

Improvement of higher education: how to bridge the digital divide during the transformation?

Viktoriia V. Sydorenko¹, Inna O. Akhnovska², Sergiy V. Smirnov³, Igor A. Verbovskiy⁴,
Olha V. Melnychuk⁵

¹Bila Tserkva Institute of Continuing Professional Education, Bila Tserkva, Ukraine

²Department of Entrepreneurship, Corporate and Spatial Economics, Vasyl' Stus Donetsk National University, Vinnytsia, Ukraine

³Department of Ship Handling, Educational and Scientific Institute of Maritime Transportation and Technology,
National University "Odessa Maritime Academy", Odessa, Ukraine

⁴Department of Pedagogy, Professional Education and Academic Establishments Management, Zhytomyr Ivan Franko State University,
Zhytomyr, Ukraine

⁵Department of Scientific Discipline of Documentation and Information Technologies, Academy of Recreational Technologies and Law,
Lutsk, Ukraine

Article Info

Article history:

Received Jun 30, 2023

Revised Jan 16, 2024

Accepted Feb 21, 2024

Keywords:

Artificial intelligence

Digital divide

Digital transformation

Digital university

E-internationalization

ABSTRACT

The research is focused on a comprehensive analysis of digitalization as a prerequisite for higher education modernization. The authors of this article consider the digital divide as a component of information inequality, which has a technological nature and presupposes unequal opportunities for access, use, and production of information and knowledge or new technologies for their effective use in practice. The authors determined the digital divide is intensifying under pandemic and quarantine restrictions when the preference is given to blended learning technologies, collaborative learning, integrated learning, flipped classroom technology, storytelling, inquiry based learning (IBL), and project based learning (PBL). The research result is a unified information and communication ecosystem developed, which unites the scientific, technological, and educational potential of the network educational digital environment. The ecosystem also provides for the transformation from a lineal to a cluster model of competence cultivation, the formation of digital skills, growth in the volume of information, and creation of digital products.

This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



Corresponding Author:

Viktoriia V. Sydorenko
Bila Tserkva Institute of Continuing Professional Education
Bila Tserkva, Ukraine
Email: viktoriia.sydorenko@pltch-sci.com

1. INTRODUCTION

The digital transformation is one of the global challenges for the modern economy, society and education, in particular, a manifestation of the global digital revolution. It changes the environment of tertiary education and the training of a new type "digitalized specialist", for whom digital technologies becomes an integral part of productive professional activity and social integration. With the basic principles, values of teaching and learning are being reconsidered, the established models of communication and life-long career progress through formal, non-formal and informal education are being changed, forms, methods and technologies of adult education are being modernized. We can talk about the emergence of new forms of developing and generating knowledge, professional communication, cognitive abilities, types of thinking.

The application of digital tools in education is one of the prominent trends in the development of education. Digital technologies make it possible to improve education by making it flexible to the realities of

today. Most importantly, digital technologies create conditions for life-long education in the conditions of pandemics, military armed conflicts [1]. The practical experience and theoretical generalizations accumulated abroad regarding the impact of digital transformation become acute for Ukraine for two reasons. The first one is the need to bring national Ukrainian education in line with the forefront world experience [2]. The second reason is the critical importance of distance learning, digital services and solutions in the conditions of martial law, which was introduced due to Russia's unprecedented attack on Ukraine on February 24, 2022.

In today's dynamic development of the knowledge society, complexity of its technical and social infrastructure of the most important strategic resource for continuing professional development of the teacher becomes information. Along with traditional material and energy resources, modern digital technologies facilitate presenting information to customers of educational services and becomes not only an important factor in society, but also a means of improving management of all spheres of public activity. For professional activities and participation in society, it is important to use digital tools confidently, including digital and information literacy, communication and collaboration, and digital content creation.

Today, the United States (USA) holds a prominent position in digitizing the education sector to transform learning, setting the future roadmap for other nations to follow. In this regard, the national education technology plan (NETP) outlines the policy on education digitalization in the USA. The NETP formulates a concept of fairness and cooperation of all educational structures and stakeholders in the digitalization of education. Educational policy in the field of digitalization of the USA actively promotes [3]: i) affordable high-speed internet connection, which ensures greater fairness and equal access to education for every American citizen; ii) accelerating digital literacy, which helps students evaluate and combat misinformation; iii) blockchain technologies in education, which improve, protect and verify a transaction or publicly confirm ownership of a digital asset, allow students to gain control and ownership of all their education data, expand opportunities for international mobility; and iv) artificial intelligence technologies in education facilitate the adaptation of participants to meet their educational needs effectively, avoid time consuming activating and concentrate on the key educational purposes [4].

The European Union (EU), like the USA, constantly encourages the establishment of efficient digital education infrastructure in Europe and aims to increase digital competences of citizens. Many American and European educational institutions widely use digital solutions, but most schools and universities around the world realized the importance of digital transformation of education only during pandemic. Coronavirus disease (COVID-19) revealed how important digital technologies and skills are for work, learning and communication. Governments in various countries have made significant efforts to mitigate the immediate effects of school closures and promote continuity of education for all [5]. The COVID-19 pandemic has exacerbated various pre-existing problems and disparities concerning access to digital technologies, particularly impacting individuals from vulnerable backgrounds. It also identified some obstacles in educational and training frameworks pertaining to the digital preparedness of educational institutions, the training of educators, and the general level of digital competencies. Although the pandemic negatively affected the educational process, it demonstrated the need for enhanced digital capabilities in educational settings, caused rapid, large-scale positive changes-the acceleration of the digital transformation of education [1].

The EU faced not only problems, but also outlined further opportunities, namely: to intensify efforts and gradually move from temporary distance education focused on emergency situations towards a more efficacious and enduring equitable digital education within innovative, adaptable, contemporary, and inclusive educational practices. This requires strategic and collaborative measures, alongside the consolidation of resources, investments, and political determination to further advance the digital transformation of education at national and EU level. Therefore, today the EU countries are aimed at updating educational systems through the creation of strategic frameworks, delineation of precise initiatives, allocation of resources for research and innovation in digitalization, and advocacy for digital technologies in educational processes. Among the components of digital transformation are bringing any kind of information into digital form using digital technologies, creating an open educational space, online education, electronic resources, learning with simulators, virtual reality, the development of digital competence required to perform professional roles and functions.

The terms “digital gap”, “digital divide”, “digital barrier” “information inequality”, “information or digital divide”, “digital or electronic breach” appeared in the late twentieth century to denote the difference in the ability to obtain information, knowledge, the lack of a certain computer literacy, necessary basic digital skills, insufficient digital involvement of the population. The unevenness of this development is manifested in the fact that people who have sufficient education and a certain financial situation have access to information technologies, which in turn allow them to carry out social communication and also develop intellectually, while many prefer remote or independent learning using electronic resources. This causes a growth of living standards. Those who for certain reasons do not have access to high technologies, develop much more slowly, their standard of living is low [6].

This is due to insufficient development of infrastructure, national and local information content (content), local digital information resources, lack of adequate education for the formation of digital capital, including cultural and educational capital, as well as the inability of the vast majority of people to benefit from information-intensive activities. At the same time, the term “digital capital” means the acquired digital skills and digital competencies that allow to achieve certain social, professional, personal goals in the knowledge society, to successfully implement their life strategies. The term “digital divide” originally denoted the discrepancies in digital technologies used by different social groups. Nonetheless, internet accessibility is commonly recognized as a significant advantage facilitated by numerous technologies, given the enormous amount of information and data. As a result, there is a trend towards the closure of the digital divide due to the widespread availability of inexpensive mobile devices and enhanced global network coverage.

Thus, the digital divide has a technological nature, characterizing the different ability of countries, regions to provide both nationally and for certain groups of individuals, individuals access to modern information infrastructure (internet, databases, and knowledge bases) in order to use it effectively in practice. For a comprehensive analysis of the digital divide, researchers use the theory of three levels of digital inequality, including features of internet access and digital technologies (digital gap of the first level), practices of their application, inequalities that develop in those users who have access to the network (digital gap of the second level) and social benefits that the modern individual receives (digital gap of the third level) [7]. The digital divide is widening in the context of pandemics and quarantine restrictions, when the priority in the educational process is given to innovative technologies of blended learning, collaborative learning, integrated learning, inverted classroom technology, storytelling, inquiry based learning (IBL), project based learning (PBL) and more. Among the current problems of bridging the digital divide are: i) the implementation of a single educational digital space in Ukraine; the improvement of the existing legal framework, which ensures the creation of a modern digital university as a basic prerequisite for updating of tertiary education; ii) the improvement of the essential components in regional information and telecommunication networks, interlinked both internally and with the worldwide via internet; iii) development and improvement of digital competence of participants of educational process, use of innovative methods and approaches in educational process; iv) providing all participants involved in the educational sphere with equal access to services, information and knowledge provided via information technologies; v) providing socially vulnerable categories with free conditions for access to modern digital technologies; and iv) creation of public places for digital literacy training: consultation centers, and computer courses.

The Law of Ukraine “on higher education” [8] states that the priorities of the educational system of Ukraine are openness of higher education institutions, unlimited access to educational materials and integration with the European educational space. The digital agenda of Ukraine 2020 determines that “digital” transformation will create the fundamentals of the Ukrainian society, governmental institutions, and business, agenda guiding Ukraine towards prosperity [9].

All this highlights the problem of bridging the digital divide in education, the organization of a modern digital educational environment, which prepares a comprehensive harmonious personality, able to choose an individual educational trajectory, lifelong learning, career development, professional mobility and quick adaptation to socio-cultural changes are essential for acquiring competencies, skills, capacities, and the demands of the national economy and society.

In the field of higher education, socio-system globalization, openness, digital transformation has led to increased mobility of ideas, opportunities to learn, teach, and carry out research using information and communication technologies, expanding opportunities for cooperation and global dissemination of knowledge, integration in international, intercultural and intellectual direction to achieve goals in teaching, research, social responsibility. The digital transformation of higher education involves the establishment of a contemporary digitalized university [10], which is undergoing profound digital transformations of education management, educational activities, research initiatives, human capital, digital infrastructure and digital ecosystem.

The purpose of this research is to thoroughly investigate digital transformation as an essential component in the modernization of higher education to prepare a comprehensively developed harmonious personality, who can select their educational paths, engage in lifelong learning, and advance their professional careers. The purpose stipulates the following primary objectives: i) to substantiate the digital transformation of higher education as a basic imperative of its modernization, a manifestation of the global digital revolution; ii) to clarify the existing approaches to the analysis of the digital transformation of higher education; iii) to study the changes that occur during the informatization of modern society, as a result of which there is a digital divide; iv) to identify the factors that determine the state of the digital divide in higher education institutions for the formation of a knowledge society; v) to describe the ways and methods of application of the European self-reflection on effective learning by fostering the use of innovative educational technologies (SELFIE) instrument for conducting a comprehensive self-assessment of the digital transformation of a higher education institution; iv) to develop directions for overcoming the digital divide in the institution of higher education (organizational and managerial, educational, scientific, human capital development, creation of a digital ecosystem); and vii) to

clarify the content of the basic concepts of the study: “digital divide”, “digital transformation”, “key competence”, “digital competence”, “digital capital”.

During the study of overcoming the digital divide in the process of transformation and improvement of higher education, a complex of general scientific methods, legal methods, and principles of theoretical and cognitive activities in the field of education were used. One of the leading research methods is the theoretical method, the method of analysis and synthesis. With the help of these methods, Ukrainian and European scientific sources on the above topic were analyzed and summarized, which made it possible to form the scientific and theoretical basis of our research. The source base of the research consists of official documents, statistical data and materials on higher education, professional education and training in EU countries and Ukraine. Thus, the theoretical framework of the research is scientific provisions and conclusions regarding digitalization of education, as well as normative documents of Ukraine and the EU. Among the general scientific methods of cognition, the methods of system analysis were used. The methods of analysis allowed to identify the structure and components of digital transformation, including in European countries and Ukraine in particular.

The subject of the study also determined the use of methodological provisions. The empirical research method is important in the course of this research. In the course of using empirical research methods, a study of the level of digital competences of the Ukrainians was analyzed, as well as a survey and online interview were analyzed and conducted, including on the resource the educational platform “Profosvita” [11] and a questionnaire of customers of learning management systems (LMS) educational services “Profosvita” [11]. Comprehensive monitoring with the aim of identifying the digital gap in the educational process and predicting ways to overcome it was carried out during 2019 to 2020 and January to April 2021 on the basis of Bila Tserkva Institute of Continuing Professional Education of the "University of Education Management" of the National Academy of Sciences of Ukraine. Within the research, a survey was conducted regarding the quality of the created digital educational environment. As a result of the survey, the main directions of further overcoming the digital divide were predicted, which involves the transition to a new educational model, the replacement of the traditional classical educational space with a virtual network, the digital transformation of the entire activity of the Institute, using the statistical research method, the level of digital competences was determined. Moreover, a special analysis was required to identify the possibilities of a systematic approach specifically for the analysis of the research subject. All the mentioned methods were used in the appropriate combination, which was determined, first of all, by the nature of the studied objects.

The configuration of tertiary education in Ukraine adheres to the educational framework in developed countries worldwide, as determined by United Nations Educational, Scientific and Cultural Organization (UNESCO), and the United Nations. Ukrainian education adopts a European model, embracing such stages as preschool education, general secondary education, supplementary education, vocational and technical training, university education, doctoral programs, and self-education. Various levels of education are defined, including primary general education, basic and general secondary education, vocational and technical training, basic higher education, and advanced higher education. In accordance with the Ukrainian law “on education”, the Ukrainian citizens can exercise the right to pursue education in diverse modalities such as full-time attendance, evening classes, distance learning, or external study. With the advancement of information technologies, distance learning is evolving and refining, particularly in the distance-correspondence format. Priorities for the current stage of digitalization of education, the formation of a global educational space are declared in international regulations [12].

Digital inequality as a complex and multifaceted phenomenon, a form of social stratification, which is manifested in the disproportion of access and use of modern digital technologies is studied by foreign and domestic scientists, representatives of various sciences. Theoretical and practical aspects of a new type of social differentiation to solve world social problems are substantiated in sociological research. The problem of digital inequality in health issues, the introduction of digital medicine in developed countries (“digital medicine” or “ehealth”), which allows to perform self-monitoring or remote monitoring of the disease, to communicate with health care providers or drug providers researched by foreign researchers [13].

However, analysis of the scientific and educational sources, the regulatory framework demonstrates a lack of basic research, which could reasonably substantiate digital transformation of higher education as a basic imperative of modernization manifestation of the global digital revolution; the aspects that determine the state of the digital divide in the institution of higher education are identified; directions for overcoming the digital gap in higher education institutions have been developed. At the same time, the digital transformation of tertiary education, the creation of a modern digital university should take into account the principles of building open education. These principles embrace advancing sustainable development through the cultivation of competitive human capital and facilitating life-long learning. They also include ensuring access to higher education, maintaining the autonomy of higher education institutions from political, public, and religious affiliations. Additionally, these principles emphasize student-centered learning, with the

educational process being tailored to individual needs, talents, professional requirements, and developmental stages. Other important aspects of open education involve systematicity, academic integrity, and academic mobility. The underdevelopment of this issue in pedagogical theory and the demands of educational practice motivated the selection of this research topic.

2. METHOD

In 2020, the Ministry of Digital Transformation carried out a comprehensive survey of digital skills level of the population of Ukraine. It was found that 53% of respondents (aged 17 to 70) master digital skills at a level “below average”, according to the methodology of the European Commission (EC); 15% do not have such skills. Meanwhile, 70% of Ukrainian predominantly have communication and information skills; however, software and problem-solving skills need the most attention. The survey shows that there are age differences in digital skills: although 66.1% of Ukrainians aged 10 to 17 have skills above the “basic” (according to the methodology of the EC), this age group is only 25.5% of the total population [14].

To close the digital divide, on December 24, 2019, the Ministry of Digital Transformation developed the National Digital Literacy Platform “Diya: digital education” [9]. Public courses aim to mitigate the digital gap and enhance individuals’ prospects for advancement. The framework program for updated key competences for lifelong learning, endorsed by the European parliament and the council of the EU on 17 January 2018, defines eight essential competencies. Key competencies are necessary for increasing personal capacities and enhancing employment prospects, social inclusion, and engaged citizenship, are cultivated through life-long learning in formal, non-formal, and informal educational institutions. Digital competence is defined as one of the key ones [15].

The concept “New Ukrainian School” and the state standard of primary education identify information and digital competence as a key competency for teachers. This refers to the ability to navigate the information space, obtain information, use it in accordance with personal needs and the requirements of modern digitalized information society, create their own electronic products, build their style of communication in a learning society, use modern information-communication technologies, computer equipment, including in particular network search and information processing systems. Electronic library resources, multimedia equipment; online resources of the New Ukrainian School. Computer programs for statistical analysis and visualization of experiments results [16].

The European reference framework defines the key competence of digital media skills as the critical use of information technologies for work, entertainment, and communication. The developed European digital competence framework describes the digital skills needed for learning, employment and coexistence in the digital society. In the document “DigComp2.0: digital competence framework for citizens” [17]. First published in 2013 by the institute for advanced technological research of the joint research center of the EC, developed a conceptual reference model for the system of digital competence of citizens at the European level and at the level of the EU member States. The content of the system is reflected in two dimensions, in particular dimension 1-the area of competency and dimension 2-competences:

- Information and ability to work with data, including the competence to view, search and filter data, information and digital content. Besides, it involves evaluating and managing data, information, and digital content.
- Communication and cooperation, which includes competencies of interaction with the help of digital technologies; exchange of data and information, acting as a mediator, and using public and private digital services to participate in decision-making. It also includes network etiquette and management of digital identity.
- Creation of digital content, covering the competence of digital content development, creation and editing of digital content in various formats, self-expression by digital means; processing of digital content to create new content; copyright and licenses; programming, planning and developing of a clear procedure to perform specific tasks.
- Security, which includes competencies to protect devices and digital data, considering the risks in digital environments; protection of personal data and privacy; protection of physical and psychological well-being during the use of digital technologies; environmental protection.
- Problem solving, which includes the competence to solve problems related to functioning of devices; identify needs and technological responses to meet those needs; creative use of digital technologies to create knowledge and make innovative changes in processes and products; identifying gaps in digital competence and finding opportunities for self-development [17].

In 2021, the framework of digital competences of citizens of Ukraine [15] was developed as a tool to improve the digital skills by different social groups. The framework was approved as the result of research within the international project Erasmus+ “Framework structure of digital competencies for Ukrainian teachers

and other citizens” (dComFra). The framework contains 4 dimensions: i) areas of competence; ii) names and descriptors of competencies related to each area; iii) levels of ownership acquired by citizens in each competence; iv) knowledge, skills, abilities applied to each competence) 6 aspects (fundamentals of computer literacy, information literacy, data analysis, digital content creation, security in the digital environment; problem-solving, and lifelong learning), 30 digital competencies and 6 levels of digital skills [18].

Digital competence, identified as key in the document, includes confident use of digital tools for learning and working. Digital competence includes information literacy, media literacy, communication, security, multifaceted problem solving and lifelong learning. This dynamic structure can be updated, revised in connection with the emergence of new technologies, changing needs and the state of development of digital literacy. Areas of use include the creation of state or regional policy on the development of digital competences, for planning educational and social initiatives, making adjustments in education standards and job demands, creating training programs, trainings, educational resources aimed at improving digital competencies.

In this regard, addressing social and educational issues, evaluating the present status of higher education digitalization entails implementing novel educational process organization formats and teaching methodologies (such as e-learning, mobile learning, collaborative learning, smart learning, simply means educating students in four specific disciplines, namely, science, technology, engineering, and mathematics (STEM) education, open online courses, blended learning, and social training) utilizing cloud technologies, Web 2.0 platforms, and electronic social networking services.

A multi-faceted monitoring to identify the digital divide in the educational process and forecast ways to overcome was conducted during 2019 to 2020 and January to April 2021 on the basis of Bila Tserkva Institute of Continuing Professional Education SIHE “University of Educational Management” of the NAES of Ukraine (n=299, educational level “bachelor” and “master”, research and teaching staff 94). 1,000 respondents were involved in the study. When preparing for monitoring activities, gender equality was not taken into account. The teaching staff consists of 50 women and 44 men. The percentage of students among students is 65% women, 35% men. Transgender people, or people who have not determined their gender, were not detected during the monitoring activity. During the initial phase of the experiment, we established a unified information and communication ecosystem. This ecosystem integrates the scientific, professional, and educational resources of participants within the educational and digital realm. It facilitates the utilization of digital, andragogical, and interactive technologies in cyberspace. Furthermore, it transitions from a linear to a cluster model of developing key and interdisciplinary skills. In addition, it enhances communications between educational institutions, their clients, and stakeholders, while fostering the development of digital tool proficiency and the creation of digital products. There were no ethical problems that could arise during data collection. The single information and communication ecosystem includes: LMS “Profosvita”, information and analytical resource “methodical treasury”, virtual school of pedagogical coaching, online consultation station “latest production technologies”, digital educational courses, digital program-methodical complexes, and personal teachers web-resources [11].

The primary objective of integrating digital technologies into the educational curriculum at Bila Tserkva Institute of Continuing Professional Education is to foster the digital proficiency of both students and the faculty. This entails enhancing and acquiring skills necessary for confident, discerning, and ethical engagement with digital tools, essential for navigating today’s digital society. The initiative involves crafting personalized pathways for digital competence development and acquainting with cutting-edge digital trends. These encompass a scope of technologies, including the internet of things, robotics, artificial intelligence, big data analytics, paperless workflows, 3D printing, cloud computing, virtual and augmented reality, and biometrics. Therefore, the following digital technologies feature prominently in education: i) communication digital technologies for online activities in video and audio formats such as online lessons, web conferences; ii) Google cloud technologies for managing paperflow, visualizing timing of educational projects; iii) social networks for the exchange of information, messages, and news; iv) YouTube for carrying out educational and scientific activities online; v) cybersecurity technologies for information security of scientific and pedagogical workers; vi) digital technologies for verifying academic integrity; vii) visualization technologies for infographics, QR codes, multimedia presentations, intelligence maps, word clouds, 3D modeling, augmented and virtual reality; viii) electronic testing systems and analytics in the educational process developed on LMS “Profosvita” such as testorium, master-test, online test pad; and ix) creating profiles of research and teaching staff in scientometrics databases.

For the effective work of research and teaching staff and students, digital workplaces have been developed, which ensures communication with teachers in real time and at online meetings, including audio, video and web conferencing. During 2020, 108 personal web resources for “bachelor” and “master” students were created at the LMS “Profosvita” [11] by the research and pedagogical workers of Bila Tserkva Institute of Continuing Professional Education as shown in Figure 1. The structure of teachers’ personal web resources is presented by the following sections [19]: i) management of the educational process, which

involves handling teaching materials, including those used on digital platforms, class schedules, and overall program timetables; ii) syllabuses of academic disciplines in accordance following the curriculum (educators provide them according to set schedules, offering resources for self-study, self-assessment queries, and extra materials for deeper understanding of the subject matter); and elements of feedback (chats, thematic forums, and self-control tests).

Additionally, virtual communication platforms have been organized for conducting online conferences. If necessary, surveys and online interviews are conducted, including the resource the educational platform “Profosvita” [11]. Thanks to digital technologies, virtual internationalization (e-internationalization) of education is realized. It involves different research and teaching activities performed in higher education institutions with the help of digital technologies.

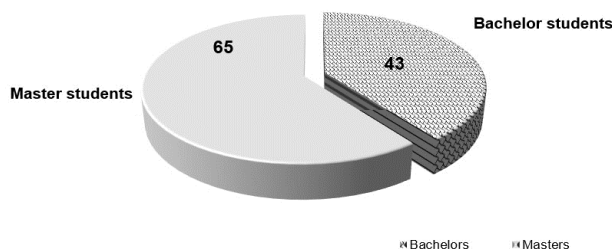


Figure 1. Web resources for students on the educational platform “Profosvita” [11]

3. RESULTS

During the monitoring, the level of formation of digital competence was determined. 89.8% of respondents are aware of the problem of the “digital divide” in Ukraine, while 12.2% of respondents believe that the problem of the “digital divide” does not exist in our society as shown in Figure 2. For indicators that reproduce the quantitative criteria for cultivating digital skills, a 12-point scale was adopted in direct correlation with the achieved levels, including reproductive (1 to 3 points), optimal (4 to 7 points), perfect (8 to 9 points), productive and technological (10 to 12 points). According to the results of self-diagnosis of the subjects of the educational process revealed the level of formation of digital competence: reproductive 3%, optimal 31.4%, perfect 49.6%, productive and technological 16% as shown in Figure 3.

The research results prove that the majority of the surveyed students, 82.1% systematically use a computer. 94% of the surveyed students have their own computer for private use, 6% do not have it. 15.7% of respondents periodically use the internet in education, 84.3% of surveyed students constantly use the internet to prepare for classes, deepen knowledge, independent work. Among the most common sources of knowledge, students are arranged in the following order: lectures by teachers, the internet, work with literature (books), non-formal education.

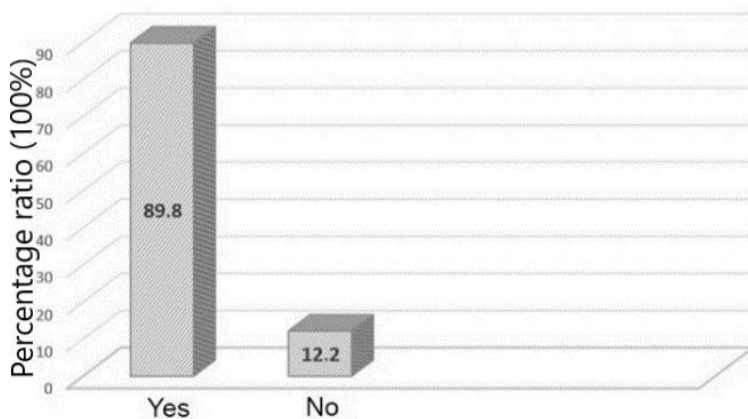


Figure 2. Whether digital divide is existing in Ukraine

At the control phase of the experiment, a self-assessment of the real state of education digitalization was conducted using a European tool [20]. The SELFIE platform was initiated by the EC in collaboration with a team of experts from schools, ministries of education and research institutes across Europe. According to data for 2019, the platform is used by 55 countries, 6 484 schools have been polled that covered 550,082 of users [20].

SELFIE is an instrument for self-essessment of the educational institution that helps to analyze the quality of the created digital educational environment, identify problems, effectively implement digital technologies in the educational process. The survey is conducted anonymously, using questions that require concise responses rated on a scale from 1 to 5. The comprehensive survey embraces various categories, including leadership, infrastructure, teacher preparation (covering educational methods, assessment, and ongoing professional growth), and the digital proficiency of students as shown in Figure 4.

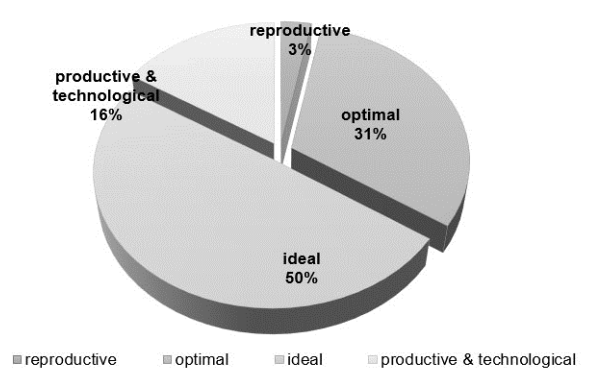


Figure 3. Levels of digital competence formation of students

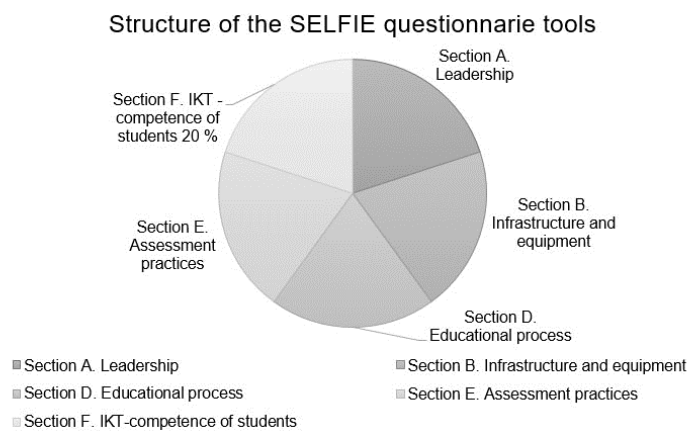


Figure 4. SELFIE questionnaire tools [20]

Section A (leadership) is focused to the analysis of the leader’s role in the implementation and effective use of digital technologies in educational activities, the disclosure of positive and negative examples of the use of digital technologies in the educational process. Section B (infrastructure and equipment) is related to the analysis of the state of reliability, security and infrastructure of the educational institution (equipment, software, information resources, internet connections, technical support and availability of premises). Section C (continuing professional development) considers providing a supportive environment for continuous professional growth of the teaching staff, the introduction of new teaching methods and digital technologies that will contribute to the achievement of high educational outcomes. Section D (implementation of the educational process) is concentrated to the analysis of the cultivation of information and communication technologies (ICT) skills in teachers, their skills and abilities to apply digital tools to ensure the education quality. Section E (assessment practices) contains questions on the ability and skills of

teachers to apply innovative pedagogical and digital technologies in the system of assessment of student achievements, which provide a transition from traditional methods of control to the implementation of a comprehensive assessment system. Section F (IKT competence of students) focuses on the analysis of the cultivation of skills, knowledge and abilities that allow students to confidently, creatively and critically use digital technologies.

Following a SELFIE-based survey, an interactive report on the Institute's achievements and drawbacks in the use of digital tools in educational activities was generated. The analysis made it possible to develop the concept of digitalization of the institute (2021 to 2025), to predict the main directions of further overcoming of the digital divide, providing for the transition to a new educational model, replacement of traditional classical educational space with virtual network, digital transformation of all activities of the institute [3].

- Organizational and managerial activities: introduction of a through system of electronic document management; providing IT support for management decision-making processes; digitization of management bodies that ensure the implementation of new functions and improve the quality and efficiency of management methods.
- Educational activity: development of a single information and educational platform of the institution with the application of digital technologies; satisfaction of digital needs of subdivisions that provide educational activities; study of best practices, development and implementation of courses on new technologies (robotics, data science, internet of things; dissemination of STEM education programs among students.
- Scientific activity: providing access to digital banks of scientific information, electronic library funds; IT support for the participation of students, graduate students and faculty in national and international research programs; development of a digital platform for basic and applied research; increasing the reliability and efficiency of processing large amounts of information.
- Development of human capital: improvement of digital literacy, development of digital competence of scientific and pedagogical workers and students; implementation of existing, as well as the development, development and application of digital technologies to enhance the digital culture of users; and training of personnel for the transition to paperless work technologies.
- Creating a digital ecosystem involves the development of a single digital environment to support effective interaction of participants. This system embraces regulations, standards, information infrastructure, personnel and information security. It also entails developing data protection systems within electronic information systems and combating cybercrime. Besides, it presupposes the development of resource and service characteristics of the internet in order to deploy high-speed broadband communication channels and establish wireless access networks to electronic databases. Furthermore, a mobile-oriented environment for users is created, providing them with access to electronic data through various devices. In addition, electronic information databases, including scientometric databases and electronic libraries, are created in order to increase the reliability and efficiency of processing large amounts of information in various areas of activity.

4. DISCUSSION

Analyzing the main causes of the digital divide, domestic and foreign researchers generally point to inequality in access to digital technologies in different countries and regions, as well as social groups; unequal access to digital technologies among the population; inaccessibility for certain ethnic groups due to traditions; discrepancy between the earnings of the populace and the expenses associated with telecommunication services; imbalance of investments in the field of digitalization; challenges in delivering services within the country or local area due to technical issues; underdevelopment of certain types of services (in developing countries, e-mail is preferred due to the high cost of broadband); lack of flexible legislation in the field of digitalization.

The digital divide in higher education in particular widened during the COVID-19 pandemic. Researchers note that transitioning to remote learning during such crises can have enduring effects on academic achievements, particularly among marginalized groups. This shift led to a decline in the quality and accessibility of education, enhancing already existing inequalities in education. At the onset of COVID-19, approximately 90% of schools worldwide closed their doors. In the spring of 2020, all educational institutions in Ukraine shifted to remote learning. Subsequently, Ukraine implemented an “adaptive quarantine” regime, categorizing regions into epidemiological safety zones: “green”, “yellow”, “orange”, and “red”. Accordingly, secondary education institutions adopted either remote or blended learning modes, whereas higher education institutions largely continued remote learning [21].

The imbalance in the development of digital space can be traced in the correlation with the unsatisfactory financial situation of students and their families, the general problems of telecommunications infrastructure in the settlements of the country. According to a study conducted in 2020, the target group “for teachers for all” international alliance that coordinates the UNESCO, based on information the UNESCO Institute for Statistics and the International Telecommunication Union [22], at present there is a global digital gap between countries in distance learning, although digital distance learning is used to ensure continuity of education. Roughly 826 million students lack access to a personal computer at home, while 706 million, which constitutes 43%, are without internet access in their households. In sub-Saharan Africa, minimal training has been received by only 64% of primary school teachers and 50% of secondary school teachers, typically devoid of information and communication technology skills. Inequality is especially relevant in low-income regions, where 89% of students in sub-Saharan Africa lack home computer access, and 82% lack internet connectivity. Approximately 56 million students reside in areas lacking mobile network coverage, with nearly half of them situated in countries in sub-Saharan Africa [22].

A study on educational disparities in Europe [23] found that in half of the 21 surveyed countries, students from poor families have reduced access to digital education resources such as personal computers, high-speed internet connection, personal study spaces or supportive parental guidance. It is noteworthy that in Ukraine, particularly in rural areas and small towns, internet accessibility is limited, potentially enhancing educational discrepancies. Research data from France, Germany, and Italy suggest that the shift to remote learning led to a decline in weekly educational progress ranging from 0.82% to 2.3% of a standard deviation.

A global survey examining the problems of online learning and distance learning, the digital gap between the participants of the educational process, was conducted on the School Education Gateway from April 9 to May 10, 2020 [24]. A record number of respondents were involved in the survey 4,859. More than 40 countries participated in the survey. Most of the participants were from France (36% of the total), Bulgaria (19%) and Portugal (14%). For 67% of respondents, the transition to distance learning was the first experience of online learning, 25% of them had some previous experience, and only 6% of the respondents had a vast experience of distance learning. Respondents were asked to choose five distance learning problems out of 17 possible. Less than 1% reported no problems. The issue that came up most often was the ability to utilize technology effectively, including access to computers, software, and a reliable internet connection. 43% reported an increase in workload and stress when working from home (with 18% believing that time management and organization are a problem). Digital competence was a problem for both learners (24%) and educators (24%). The primary issue commonly discussed regarding learning materials and evaluation was the transformation of classes and content for online or distance education, mentioned by 28% of respondents, closely followed by the preparation of content specifically tailored for online and distance classes (27%) and performance evaluation (25%) as shown in Figure 5.

Among the ways to bridge the digital divide, respondents mentioned support in the form of additional educational resources, short courses on online learning, exchange of resources, ideas and problems. Among the determining factors that cause the digital divide in higher education, researchers call the limitation of telecommunications infrastructure in some settlements of the country, the region, in particular problems with access to broadband internet (BBI). In 2020, the Ministry of Digital Transformation of Ukraine conducted a study on broadband high-speed internet accessibility. The findings revealed that over 17,000 out of 28,000 settlements lack any optical provider, leaving approximately 65% of villages without access to quality broadband. This results in 5.75 million citizens being unable to connect to reliable fixed Internet services. Moreover, significant social infrastructure facilities, including 16,040 educational institutions, 8,163 medical facilities, 3,873 public service providers, and 33,857 cultural and sports centers, are not connected to fiber-optic networks. Specifically, 40% of schools, 92% of libraries, and 37% of hospitals lack internet access. Most of these institutions are located in villages and small towns. And 1.55 million people live in remote areas of settlements where there are optical providers, but the cost of connection exceeds 150% of the average market cost of connection [25].

To overcome the digital gap, it is important to connect the learner to the internet (fixed or mobile connection). Therefore, very often the capacity indicators for each person (in kbit/s per capita) are also taken into account. There are noticeable variations in home broadband internet access among countries. Students with higher socioeconomic status are more inclined to possess a personal computer or laptop at home compared to those from less affluent backgrounds. In the USA, according to the analysis conducted by the associated press in 2019, approximately 17% of students lack a computer at home, while around 18% lack access to broadband internet [13].

A new study by the Pew Research Center, conducted in 50 states and the District of Columbia, shows that the way to access the internet is significantly different compared to previous years [26]. The survey involved 1,502 adults aged 18 and older, of whom 302 respondents were interviewed by landline and 1,200 by mobile phone. According to the survey, 17% of the USA population are “internet users who use

only smartphones”. 37% of Americans now access the internet mainly through smartphones, citing the lack of high-speed internet connection. 58% of respondents aged 18 to 29 mostly access the internet via smartphones, compared to 41% in 2013. Low-income adults will use the internet only from smartphones. There are also racial and ethnic differences: a quarter of hispanics and a relative proportion of blacks use the internet only from smartphones, compared to about one in ten whites. Half of users who do not use broadband explain this by the high cost of a monthly subscription, 31% believe that the computer cost is too high. In 2015, this ratio was 59% and 45%, respectively as shown in Figure 6.

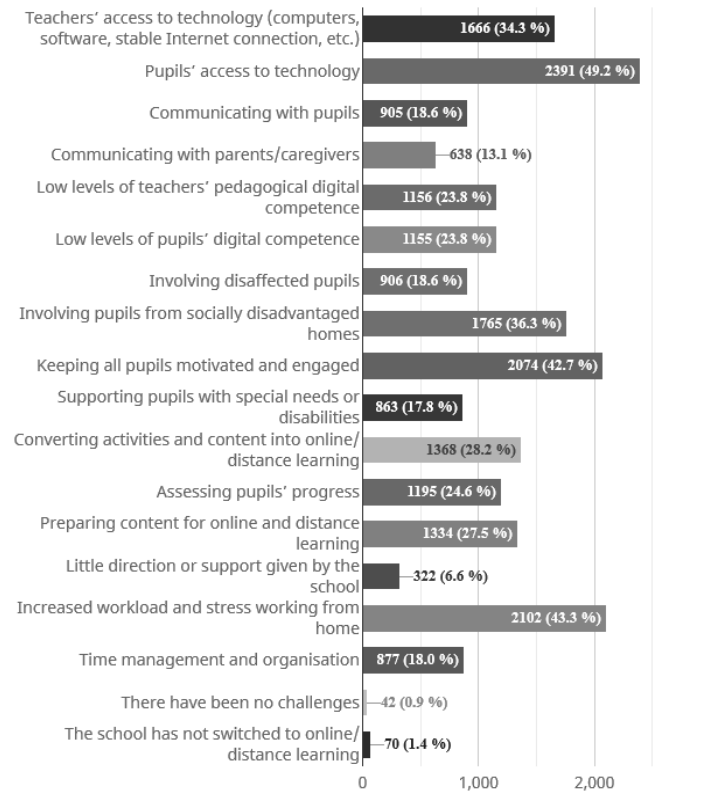


Figure 5. Problems faced by the subjects of the educational process during the shift to online learning [24]

45% of non-broadband users now cite their smartphone as a reason for not subscribing to high-speed internet service

% of non-broadband users who say the following are a reason why they do not have high speed internet service at home

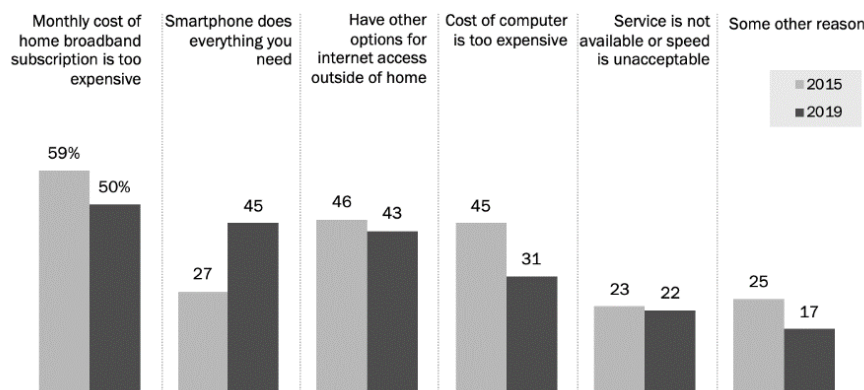


Figure 6. The application of mobile technology and high-speed internet in America [25]

A growing proportion of users who do not use broadband access consider their smartphone to be a reason to unsubscribe from high-speed home internet (45% of users). About four out of ten respondents report that they have other options for accessing the internet outside their home, while 22% say that broadband is not available where they live. Thus, the study conducted by the Pew Research Center shows that there are gaps in the prevalence of home broadband depending on the type of community, as well as race and ethnicity. However, although the coronavirus pandemic still remains an urgent problem in the world, the main obstacle to normal education in Ukraine is currently the war. From the onset of the war, remote education has emerged as the primary way for acquiring knowledge, motivating universities to adjust their functioning to warfare. Millions of people, including children and teachers, were forced to leave their homes due to the war in Ukraine, and therefore the educational process has undergone even greater changes compared to the period of the COVID-19 disease. Influential factors were: the movement of people within Ukraine and evacuation to other countries, the unpredictable schedule of alarms occurring at different times and lasting unequally in cities and regions, the introduction of curfews [27]. In certain areas, learning has been resumed offline, online or in a mixed mode, and in some areas the resumption has not taken place even in distance mode. Educational institutions and teaching teams on the ground have the right to independently choose the format, as well as the forms, methods and means of education.

However, with the start of hostilities in Ukraine, the weaknesses and threats associated with distance education have been intensified. In particular, many participants in the educational process are not ready psychologically and physically to continue their studies. In addition, learners and educators frequently lack the necessary resources to give classes, such as consistent internet access, computer equipment, and spaces [16]. The time has come for the appearance of the online platform "All-Ukrainian school online" for distance education of Ukrainian children both in Ukraine and abroad, where lessons for students of grades 5 to 11 are posted [23]. The online platform has become a key service for distance and mixed learning of students, containing interesting, accessible video lessons, notes, tests according to the state program. To date, 3,139 educational institutions have suffered from bombings and shelling. 441 of them were completely destroyed. All the material and technical support that the schools had until February 24, 2022 has been damaged or completely destroyed [24].

5. CONCLUSION

The authors conducted a statistical study of domestic and foreign trends in the digital divide, the dynamics of key indicators on the level of digital skills and digital literacy in education allows to identify priority areas for minimizing the destructive manifestations of digital inequality in higher education. A comprehensive approach to understanding the phenomenon of digital inequality in higher education involves a careful analysis of current trends in its deployment at the global, regional and local levels. The realization of public policy in the direction of minimizing the destructive manifestations of the digital divide is relevant today, which includes overcoming infrastructural constraints and ensuring a quality digitalization process of higher education; creation of digital universities, which includes the development of ways to bridge the digital divide in higher education at the organizational, managerial, educational, and scientific. levels; raising technological awareness of learners, development and improvement of their digital competence and digital literacy; stimulation and development of research centers and creation of new IT enterprises, which will allow import substitution of strategically important technologies to ensure digital sovereignty and information security in the country; development of recommendations for quality organization of classes in distance learning; establishing communication between public authorities and local governments (local education departments, united territorial communities) with education workers, students, parents and key stakeholders in order to provide information support for training in a pandemic.

ACKNOWLEDGEMENTS

The results of scientific research are obtained in accordance with the complex research topic of the Bila Tserkva Institute of Continuing Professional Education: "Improvement of modern models of vocational education teachers' refresher training in the context of formation and development of professional competence" (registration number 0117U002381, 2017-2021).





REFERENCES

- [1] O. Shparyk, "Conceptual foundations of digital transformation of education: European and American discourse," *Ukrainian Educational Journal*, no. 4, pp. 65–76, Dec. 2021, doi: 10.32405/2411-1317-2021-4-65-76.
- [2] O. Medvedovskaya, "Digital transformation of education in Ukraine," *Sustainable development in a modern knowledge society*, pp. 118–128, 2021.




- [3] Office of Educational Technology, "National education technology plan." 2017, doi: 10.4324/9781138609877-ree23-1.
- [4] O. P. Krupskyi, O. Dzhusov, N. Meshko, I. Britchenko, and A. Prytykin, "Key sources when formulating competitive advantages for hotel chains," *Tourism*, vol. 67, no. 1, pp. 34–46, 2019.
- [5] O. Uliutina, O. Artemenko, and Y. Vyshnevskaya, "Domestic violence against women in marriage and family relations: Ways of regulation and legal settlement in Ukraine," *The Journal of International Legal Communication*, vol. 1, pp. 40–46, 2021, doi: 10.32612/iuw.27201643.2021.1.
- [6] J. Osiejewicz, "Transnational legal communication: towards comprehensible and consistent law," *Foundations of Science*, vol. 25, no. 2, pp. 441–475, 2020, doi: 10.1007/s10699-020-09655-3.
- [7] V. Sydorenko, I. Shorobura, A. Ponomarenko, M. Dei, and O. Dzhus, "Application of technologies of formal and non-formal education for continuous professional development of the modern specialist," *Revista Tempos e Espaços em Educação*, vol. 13, no. 32, pp. 1–24, 2020, doi: 10.20952/revtee.v13i32.14729.
- [8] Law of Ukraine No. 1556-VII, "On higher education." 2018, [Online]. Available: <https://zakon.rada.gov.ua/laws/show/1556-18>.
- [9] Digital Agenda of Ukraine, "Conceptual ambushes (version 1.0). Priority spheres, educational programs, projects of 'digital technologies' of Ukraine until 2020." 2020, [Online]. Available: <https://ucci.org.ua/uploads/files/58e78ee3c3922.pdf>.
- [10] D. Lukyanenko and O. Stepanenko, "Digital university: Project for the development of the digital university in the DVNZ," in *Digital Economy: Collection of Materials of the National Science and Methodological Conference*, 2018, pp. 245–249.
- [11] V. Sydorenko, A. Yermolenko, A. Lukiianchuk, A. Denysova, and V. Y. Haragirlo, "Plataforma 'Profosvita' as an innovative educational and digital environment for the professional development of specialists," *Education & Training. Journal of the Graduate Program in Education at the State University of Ceará*, vol. 5, no. 3, pp. 1–17, 2020.
- [12] Law of Ukraine No. 2145-VIII, "On education." 2017, [Online]. Available: <https://zakon.rada.gov.ua/laws/show/2145-19>.
- [13] G. Di Pietro, F. Biagi, P. Costa, Z. Karpiński, and J. Mazza, *The likely impact of COVID-19 on education: Reflections based on the existing literature and recent international datasets*. Luxembourg: Publications Office of the European Union, 2020.
- [14] O. Udovyk, O. Mosalenka, and I. Kylymnyk, "Bridging the digital gap in Ukraine: a human-centric approach," *United Nations Development Programme*. 2020, [Online]. Available: <https://www.ua.undp.org/content/ukraine/uk/home/blog/2020/bridging-the-digital-divide-in-ukraine--a-human-centric-approach.html>.
- [15] European Commission, "DigCompUA for Citizens 2.1. Description of the framework of digital competence for citizens of Ukraine." 2021.
- [16] M. Marienko and A. Sukhikh, "The organization of the educational process in the ZZSO by means of digital technologies during martial law," *Ukrainian Pedagogics Journal*, vol. 2, pp. 31–37, 2022.
- [17] R. Vuorikari, Y. Punie, S. C. Gomez, and G. Van Den Brande, *DigComp 2.0: The digital competence framework for citizens. Update phase 1: The conceptual reference model*. Luxembourg: Publication Office of the European Union, 2016.
- [18] Ministry of Education and Science of Ukraine, "National qualifications framework." 2021.
- [19] UNESCO, "UNESCO ICT competency framework for teachers." United Nations Educational, Scientific and Cultural Organization, Paris, 2011, [Online]. Available: <https://www.unesco.org/en/digital-competencies-skills/ict-cft>.
- [20] European Commission, "SELFIE: A tool to support learning in the digital age." 2021, [Online]. Available: https://ec.europa.eu/education/schools-go-digital_en.
- [21] J. Nazarenko and O. Polishnuck, "Education in pandemic conditions in 2020/2021: Analysis of problems and consequences," *Cedos*. 2021, [Online]. Available: <https://cedos.org.ua/researches/osvita-v-umovah-pandemiyi-analiz-problem-i-naslidkiv/>.
- [22] Education and Science Employees Union of Ukraine, "The global 'digital divide' in distance learning: educators are looking for new solutions," *Official Website of the Education and Science Employees Union of Ukraine*. 2020, [Online]. Available: <https://pon.org.ua/novyny/7846-globalniy-cifrovyy-rozriv-u-distancynomu-navchann-osvtyani-shukayut-nov-rshennya.html>.
- [23] European Commission, "Educational inequalities in Europe and physical school closures during COVID-19," *Fairness policy brief series*. 2020, [Online]. Available: https://ec.europa.eu/jrc/sites/jrcsh/files/fairness_pb2020_wave04_covid_education_jrc_i1_19jun2020.pdf.
- [24] School Education Gateway, "Survey on online and distance learning—Results," Erasmus+. [Online]. Available: <https://www.schooleducationgateway.eu/en/pub/viewpoints/surveys/survey-on-online-teaching.htm>.
- [25] Ministry of Digital Transformation, "17,000 settlements do not have any optical provider—a study by the Ministry of Ministry of Digital Transformation," *Official Website of the Ministry of Digital Transformation*. 2020, [Online]. Available: <https://thedigital.gov.ua/news/17-tisyach-naselenikh-punktiv-ne-mayut-zhodnogo-optichnogo-provaydera-doslidzhennya-mintsifri>.
- [26] M. Anderson, "Mobile technology and home broadband 2019," *Pew Research Center*. 2019, [Online]. Available: <https://www.pewresearch.org/internet/2019/06/13/mobile-technology-and-home-broadband-2019/>.
- [27] V. Y. Bykov et al., "Scientific and methodological provision of digitalization of education in Ukraine: Status, problems, prospects," *Scientific and methodological provision of digitalization of education in Ukraine: status, problems, prospects*, vol. 4, no. 2, pp. 1–49, 2022, doi: 10.33407/lib.naes.733151.

BIOGRAPHIES OF AUTHORS






Viktoriia V. Sydorenko     is Ph.D. in linguistics, doctor of education, Associate Professor, Head of Bila Tserkva Institute of Continuing Professional Education, Bila Tserkva, Ukraine. She is a certified trainer of the New Ukrainian School. She is the author of more than 300 scholarly papers. Her research interests include higher education development, digital transformation in education, New Ukrainian School. She can be contacted at email: viktoriia.sydorenko@pltch-sci.com.






Inna O. Akhnovska    is Ph.D. in economics, associate professor at the Department of Entrepreneurship, Corporate and Spatial Economics, Vasyl' Stus Donetsk National University, Vinnytsia, Ukraine. Her research interests include knowledge economy, family education, open education, business education, innovative economic development. She can be contacted at email: inna.akhnovska@sci-univ.com.






Sergiy V. Smirnov    is Ph.D. in education, associate professor at the Department of Ship Handling, Educational and Scientific Institute of Maritime Transportation and Technology, National University "Odessa Maritime Academy", Odessa, Ukraine. He can be contacted at email: sergiy.smirnov@acu-edu.cc.



Igor A. Verbovskiy    is Head of Educational Department, Senior Lecturer at the Department of Pedagogy, Professional Education and Academic Establishments Management, Zhytomyr Ivan Franko State University, Zhytomyr, Ukraine. He organizes the work of the educational department, monitors the work of the examination commissions of the university, participates in the development of curricula, working curricula and methodological recommendations for their development, prepares a draft order on the organization and planning of the educational process, calculates and distributes the load among the departments of the university, administers the work of the Dean's Office system. He can be contacted at email: igor.verbovskiy@edu-knu.com.



Olha V. Melnychuk    is Ph.D. in history, Head of the Department of Documentation and Information Technologies, Academy of Recreational Technologies and Law, Lutsk, Ukraine. Her research interests are school education, higher education, digitalization. She can be contacted at email: olha.melnichuk@sci-academy.cc.