organize the joint work of students.

to use only sufficiently powerful devices (do not depend on the technical characteristics of a device). Therefore, the use of teachers of a service to organize the joint work of students was studied (figure 2). As can be seen from the chart, Google services are the most popular among teachers, they were chosen by 667 respondents (80.9%). Only 20.3% of respondents (167 people) use a system of distance learning courses such as Moodle to organize joint work of students in the classroom. It is unfortunate that 94 respondents (out of 824 respondents, 11.4%) do not use any services to organize group work of students.

The analysis of the answers (figure 2) shows a low level of use by teachers of distance learning systems, specialized cloud services and some tools of the European Open Science Cloud (0.6%). This indicates that there are some problems in preparing teachers of science and mathematics to work in the scientific lyceum, because this situation makes it impossible to fully organize the educational process using modern cloud services, ICT tools at a high, scientific level.

4. Conclusions

Our analysis of the results of the ascertaining stage of a pedagogical experiment on designing a cloud-oriented methodological system for training science and mathematics teachers to work in a scientific lyceum reveals a significant gap in teacher preparedness. While most participants in the experiment recognize the importance of scientific activity for teachers in a scientific lyceum, they are not adequately prepared to engage in such work.

Our observations and interviews indicate that teachers generally do not consider scientific engagement to be necessary, nor do they encourage their students to pursue it. Teachers primarily view conference participation and individual scientific activities as the main avenues for engaging in scientific work, while methodological materials and self-implementation are seen as promising ways to apply and disseminate research findings.

In terms of their use of technology, teachers primarily rely on localized resources and services, limiting their ability to fully leverage the potential of cloud-based open science services. Only a quarter of respondents are familiar with the concept of open science and the European Open Science Cloud.

As a next step, we plan to experimentally implement our cloud-based methodological system for training science and mathematics teachers at Kherson State University, Zhytomyr Polytechnic State University, and Kryvyi Rih State Pedagogical University. The final stage of our research will involve statistical analysis of the results of the formative stage of the pedagogical experiment.

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Serverless computing for data processing in open learning and research environments

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Abstract

Serverless computing is a paradigm that enables the execution of code without provisioning or managing servers. It offers benefits such as scalability, cost-efficiency, and ease of development for cloud-based applications. In this paper, we explore the potential of serverless computing for supporting data processing in open learning and research environments. We propose a concept of a hybrid serverless cloud, which combines different types of cloud services to provide access to various tools and resources for learners and researchers. We present a case study of wave files processing using a lambda function, which demonstrates the feasibility and effectiveness of our approach. We also discuss the challenges and opportunities of integrating serverless components within open systems of learning and research. Finally, we present a vision of a cloud-based open learning and research university environment that leverages serverless technologies to enhance the quality and accessibility of education and research.

Keywords

serverless computing, cloud computing, data processing, open learning, open research

1. Introduction

Cloud-based learning and research environments are emerging as a key paradigm for modernizing the educational process in higher education and fostering open science within the European Research Area [1, 2, 3]. Cloud technologies enable the creation of more convenient, flexible, and scalable systems for accessing electronic resources and services in learning and research activities, as well as facilitating collaboration, mobility, and overcoming geographical and temporal barriers [4, 5, 6, 7, 8, 9, 10]. This provides a basis for implementing the principles and technologies of open science for a wider range of users, such as creating and operating virtual research teams, improving scientific communication processes, accessing and sharing data in the research process, disseminating research results, and engaging with society [11]. Cloud computing tools and services form an information technology platform for the modern educational and scientific environment, becoming a network tool for shaping this environment

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[12]. Therefore, it is important to analyze the trends and challenges of integrating cloud data processing services into the activities of researchers and educational or research institutions.

2. The research results

2.1. The background issues

Cloud computing offers various models, such as IaaS, PaaS and SaaS, that can facilitate learning and research data processing. By abstracting resources and providing simple automation tools, modern cloud platforms simplify many routine tasks, such as installation, maintenance, backup, security, and more [5, 13]. Moreover, in the context of open science, open data and big data processing are essential. To meet the requirements of open science systems design, large amounts of data need to be available and accessible for joint processing by the community of scientists [5]. Therefore, cloud computing platforms can serve as a reasonable framework to support open learning and research processes, both in terms of managing and processing large amounts of data and making them available for collaborative use [5].

The computing capacity is crucial for processing and retrieving large amounts of data, which are needed at most stages of the research process, such as data collection, representation, visualization, analysis, interpretation and discussion. A possible way to save resources and provide flexible use of the cloud-based infrastructure is to use lambda functions within the serverless settings. This leads to the notion of Function-As-A-Service (FAAS) as a promising cloud-based model [14, 12, 15, 16].

The applications and evaluation of serverless computing in different areas are among the current issues considered nowadays, for example for machine learning [17], network functions virtualization [18], geospatial architectures [19]. Casale et al. [20] propose a platform for decomposition and orchestration for serverless computing. Ortiz [21] present architecting serverless microservices on the cloud with AWS and also issues of instructors training to use these technologies. However, the area of educational application of serverless technologies to provide better use and implementation for learning and research within the university sector is poorly investigated and needs further research. There is a need to consider methodological issues and possible ways of serverless technology application within the open learning and research university environment.

The article aims to consider and evaluate a hybrid cloud-based serverless architecture as a possible open learning and research platform to support data processing and research collaboration. The main idea is that design and development of learning and research environment due to the proposed approach will result in more efficient use of the cloud-based resources, better access to learning and research data and collaboration support. The case study of the sound signal processing as a possible example of serverless approach application for learning and research is considered.

2.2. The conceptual basis

The paper introduces the main concepts and terms related to the design and development of university cloud-based learning and research environment (LRE), based on the principles of

open science, open education, and cloud-oriented systems, as proposed by Bykov and Shyshkina [4].

The LRE of a higher education institution is defined as an environment that leverages the virtualized computer-technological infrastructure (corporate or hybrid-based) to support the content-technological and information-communication functions of learning and research activities [4].

Serverless technologies are adopted to build applications that require dynamic and unpredictable computing resources. The serverless hybrid cloud architecture enables the deployment of lambda-functions [22], which are cloud-based services that execute computing tasks on demand within the cloud-based infrastructure of a provider, without requiring the user to create and manage the server architecture.

2.3. The model and approach

Figure 1 illustrates the configuration of the serverless application architecture.

The proposed approach is to access lambda-functions through API Gateway, avoiding server management as lambda-functions return the values in static HTML format, which are stored and retrieved on S3-bucket, and can be further processed.

This approach allows the user to access specific electronic resources and computing capacities hosted on a hybrid serverless architecture from any device with an Internet connection.

The advantage of this approach is that it provides flexibility and scalability for learning or research processes that need computing resources for special purposes that may arise occasionally. For example, in the course of an experimental research, big data processing may be needed that require high computing power for a short time. It may be inefficient to maintain and manage a cloud server for these purposes. However, by using lambda-functions, the learner or researcher can access a server with powerful processing capabilities without deploying it every time as the function is needed. The necessary resources can be supplied more efficiently on demand.

2.4. Current developments and implementation

The cloud-based LRE was implemented at the Institute for Digitalisation of Education of the NAES of Ukraine as part of the research projects and pedagogical experiments conducted from 2012 to 2017. During this period, various cloud-based services were integrated into the research and educational process to support open education and open science [4].

In 2018, the V4+ Academic Research Consortium Integrating Databases, Robotics and Language Technologies was established, which aimed to address regional issues related to EU ICT research priorities. The consortium used the following cloud-based components for collaborative work:

- The BOX Cloud shared work-space – a cloud storage and transfer service that connected the researchers' computers and allowed them to share documents.
- The virtual machine with Windows 10 – a remote desktop that provided a common computing environment for the partners [5].

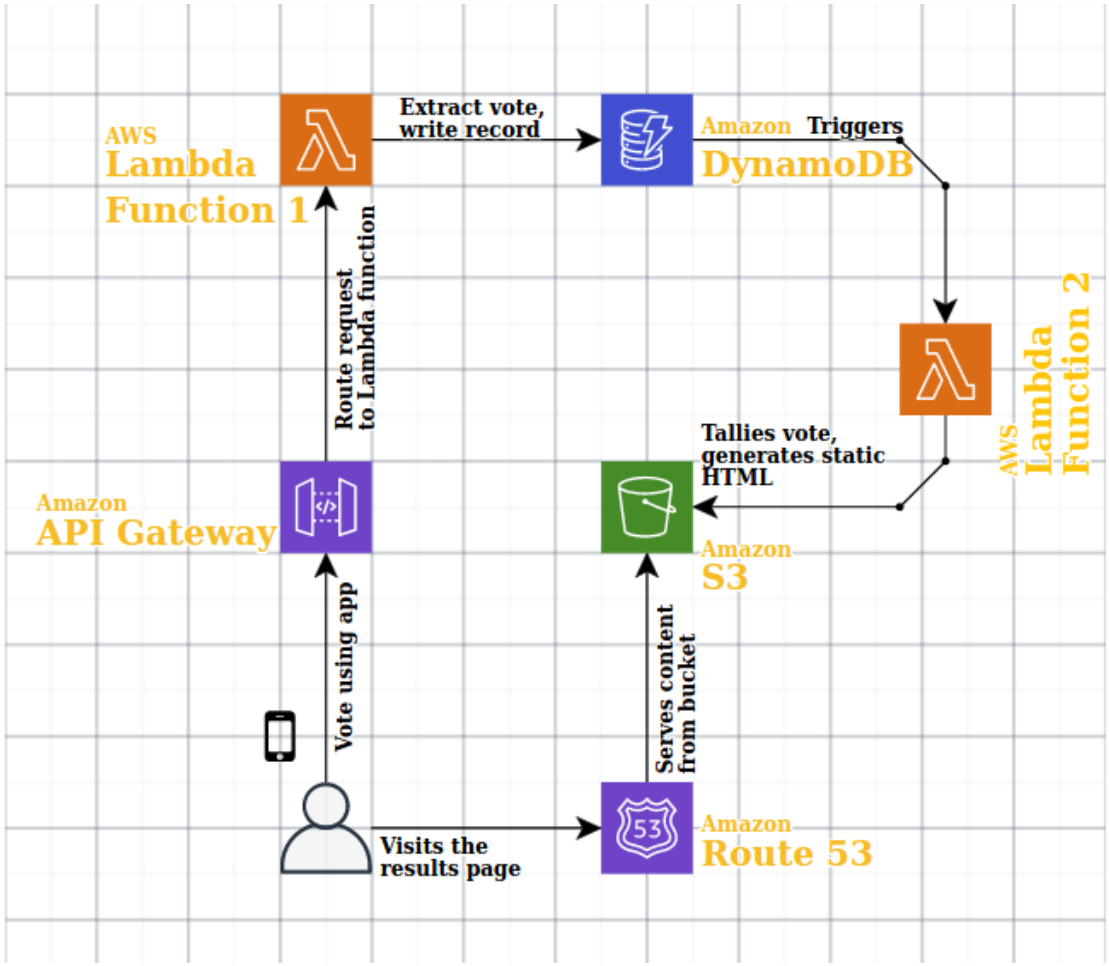

Figure 1: The serverless application architecture (retrieved from https://app.cloudcraft.co/) .

The cloud-based components that were developed and tested during this period were also applied in the learning process. The course "Cloud Computing Technologies'' was designed and introduced in National University of Life and Environmental Sciences of Ukraine for training computer science bachelors. The students learned how to build cloud-based components on virtual machines using AWS and Azure platforms. The methodology of open learning and research platform implementation proved to be effective.

The next step of the research was the creation of the serverless hybrid cloud architecture to support collaborative research with Kyiv Glushkov Institute of Cybernetics of the NAS of Ukraine. The goal was to use lambda-functions for sound signal processing and analysis. Figure 2 shows an example of a sound signal oscillogram generated by a lambda-function.

The serverless environment was used for the following tasks:

1. A Python-based web application was created using the Flask framework and tested on localhost.

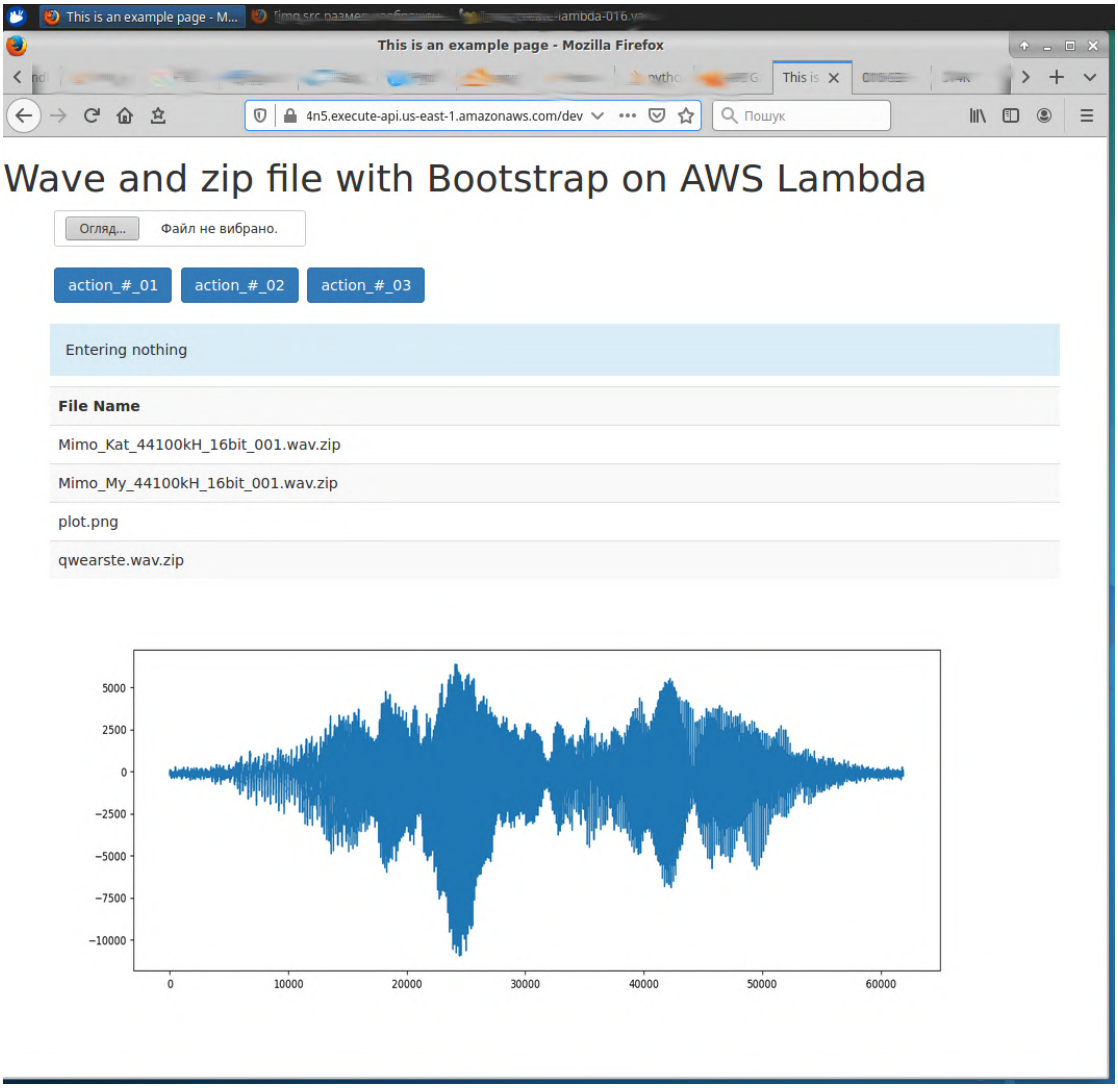

Figure 2: The result of the lambda-function processing the wave file.

2. A user account with necessary permissions was created in the AWS console to secure future applications. An S3 bucket and an EC2 server were also created in the AWS console. The working folder with the Python script (or another compatible language for AWS Lambda) was uploaded to S3.
3. To enable the processing, one or more layers with the required libraries were attached to the lambda-function. The libraries were installed in a virtual environment on the EC2 server. An additional layer was created from this environment. AWS Lambda also provides some freely distributable layers that can be used in future applications.
4. A YAML file was created using CloudFormation tool to specify the available resources for the application. The YAML file created a separate role for working with the future

application.

4.1 Using this role, a lambda-function was created, and its code was downloaded from the zip file created in S3.

4.2 Using this role, an API Gateway was created to allow calling the lambda-function from a browser.

5. The application was debugged and tested.

Using this sequence of steps, a hybrid environment with lambda-function was created and tested for sound signal processing.

3. Conclusion

The paper has presented the rationale and the methodology for introducing cloud technologies in the educational and research process of higher education institutions, as well as the design and implementation of the learning and research environment based on these technologies. The paper has demonstrated how cloud technologies can enhance the access to electronic educational resources, improve the efficiency of ICT infrastructure, and support open education and open science principles. The paper has also proposed a novel approach for using serverless technologies to provide cloud services for data processing, visualization and retrieval, which is a relevant and promising area of development and modernization of the university open learning and research environment.

The paper has reported the experience of developing and applying various cloud-based components for educational and scientific purposes based on the proposed architecture of the hybrid cloud-based environment with lambda-functions. The paper has shown how lambda-functions can enable flexible and scalable computing resources for learning or research tasks that require dynamic and unpredictable computing power.

This approach still needs further implementation and evaluation in different contexts and domains. Future work will focus on expanding the functionality and usability of the cloud-based components, as well as assessing their impact on learning outcomes and research quality.

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Teaching computer game development with Unity engine: a case study

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Abstract

Computer game development is a popular and engaging topic that can motivate students to learn various aspects of software engineering, such as design, programming, testing, and teamwork. However, there is a lack of research on how to effectively teach this topic in the context of secondary education. In this paper, we present our experience of designing and delivering a course on computer game development for master's students in the specialty 014.09 Secondary education (Informatics) at the Kryvyi Rih State Pedagogical University. We describe the objectives, content, software tools, and teaching methods of the course, as well as the challenges and outcomes of its implementation. We also evaluate the course using a framework proposed by Ritzhaupt [1] based on student feedback and learning outcomes. Our results show that the course was successful in achieving its goals and enhancing students' knowledge and skills in game development. We also identify some areas for improvement and provide recommendations for future iterations of the course. We conclude that Unity Engine is a suitable platform for teaching game development in secondary education, as it offers a low barrier to entry, a rich set of features, a cross-platform compatibility, and a wide adoption in the game industry. We also argue that a team-based approach is beneficial for fostering collaboration and creativity among students.

Keywords

computer game development, software engineering education, Unity Engine, secondary education

The software industry is a dynamic and market-oriented industry that requires constant innovation and adaptation to changing customer needs and technological trends [2]. One of the most prominent and lucrative segments of this industry is the video game industry, which produces interactive entertainment products that appeal to a wide range of audiences and platforms [3, 4].

According to a report by Gamesindustry.biz and Newzoo, the global games market value reached $189.3 billion in 2022, surpassing the film and music industries combined (figure 1).

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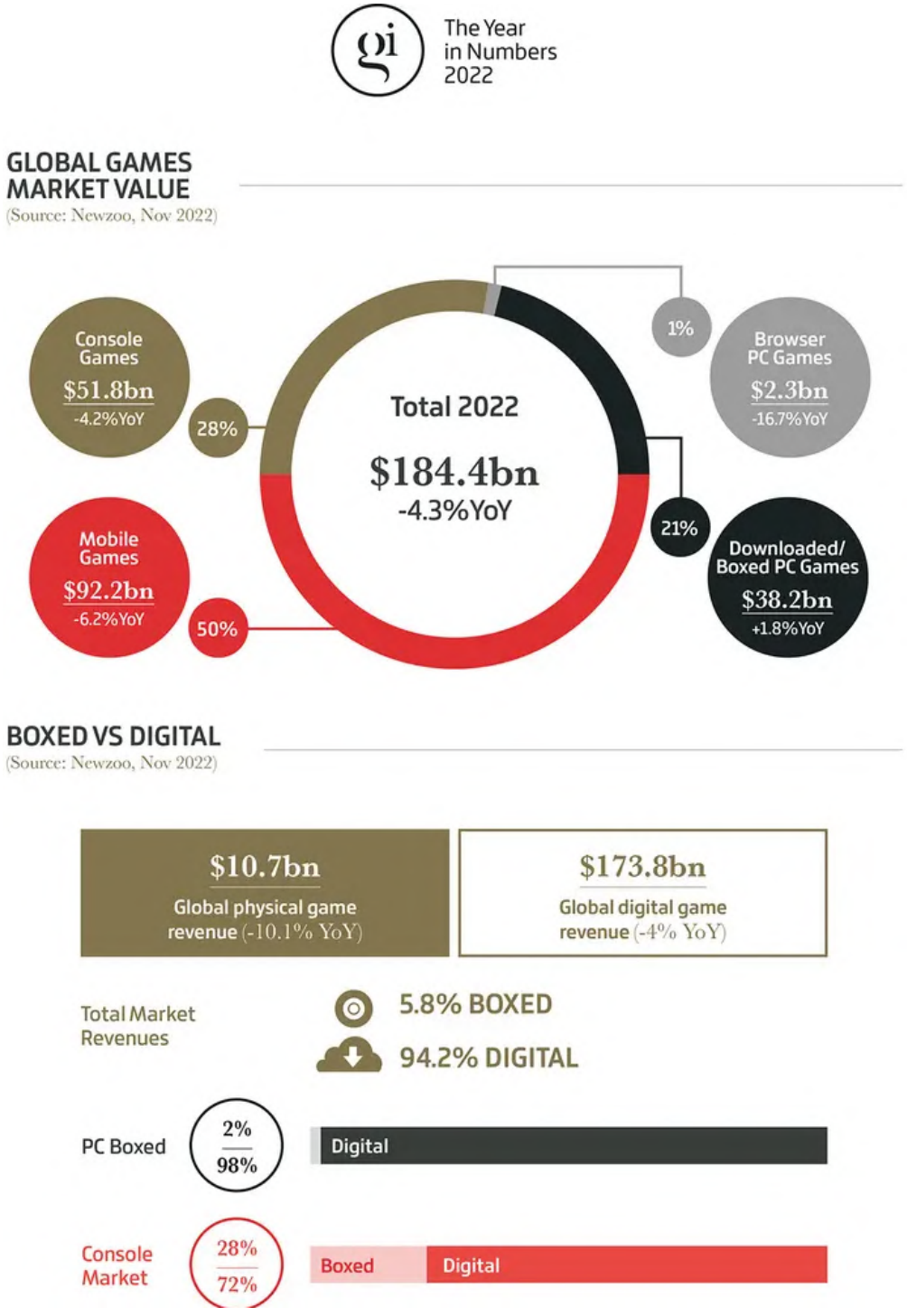

Figure 1: Global Games Market Value 2022 [5].

The report also projected that the games market will grow to $217.9 billion by 2025, driven by the increasing popularity of mobile, cloud, and streaming gaming [5].

Given the significance and potential of the video game industry, many educational institutions that train software engineers have incorporated game development as a part of their curriculum. The main motivations for teaching game development include enhancing the attractiveness and effectiveness of the curriculum [6, 7, 8, 9, 10], preparing graduates for the competitive and demanding game industry [11, 12], fostering teamwork and collaboration skills [13, 14], and developing project management and problem-solving abilities [6, 7].

However, teaching game development is not without challenges and difficulties. Some of the common barriers that hinder the integration of game development courses in higher education are the lack of interdisciplinary skills, time constraints, insufficient interest and expertise among teachers, and the perception that game development is not a serious academic topic [15, 16].

As teachers of Computer Science at the Kryvyi Rih State Pedagogical University, we believe that offering an elective course on computer game development for master's students in the specialty 014.09 Secondary Education (Informatics) is a valuable and rewarding opportunity to increase their motivation, engagement, and professional satisfaction.

The *purpose* of this paper is to share our experience and insights on designing and delivering a course on computer game development using the Unity Game Engine [17], which is one of the most widely used and powerful platforms for creating games across various genres and devices. The aim of this course is to introduce students to the principles and practices of game development using industry-standard software tools. We emphasize problem-solving, project planning, SDK work, and teamwork as essential skills for successful game development. We also view this course as a way to entertain and inspire students to pursue their passion and creativity.

The rest of this paper is organized as follows: Section 2 reviews the related work on teaching game development in higher education. Sections 3 and 4 describes the design and implementation of our course, including its objectives, content, software tools, and teaching methods. Section 5 discusses the challenges and lessons learned from our experience. Section 6 concludes the paper with some recommendations and future directions.

1. Background

The first task of the game development course was to select an approach. Defining the content, goals and objectives of game development is an important step, especially in the light of limited material and time resources.

A review of publications on the subject shows that the implementation of training programmes on game development is quite diverse. It varies from individual courses (Jones [18], Parberry et al. [19], Sweedyk and Keller [20]) and the inclusion of relevant sections in the traditional computer science program (Coleman et al. [21]) before the course sequence (Clark et al. [22], Fachada and Códices [23], Parberry et al. [24], Rocco and Yoder [25], Prokhorov et al. [26]). Content of individual courses from the use of engines developed for training (Gamemaker [7], RPG Maker [6], Alice [27]), development of own game engines (Labyrinth [28, 29], CAGE [30]), technical design [24], Flash [31] to a complete game development training course covering all aspects of

the game [18, 16].

The idea of developing a proprietary engine seems tempting at first, but, in experience, does not pay for itself by the time it takes, and eventually students will never see it again after the course [32]. The real game engine should simplify and speed up the development process and allow students to create interesting games in a short period of time. The problem of finding the most suitable game engine for this course is not very simple, and there are different opinions on this issue from the XNA Game Studio library to Unity and Unreal [32, 33, 34, 35, 36, 19, 37]. Dickson [32] offers to use the Unity game engine [17] to teach game development. Given its widespread use in the industry (de Macedo and Rodrigues [38], Toftedahl and Engström [39]) and even for teaching game development in the middle school [40], this seems logical.

There are also several important CS sections directly used in the development of computer games: the basics of physics, multimedia, network basics, computer graphics, and the basics of game artificial intelligence (Ahlquist and Novak [41], Millington [42], Yannakakis and Togelius [43]).

Game design usually refers to the design of the game and focuses on story, mechanics, character modelling, environment, process content generation, etc., which is enough material to take a whole semester without going into too much detail. There are many textbooks covering these broad topics, such as Adams [44], Ahlquist and Novak [41], Saulter [45], Bond [46]. These areas are compulsory for the course.

2. Selecting the software

Once the approach to the gaming course was defined, the next question we faced was what tools to use to create games.

More recently, developers have made widely available many powerful game engines and development environments that provide functionality for video game development. An overview of some of the best known is presented below.

Godot Engine [47, 48]

Cost and Licensing: Completely free and open source under the permissive MIT license.

System Requirements (minimum): Memory: 4 GB, Graphics Card: NVIDIA GeForce 6200, CPU: Intel Core 2 Duo E8400, OS: Windows 7.

Platforms: Linux, Windows, OS X, Wii, Nintendo 3DS, PlayStation 3, PS Vita, Android, iOS, BBX, web-games with asm.js, NativeClient.

Overview and Features: Godot Engine is a feature-packed, cross-platform game engine to create 2D and 3D games from a unified interface. It provides a comprehensive set of common tools, so users can focus on making games without having to reinvent the wheel. Games can be exported in one click to a number of platforms, including the major desktop platforms (Linux, macOS, Windows) as well as mobile (Android, iOS) and web-based (HTML5) platforms.

Unity Engine [17]

Cost and Licensing: Personal Free version (your project revenue or funding cannot exceed $100,000 a year), Unity Pro package $125 per month (includes an impressive amount of services not included in the free version).

System Requirements (minimum): Graphics Card: DX10, DX11, and DX12-capable GPUs,

CPU: X64 architecture with SSE2 instruction set support, Windows 7 (SP1+) and Windows 10, 64-bit versions only.

Platforms: Android, iOS, Windows Phone 8, BlackBerry, PS3, Xbox360, Wii U and web-browsers.

Overview: Unity is a cross-platform game engine. The engine can be used to create 2D/3D, virtual reality, and augmented reality games, as well as simulations and other experiences (Axon [49], Takahashi [50]). The engine has been adopted by industries outside video gaming, such as film, automotive, architecture, engineering and construction.

Features: Creating and Destroying GameObjects, Access the Components, Events for GameObject, Dealing with Vector Variables and Timing Variables, Physics Oriented Events, Coroutine and Return Types.

Unreal Engin [34]

Cost and Licensing: Free (5% royalty on gross revenue more than $1,000,000),

System Requirements (minimum): CPU: Quad-core Intel or AMD processor, 2.5 GHz or faster, Graphics Card: NVIDIA GeForce 470 GTX or AMD Radeon 6870 HD series card or higher, RAM: 8 GB Windows 7 64-bit or Mac OS X 10.9.2 or later.

Platforms: iOS, Android, Windows Phone 8, Xbox360, PS 3, PlayStation Vita, Wii U.

Overview and Features: Unreal Engine is a complete suite of development tools for anyone working with real-time technology. From design visualizations and cinematic experiences to high-quality games across PC, console, mobile, VR, and AR, Unreal Engine gives you everything you need to start, ship, grow, and stand out from the crowd.

XNA Game Studio [35, 36, 51]

Cost and Licensing: Free download from Microsoft site.

System Requirements (minimum): Graphics Card Shader Model 1.1 support, DirectX 9.0 support, Operating System: Windows Vista SP2, Windows 7 (All editions except Starter).

Platforms: Windows, Xbox 360, Zune.

Overview and Features: XNA Game Studio 2.0 – application framework, integrated development environment. Features: Game component models, New framework library designed to support Microsoft Windows, XBOX 360, and Zune game development, Integration with XNA Framework Content Pipeline.

From an analysis of the capabilities of the video game development tools described, it can be concluded that they are all quite powerful. The choice of a specific tool is determined by the characteristics of the project being developed. Their use for educational purposes is almost equal, although the choice may be influenced by the size of the proposed course.

The second parameter to choose the instrument was its cost. All the tools described are free of charge for educational purposes and thus meet our needs.

The third, perhaps most essential, requirement is compliance with the minimum system requirements of the equipment and associated software. State educational institutions are at a disadvantage in this respect. Therefore, for the first version of the course "Computer game development" in our university was chosen Microsoft XNA Game Studio, which has a narrower range of possibilities.

We assumed that the experience of our students in C/C++ and C# programming would allow them to easily learn XNA. However, we were wrong. By the end of the course, many of them were halfway to the games. The greatest success was achieved by the group of students

who developed the Tower Defence class game, but it was completed as part of the bachelor's qualification work.

The problem with this approach is that in order for students to feel the process of developing games, they need an environment that they can easily use to create games. The focus of the course was to make the game good, not just work at all. We wanted our students to have experience working with a real engine, real skills if they decided to develop games.

The situation improved after the computers at our university were upgraded. We were able to work with a serious game engine. We decided to use the Unity Engine because it has a less steep learning curve than Unreal. It can be used to develop games for any platform, including the Web, for real games, not just training games for learning. Unity scripting can be done in C# or JavaScript, with which our students have already had experience.

3. Organization of the course

We wanted to build the course in such a way that students could learn the basics of Unity quickly enough and focus on creating the game for most of the semester.

After studying Paul E. Dickson's works (Dickson [32], Dickson et al. [33]), our first thought was to build a course based on a book with examples that could guide both us and our students, for example, Unity 3.x Game Development Essentials [52]. One game is built throughout the book, each chapter introduces a new concept and aspect of the game. All examples of code are written in JavaScript and C#. This book quickly gives an idea of colliders, particle systems, etc. for anyone with no experience in game development. The work on the book provides enough information to study the basics of Unity.

One of the problems is the rapid development of Unity and the need to find relevant materials for work. Unity has an active online community that helps to find textbooks to cope with the new features and changes in Unity and could base the course on one of the online textbook series. However, since the duration of the course was only one semester, it was necessary to develop a manual sufficient to carry out the laboratory tasks in order to use the books only as an additional source of information.

Our goal in this course is to give students a sense of the game development process with a focus on project management, teamwork, and problem solving. The first part of the course focuses on teaching students to use Unity, and the second part focuses on developing real play by groups of students. Classes were held for 3 hours per week: 1 hour of lectures and 2 hours of laboratory work. The basic structure of the course is shown in table 1, 2.

The method that we used in the first part of the course, to organize the study of Unity students, was to combine work on the assignments in the classroom with the performance of additional creative tasks by ourselves. In each work, students had to understand in detail what had been done in the classroom in order to determine how to complete the extra assignment. During the first part of the semester, students sought to learn how to solve various problems with Unity before they began working on their final game projects that required these skills. During this work, students built a basic game in which the player could control the movement and actions of the character in their environment.

Table 1
Course part 1. Basics of work in Unity.

Topics	Duration, hours	Course Materials	Deliverables
1. Introduction to Unity	3	Unity features. Examples of games created on Unity. Unity installation. The difference between 2d and 3d design. Overview of the main elements of the scene: Camera, GameObject, Direction Light. Moving the scene. Camera object. Location of objects on a 3d scene.	Laboratory work 1
2. Textures, materials and elements of the scene	3	Adding new textures to the project. Creation and use of materials. Shaders and their use. Work with aggregated characters and their components. Creating a Terrain. Terrain Landscape Editor. Trees, grass and surroundings. Placement of a player on Terrain.	Laboratory work 2
3. Scripts and object movement	3	Install Visual Studio Plug-in for Unity3d. Creating scripts. Apply a script to an object on the stage. The structure of the automatically generated script. Creating a character movement using a script.	Laboratory work 3
4. Player management	3	Using the Asset store. Download unitypackage. Use ready-made unitypackage. Creating unitypackage. The structure of projects created by other developers. Use of ready-made asset. Character Controller and its application. Move the object with the keyboard. Dynamic object creation.	Laboratory work 4
5. User interface	3	User interface and its application. Examples of basic controls. Bindings and orientation of controls relative to the working area of the screen. Creating elementary events. Customize Canvas to different screen resolution properties	Laboratory work 5
6. Animation	3	Using ready-made character animations. Create your own animation. Editing curves. Structure and main properties of the Animation component. Animator component	Laboratory work 6

4. Results

It's hard to measure success when students are building different games. By calling the game playable, we mean that the students have created a mechanic for the game (possibly with minor errors), combined the art assets with the mechanics and made some introduction (history, list of game items) that enters into the game. In order to evaluate the results of our course "Computer game development" we used some parameters offered by Ritzhaupt [1] to evaluate its such course.

Table 2
Course part 2. Game development based on Unity.

Topics	Duration, hours	Course Materials	Deliverables
1. Game Development Basics	1	Game development life-cycle. Game terminology. Overview of game industry	Game Concept plan
2. Creating a character	3	Uploading models to the project. Features of creating game characters. Customize avatars for models that use humanoid animations. Working with the Animator component. Animator controller settings. Retargeting of humanoid animated clips.	Characters modelling and animation
3. Finding a way	3	Creating a game scene. Navigation grid settings. Add and adjust obstacles. Implementation of the movement of the character on the navigation grid.	Group projects element
4. Inverse kinematics	5	Animation settings. Attaching skeletal parts to objects. Creating a script to work with inverse kinematics. Fixation of skeleton points. LineRender component.	Group projects element
5. Characters not controlled by the player	6	Creating a slider and stylizing it. Move the coordinates of the slider to the position above the target. Creating goal health scripts. Using Raycast.	Group projects element
6. Construction of game levels	12	Creating a game level. Overlay post effects on the main camera. Set up bots to search for enemies. Game level layout. Creating multiple teams. Configuration and error correction. Possibility of application of scattering of bullets at shooting.	Final Game

4.1. Usefulness of course elements for students

For studying the elements of the course that proved successful, we asked the students to indicate which elements of the course were useful for learning in the range from 1 – "not useful" to 5 – "very useful" (table 3). Of particular interest are the highly rated elements: teamwork in labs ($M = 4.05$; $SD = 0.71$), working with peers inside and outside of class ($M = 3.9$; $SD = 0.9$), and the hands-on labs activities ($M = 4.03$; $SD = 0.92$). These results underline the importance of sufficient work in the computer laboratory and cooperative training in the game development course.

4.2. Student assessment of gains

Students were asked to evaluate their post-graduate achievements in a number of areas related to the development of games on a scale of 1 to 5 (table 4). The results showed that they made the most progress in understanding the game's development ($M = 4.03$; $SD = 0.83$) and the ability to use the Unity Engine ($M = 4.18$; $SD = 0.87$). In all other areas, progress has also been above average.

Table 3
Useful course element percentages, mean, and standard deviation.

Useful Elements	1	2	3	4	5	M	SD
The way in which the material was approached	0	5	40	32,5	22,5	3,73	0,88
The pace at which we worked	2,5	10	45	30	12,5	3,4	0,93
Working with peers inside and outside of class	0	7,5	22,5	42,5	27,5	3,9	0,9
Viber discussion group	2,5	7,5	32,5	40	17,5	3,63	0,95
Teamwork in labs	0	2,5	15	57,5	25	4,05	0,71
The presentation of the final group project	0	10	20	45	25	3,85	0,92
The hands-on labs activities	0	5	25	32,5	37,5	4,03	0,92

Table 4
Student learning gains percentages, and mean.

Student Gains from Course	1	2	3	4	5	M	SD
Understanding the main concepts in game development	0	5	25	42,5	27,5	3,93	0,86
Understanding the game development process	2,5	2,5	10	60	25	4,03	0,83
Understanding Unity Engine using in game development	0	5	15	37,5	42,5	4,18	0,87
Ability to think through a problems in game development	0	1	10	20	9	3,93	0,76
Confidence in your ability to work in game development	0	5	25	47,5	22,5	3,88	0,82
Feeling comfortable with complex game development	0	2,5	35	45	17,5	3,78	0,77

4.3. Final project game

In the second part of the course, students worked in groups (3–4) to create final game projects. We allow students to decide for themselves which games they want to develop and how to split into groups. Each group decided who would play what roles and what they would need to do to finish the game. Lectures on this part of the course covered a wide range of topics. Some specific aspects of game development that students are likely to need were discussed. All practical tasks for this part of the course are related to keeping students on their way to finishing the final project games. These include students presenting game ideas, project plans, vertical slices, usability tests, a final game, and weekly reports on who has achieved what.

Most of the groups were able to successfully build a playable game for the final project, which is significantly better than the previous version of the course. Students created RPG games (figure 2), quest games (figure 3), logical games (figure 4) and action games (figure 5). The variety of these games shows that students are free to create games of their choice instead of being limited to the genre and content given by the teacher.

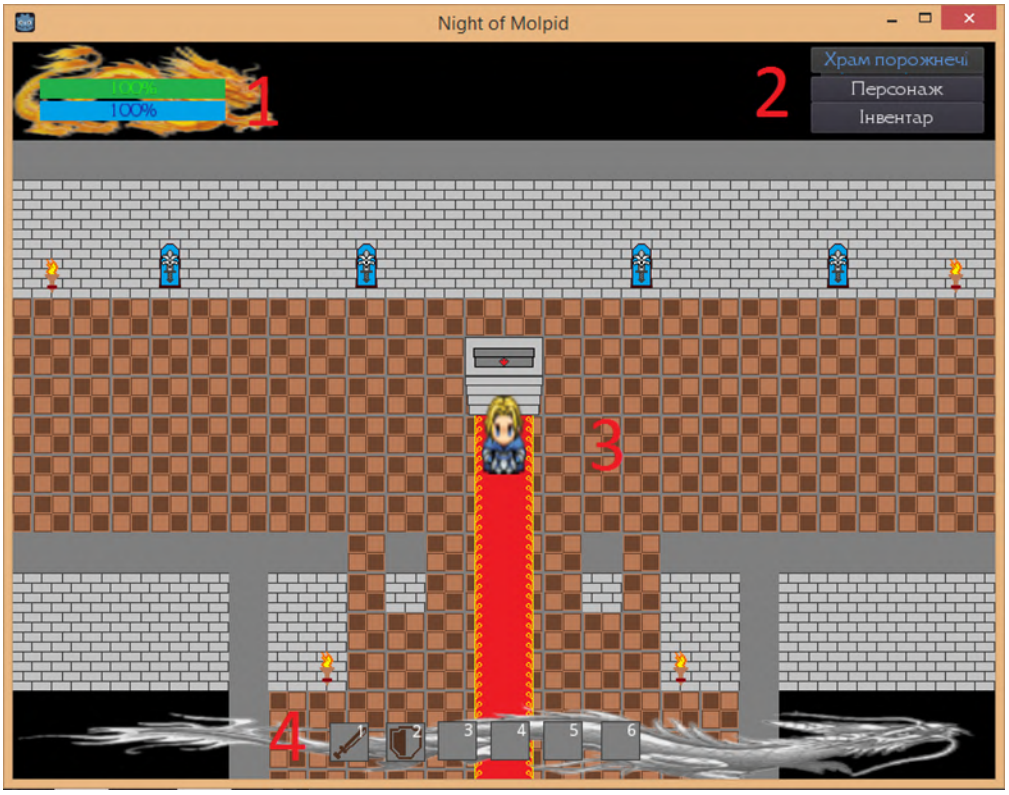

Figure 2: RPG game.

Figure 3: Quest game.

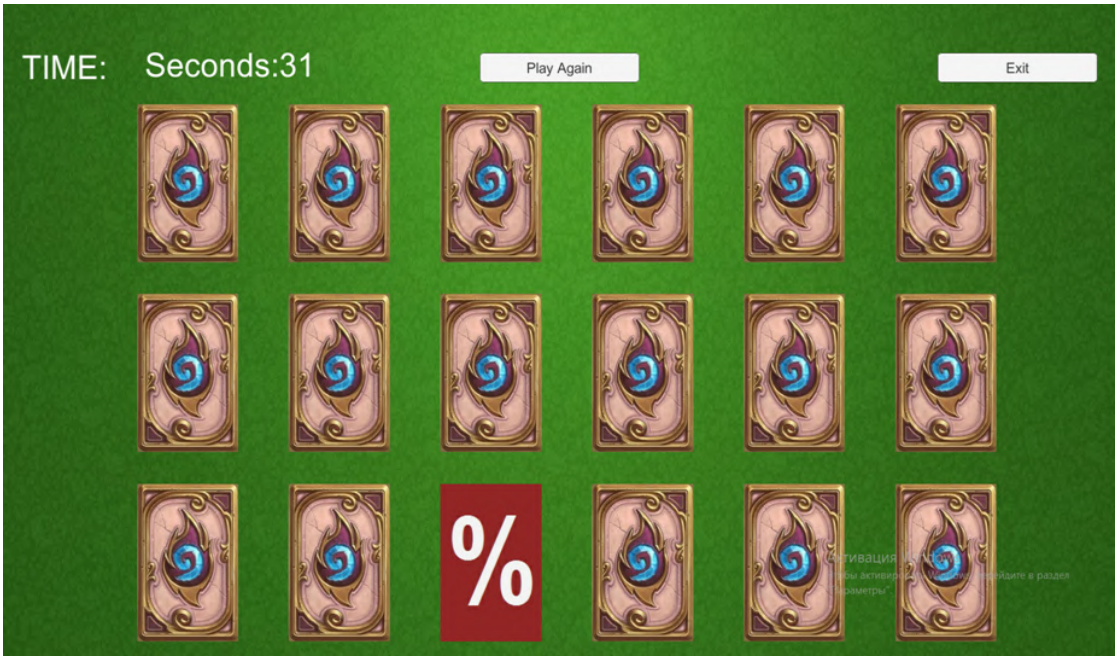

Figure 4: Logical game.

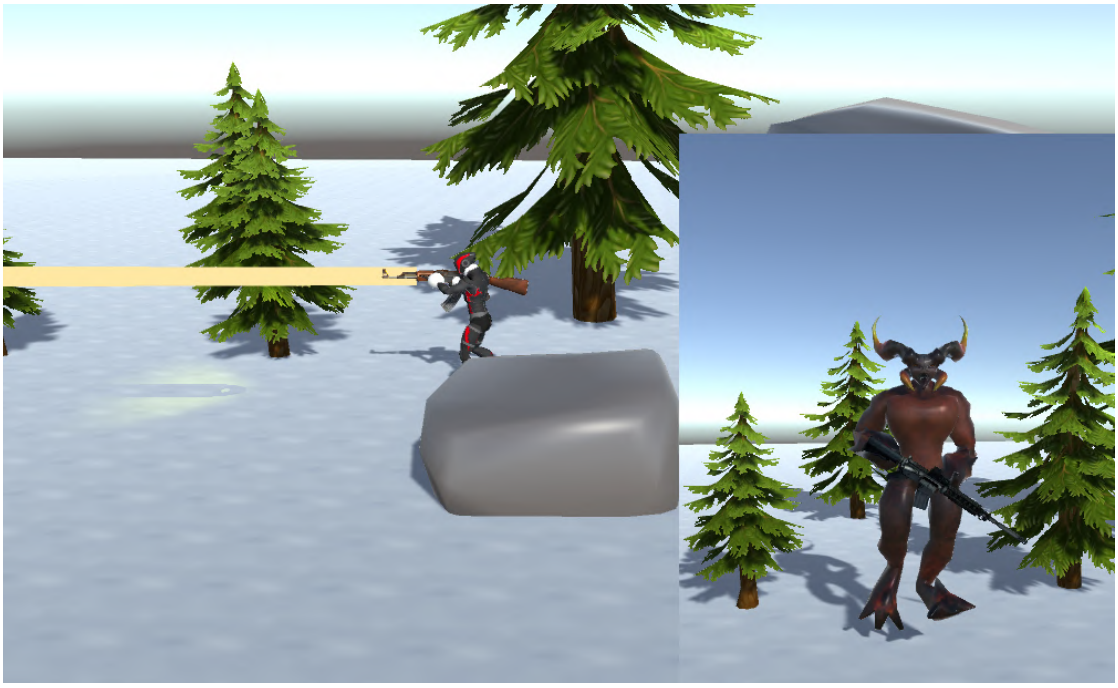

Figure 5: Action game.

5. Conclusions

In this paper, we have presented our experience and evaluation of teaching a course on computer game development using the Unity Game Engine for master's students in the specialty 014.09 Secondary Education (Informatics) at the Kryvyi Rih State Pedagogical University. We have described the design and implementation of the course, as well as the challenges and outcomes of its delivery. We have also assessed the course using a framework proposed by Ritzhaupt [1] based on student feedback and learning outcomes.

We have found that our course was successful in achieving its objectives and enhancing students' knowledge and skills in game development. We have also observed that students were highly motivated, engaged, and satisfied with the course. We have identified some areas for improvement, such as providing more guidance and feedback, balancing the workload and difficulty, and diversifying the assessment methods.

We have concluded that the Unity Game Engine is a suitable platform for teaching game development in secondary education, as it offers a low barrier to entry, a rich set of features, a cross-platform compatibility, and a wide adoption in the game industry. We have also argued that a team-based approach is beneficial for fostering collaboration and creativity among students.

We have also reflected on the pedagogical implications of teaching game development in secondary education. We have suggested that teaching game development requires a shift from a teacher-centred to a learner-centred environment, where students have more autonomy and control over their learning process and teachers act as facilitators and mentors.

We hope that our paper will inspire and inform other teachers who are interested in teaching game development in secondary education. We also hope that our paper will contribute to the growing body of research on game development education and its impact on student learning and motivation.

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