

Digitalisation and its role in developing hard skills among university students in Ukraine



Nataliia Vovchasta^a   | Olena Kan^b  | Yuliia Hlavatska^b  | Kateryna Sovach^b  |
Svitlana Makukhina^b 

^aDepartment of Foreign Languages, Lviv Polytechnic National University, Lviv, Ukraine.

^bDepartment of Public Administration, Law and Humanities, Faculty of Economics, Kherson State Agrarian and Economic University, Kherson, Ukraine.

Abstract The rapid growth in the significance of digital technologies in education has created new opportunities for developing hard skills in specialists across various economic sectors, especially in the dynamic modern labour market. However, in the Ukrainian context, the digitalisation of the educational process is accompanied by several challenges, including financial issues, ensuring equal access to education, and adapting traditional teaching methods to the aftermath of a prolonged war, the destruction of critical infrastructure, and political instability. This study aims to determine the impact of digitalising the educational process on the formation and development of hard skills among Ukrainian higher education institution students. The article analyses the latest approaches, methods, and technologies relevant for implementation in modern educational programmes and evaluates their effectiveness in developing students' professional skills in various specialities. Additionally, the article identifies the challenges and opportunities associated with digitalising education during a prolonged war. This study employs general scientific methods of literature review, systematisation, synthesis, and expert evaluation to obtain initial data on the level of acquired hard skills among 25 third-year students at the two Ukrainian universities. This is attributed to the university's modern approach to the educational process, characterised by using the Major&Minor model and microlearning. At the same time, students at Taras Shevchenko National University of Kyiv, despite having high academic performance, are less progressive but are also gradually adopting modern digital practices. Ukraine's experience under the prolonged impact of armed conflict highlights the need to address inequalities in access to quality education for students from different regions, ensure optimal financial support, and create an adaptive and inclusive learning environment to enhance students' professional skills and digital competence under crisis conditions. Therefore, the Ukrainian educational community must improve students' acquisition of hard skills in various fields by optimising educational programmes in light of resource constraints and security risks.

Keywords: digital transformation, practical skills, higher education, educational programme, distance learning, innovative technologies

1. Introduction

The digitalisation of the educational process is one of the driving forces behind the current transformation in education. This development has become particularly relevant worldwide due to the prolonged COVID-19 pandemic. In this context, the priority direction for advancing education is the implementation of innovative technologies and methods for distance, remote, and blended learning (Yuzkiv et al., 2020). Over 77% of public and 73% of private schools in the United States have shifted to online learning formats to ensure uninterrupted access to education for all student categories (Allen, 2024). The widespread adoption of distance learning in educational practice has necessitated enhancing participants' digital literacy in the learning process, improving the qualifications of teaching staff, and ensuring a psychologically conducive learning environment amidst rapid technological advancements. Although the scientific discourse does not dispute the continued effectiveness of digitalisation in the educational process for developing professional competence and priority hard skills among students, existing barriers to the widespread use of new technologies—including primarily staffing and financial resources—slow the implementation of advanced educational practices. Additionally, local issues, such as the ongoing war waged by Russia against Ukraine, on one hand, prompt educational institutions to seek new solutions, while on the other, they create an unfavourable environment for integrating innovative methods and technologies into the overall education system.

This scientific article aims to investigate the impact of digitalisation on developing and enhancing priority hard skills among students of higher education institutions in Ukraine. It analyses the innovative digital technologies being implemented in the educational process in response to the acceleration of technological progress. Within the framework of this study, it is essential to assess the effectiveness of the identified measures in developing critical professional skills among students from various specialities, particularly those in technical fields.



The digitalisation of education requires higher education institutions to create an effective digital educational environment, necessitating a profound modernisation of the educational process to prepare students for professional activity in a digital society (Kremen et al., 2022). However, the digitalisation of the educational process negatively impacts training students in various specialisations. For instance, Dymar et al. (2021) noted the difficulty of forming professional competencies in medical students under remote learning conditions. Additionally, Bakhmat et al. highlighted that the development of digital technologies leads to a skills gap among students due to varying opportunities and the quality of education in different countries or even within different institutions in the same country noted (Bakhmat et al., 2023). Several contemporary studies are focused on identifying the impact of digitalisation on students' academic performance, skill levels, and overall perception of the learning process. For example, Cicha et al. identified critical trends in Polish students' attitudes towards an alternative learning model based on a general mastery of e-learning technologies (Cicha et al., 2021). The findings of this study confirm the appropriateness of using this technology to engage Polish students and increase their satisfaction with the quality of education obtained remotely.

In contrast, Rusakova et al. analysed the recent changes in interaction and communication between teachers and students in higher education institutions, emphasising the need for ensuring the quality of technical and technological support for learning, as well as integrating inclusive and flexible approaches to maintain the adequacy of the learning process and communication between participants in the educational process. In some countries, the necessity of shifting education to a remote or hybrid format has not diminished even after the lifting of quarantine restrictions (Rusakova et al., 2023). In particular, the case of Ukraine, which is enduring a prolonged war, shows that direct interaction and personal presence remain the privileged modes of education. At the same time, online learning has become a new reality under Russia's armed aggression. This shift ensures the accessibility and continuity of quality education for many learners (Marchuk, 2023). In Ukraine, today's realities require not only the gradual implementation of digital practices in educational programmes but also the urgent need to provide access to learning materials regardless of students' location, especially given the inability to safely conduct offline education in most regions of the country (Didkivska, 2023).

Furthermore, the psychological state of the population is unsatisfactory, necessitating that higher education institutions focus on creating a safe space for effective collaboration, learning, self-learning, and establishing efficient communication among all participants in the educational process in a networked environment (Humeniuk et al., 2023). In this context, an essential area for improving the work of educational institutions is raising the level of digital competence and literacy among students (Tytova & Mereniuk, 2022); preparing, retraining, and improving the qualifications of teaching staff in the context of digital technologies (Banyoi et al., 2023). Applying educational design and psychological support to adaptive information-digital didactic systems that consider learners' cognitive interests, intellectual abilities, and psychological development characteristics (Lazareva et al., 2024). The modern opportunities offered by new educational technologies and the challenges accompanying the digitalisation of educational institutions necessitate the formation of new approaches to acquiring hard skills among students of various specialisations and learning formats (Goulart et al., 2022). Among the most progressive approaches are gamification of learning, the integration of virtual (VR) and augmented reality (AR) (Lampropoulos et al., 2022; Lu et al., 2021; Pinchuk et al., 2019), the implementation of project-based learning (PBL) (Hsbollah & Hassan, 2022; Kim, 2019), the development and implementation of learning management systems (LMS) (Kuzheliev et al., 2023), simplifying learning through microlearning (Taylor & Hung, 2022), and the Major&Minor model, which allows educational institutions to realise the principle of interdisciplinarity (Fedorova & Shuliak, 2020; Zlenko & Isaikina, 2019). However, according to Hrynevych is essential to consider that during wartime, it is challenging to introduce new approaches and methods into an already established educational process, given that educational institutions lack the resources to provide the most modern equipment and technologies. At the same time, others find it challenging to attract and retain highly qualified teachers due to reduced funding for local education (Hrynevych, 2024).

2. Materials and Methods

In the course of the research, the following methods were employed:

- Literature analysis was used to identify the key challenges and opportunities of digitalising the educational process concerning the hard skills of students in higher education institutions.
- The generalisation method was applied to formulate the most effective approaches to enhancing learning efficiency within a digital educational environment.
- The systematisation method explored the barriers to implementing innovative digital practices in the education system under war conditions, crises, and political instability.
- The comparative analysis was used to evaluate students' success rates in acquiring education and the necessary hard skills for further academic and professional activities in the IT sector.
- Statistical data analysis was employed to assess the effectiveness of modern teaching approaches in IT students acquiring hard skills by identifying statistically significant differences between the metrics.

For this study, a total of 12 instructors from IT STEP University and Taras Shevchenko National University of Kyiv were surveyed regarding the level of hard skills acquired by third-year students (Group 1 = 25 individuals; Group 2 = 25 individuals) enrolled in the "122 Computer Science" educational-professional programme. The initial data are presented in Appendix. During the interpretation of the survey results, average success rates were calculated for each of the identified hard skills using the "Average" function in Excel's analysis package. The subsequent research was based on the need to determine the effectiveness of modern teaching approaches in acquiring hard skills. For this purpose, a Paired Samples T-Test was conducted using the JASP statistical program, and the Standard Error (SE) Definition was determined using the "Classical Paired Samples T-Test" tool. The results allowed for conclusions regarding the statistical significance of the differences between the assessments of acquired hard skills.

3. Results and Discussion

The modern development of digital technologies has significantly impacted the transformation of the educational process, notably fostering the active implementation of online learning formats. Given that distance learning is becoming an effective alternative to traditional methods, especially in the context of global challenges, it is essential to ensure access to educational materials for all participants in the educational process, regardless of their location, and to create a safe space for learning and effective collaboration (Didkivska, 2023; Humeniuk et al., 2023).

The most relevant approaches to enhancing the effectiveness of education for developing hard skills among higher education students include gamification, which improves student engagement by incorporating game elements that encourage task completion, reward earning, and problem-solving within educational courses (Lampropoulos et al., 2022). Additionally, increasing practicality and visual appeal through the integration of virtual (VR) and augmented reality (AR) elements to create educational environments allows students to interact with educational materials, merging digital aspects with real-world environments (Lu et al., 2021; Pinchuk et al., 2019).

Project-based learning (PBL), on the other hand, focuses on applying knowledge in real-world conditions through the creation and execution of projects aimed at solving specific problems. Furthermore, by developing critical thinking, collaboration, and an original approach to problem-solving, this type of learning ensures the acquisition of relevant skills for future professional activities (Hsbollah & Hassan, 2022). It is also essential to ensure quality management, organisation, and regulation of the educational process by utilising specialised LMS software, which enables tracking student progress, centrally storing and distributing educational resources, and assessing learning outcomes (Kuzheliev et al., 2023).

Introducing new approaches to the educational process also contributes to developing hard skills among higher education students across various educational fields. For example, microlearning, which involves dividing material into short, easily digestible segments, enhances students' understanding of the practical application of acquired skills (Taylor & Hung, 2022). Meanwhile, the Major&Minor model helps concentrate on developing priority hard skills in a student's primary field of study (Major) while combining them with skills in an additional field (Minor), broadening students' qualifications. This model improves the educational process by fostering multidisciplinary and developing comprehensive knowledge in students from various educational programmes (Fedorova & Shuliak, 2020).

In light of the identified directions for digitalising the educational process, it is essential to investigate how effective the updated system is, incorporating elements of microlearning, gamification, and other innovations in the educational process for students of different specialities. To conduct such research, an expert survey was conducted among instructors from two Ukrainian universities regarding students' success in acquiring education and the necessary hard skills for future scientific and professional activities in the IT field. The criteria of this analysis are comprehensive and include the following hard skills:

- Programming: This includes proficiency in programming languages (Python, C++, JavaScript) and working with frameworks (Spring, React, Angular).
- Data Analysis and Processing: This involves students' ability to work with databases, including SQL and NoSQL.
- Software Development: Software Engineering, Unit testing and automated software testing.
- Web Development encompasses web design, page layout, client-side and server-side web programming, and web server configuration.
- Cloud Platform Work: This involves proficiency with cloud platforms such as AWS, Microsoft Azure, and Google Cloud.
- Machine Learning Model Development: This includes neural networks, dimensionality reduction, clustering, and regression.
- General English Language and Professional English Proficiency.

The obtained data include the academic performance results of third-year students from IT STEP University (Group 1 = 25 students) and Taras Shevchenko National University of Kyiv (Group 2 = 25 students), who are studying under the educational and professional programme "122 Computer Science" (Appendix A). To interpret the survey results, weighted average

performance indicators for each identified hard skill were calculated using Excel's analysis package (the "Average" function), summarised in Figure 1.

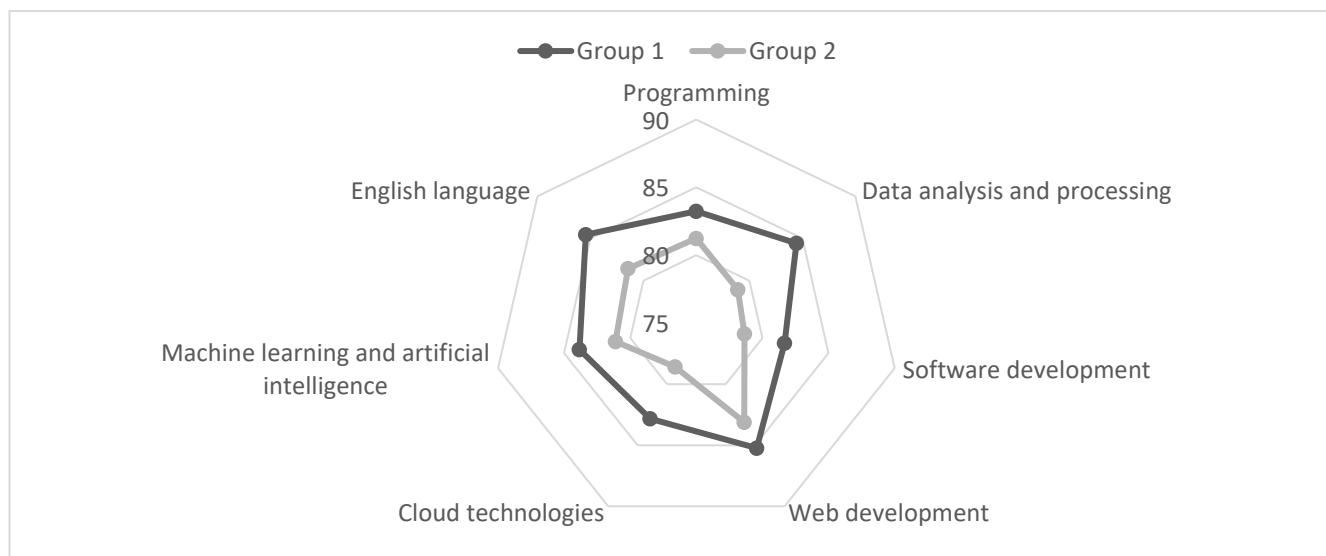


Figure 1 Results of assessing students' hard skills in IT.

The noticeable gap in hard skills mastery among students at IT STEP University is due to the institution's modern approach to modelling the educational process. Specifically, the Major&Minor educational model, combined with microlearning elements, allows students to focus on the most prioritised skills while reinforcing them with necessary or complementary knowledge. This approach accounts for the high proficiency in English (85.4), programming skills (83.2), and data analysis and processing (84.4). Additionally, the university ensures a high level of competency in the context of the knowledge, skills, and practical abilities demanded by the IT industry. This is achieved through the formation of knowledge and motivation to create unique student projects, significantly easing the assimilation of educational programmes related to software development (81.7) and web development (85.2). Relatively new educational areas focused on mastering cloud technologies (82.8), machine learning, and artificial intelligence technologies (83.8) are also better absorbed by IT STEP University students, primarily due to the personalised and project-oriented approach to learning. However, traditional education systems are still relevant. Taras Shevchenko National University of Kyiv also develops relevant skills and knowledge for IT students and gradually implements new solutions in its activities. For instance, the university actively utilises LMS, particularly Moodle, to create a quality virtual learning environment, optimise time, and improve the content of educational programmes.

For a more comprehensive comparative analysis between the two groups of students, a Paired Samples T-Test was applied, and the Standard Error (SE) Definition was determined by processing the raw data from Appendix A in the JASP statistical program (using the "Classical Paired Samples T-Test" tool). The essence of this test lies in comparing the results of two student groups, one of which studied online with modern curricula using new approaches to information delivery and knowledge acquisition. In contrast, the other used a traditional offline system (Halter, 2018). The results of the analysis are presented in Table 1.

Table 1 Analysing the effectiveness of modern teaching approaches in the process of acquiring hard skills by it students.

Measure	Paired Samples T-Test			Mean Difference	SE Difference
	t-value	df	p		
Programming	0.645	24	0.263	2.000	3.103
Data analysis and processing	1.781	24	0.044	5.520	3.100
Software development	1.082	24	0.145	3.040	2.809
Web development	0.684	24	0.250	2.120	3.097
Cloud technologies	1.473	24	0.077	4.240	2.879
Machine learning and artificial intelligence	0.981	24	0.168	2.720	2.772
English language	1.843	24	0.039	4.000	2.170

Note: The alternative hypothesis specifies that Measure 1 is more significant than Measure 2 for all tests.

Note: Student's t-test.

The analysis revealed a statistically significant difference between the data analysis and processing skills scores among students ($t = 1.78, p = 0.04$), where the innovative approach to education showed a clear advantage with a high mean difference in scores ($MD = 5.52$). A significant difference was also found between the performance of the two groups in English language



studies ($t = 1.84$, $p = 0.04$), where the mean difference ($MD = 4.0$) indicates a positive impact of digitalisation on the development of the language learning curriculum. Additionally, there is a trend toward an increasing gap in the scores of students when mastering cloud technology materials ($MD = 4.24$) and a predominance of scores for students studying remotely using modern technologies ($t = 1.47$, $p = 0.08$). The modern software development skills training system at IT STEP University, compared to Taras Shevchenko National University of Kyiv, allows students to be highly engaged in practical sessions, resulting in a moderate level of statistical significance ($t = 1.082$, $p = 0.15$) but a high mean advantage ($MD = 3.04$), suggesting that traditional methods can still compete with digital approaches. On the other hand, the difference in students' ability to work with machine learning and artificial intelligence technologies is insignificant ($t = 0.981$, $p = 0.17$) with a high mean advantage of ($MD = 2.72$), indicating that IT STEP University does not have a pronounced advantage over traditional teaching methods in this area. Meanwhile, programming ($t = 0.65$, $p = 0.26$) and web development ($t = 0.68$, $p = 0.25$), which have been taught traditionally for a long time, did not show statistically significant differences between the two groups. However, the analysis points to a slight advantage in the scores of IT STEP University students.

The digitalisation of the educational process is a fundamental factor in transforming modern higher education in the global educational environment. Given the necessity for digitalisation and distance learning that arose during the COVID-19 pandemic, the global community has intensified efforts to create and implement effective digital educational environments. In this context, an essential aspect of improving the education system is adapting university curricula and programmes to digital environments, prompting educational institutions to enhance digital literacy among participants in the educational process and implement inclusive approaches to ensure their effective interaction.

This study has confirmed the views of several leading scholars regarding the necessity of creating an effective digital educational environment in the context of the rapid development of innovative educational technologies (Kremen et al., 2022; Yuzkiv et al., 2020). The challenges of modernising the educational process through digitalisation include the uneven qualifications of students (Bakhmat et al., 2023) and ensuring the consistency and effectiveness of interactions among educational process participants (Rusakova et al., 2023; Humeniuk et al., 2023). However, this study showed that the most critical area is improving the process of acquiring relevant professional competencies and hard skills among students of various educational programmes (Cicha et al., 2021; Dymar et al., 2021; Kubitskyi et al., 2022). The case of Ukraine provides insights into the difficulties of digitalising the educational process during periods of war, crisis development, and political instability. In this context, we agree with Marchuk on ensuring accessibility and continuity of education for students in frontline and remote regions and the need for additional financial resources (Marchuk, 2023; Hrynevych, 2024).

In the Ukrainian context, the transformation of higher education is accompanied not only by the aftermath of quarantine restrictions but also by the prolonged military aggression by the Russian Federation. Integrating innovative technologies, primarily learning management systems (LMS) and tools for online learning, in Ukraine is necessary to prevent inequality in access to quality education between regions directly affected by the war and more peaceful areas where distance education is not widely used. Moreover, the financial support for quality student preparation for professional activity in the digital society under Ukrainian realities must cover educational needs and safety, such as equipping bomb shelters, providing equipment and opportunities for educators, and creating psychologically conducive educational programmes. This situation partially addresses the challenges in forming professional competencies and unequal access to quality education. However, it remains a pressing issue for many higher education institutions and the scientific community. However, in wartime conditions, most of the country's universities have focused on ensuring an adaptive and inclusive educational environment that maintains the quality of students' professional knowledge and skills and enhances their digital competence.

Furthermore, we believe that enhancing the digital literacy of educational process participants (Tytova & Mereniuk, 2022), improving the qualifications of educational staff (Banyoi et al., 2023), and employing pedagogical design and psychological support for adaptive information and digital didactic systems (Lazareva et al., 2024) are adequate directions for the development of Ukrainian education amid Russia's full-scale invasion of Ukraine. This study demonstrated practical approaches to developing IT students' hard skills, including creating personalised curricula based on interdisciplinarity, project-based learning, and microlearning. Therefore, it was determined that the primary means of optimising educational programmes in higher education institutions are learning management systems and online learning technologies. Given that traditional teaching methods remain relevant, a combined approach integrating innovations into a stable educational process is advisable.

4. Conclusions

The study indicates that the digitalisation of the educational process and the implementation of innovative teaching methods significantly impact the formation of IT students' hard skills. This suggests the feasibility of gamification with elements of VR and AR, implementing LMS, using PBL, and applying the Major&Minor and microlearning approaches in developing and subsequent curricula for technical specialities. However, traditional teaching and organisational methods still need to compete with new models due to years of experience and a high level of communication within the educational system. Further research should increase the sample size and expand the criteria list to understand the impact of digitalisation phenomena in education on the hard skills of students in all technical specialities or focus on STEM fields.

Ethical Considerations

We confirm that we have obtained all consent required by applicable law to publish any personal details of research participants. We agree to provide Multidisciplinary Reviews with copies of the consent or evidence that such consent was obtained if requested.

Conflict of Interest

The authors declare no conflicts of interest.

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