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# The Role of Innovative Technologies in Supporting the Educational Process of Ukrainian Higher Education Institutions in Wartime

Svitlana Verezomska[1], Nadiya Balandina[2], Nataliia Zinchenko[3], Iryna Salnyk[4], Tetiana Volotovska[5]

[1]Department of Philosophy and Social Sciences, Poltava State Medical University, Poltava, Ukraine

[2]Department of Information Activity and Media Communications, Institute of Humanities, Odesa Polytechnic National University, Odesa, Ukraine

[3]Department of Philosophy and Social Sciences, Poltava State Medical University, Poltava, Ukraine

[4]Department of Mathematics, Physics and Teaching Methods, Volodymyr Vynnychenko Central Ukrainian State University, Kropyvnytskyi, Ukraine

[5]Department of Pedagogy, Administration and Special Education, University of Education Management, Kyiv, Ukraine

Correspondence: Svitlana Verezomska, Department of Philosophy and Social Sciences, Poltava State Medical University, Poltava, Ukraine. Email: sverezomska@gmail.com

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**Abstract**

The aim of the study was to identify the role of innovative technologies in supporting the educational process in Ukrainian HEIs during the war. Attention was paid to under-researched solutions: edge/fog computing, low-resource AI for tutoring, energy-efficient offline mobile platforms, AR technologies, and blockchain registries. The study used a mixed design: questionnaires (n = 189) and semi-structured interviews. Teachers, students, and administration were involved in the study. The results showed that the highest average scores were received by energy-efficient mobile platforms (M = 4.1; SD = 0.86) and low-resource AI (M = 3.9; SD = 0.91). Edge/fog computing had an average score (M = 3.6), while AR (M = 3.3) and blockchain (M = 3.1) were rated lower. Correlation analysis revealed strong positive relationships between experience and readiness to implement technologies, particularly for AI ($r = 0.55$, $p < 0.001$). Factor analysis (PCA) identified two dimensions: “practical effectiveness” (mobile platforms, AI, edge/fog) and “innovation” (AR, blockchain), which explained 62.3% of the total variance. Qualitative analysis of interviews confirmed the presence of barriers: technical (unstable internet, lack of equipment), organizational (low support from administrations), and psychological (distrust of new tools). Respondents noted the flexibility, personalization, and motivational effect of using such technologies. These points considered that low-resource and energy-efficient solutions are the most promising for ensuring continuity of training in wartime conditions.

**Keywords:** innovations, low-resource AI, edge/fog computing, mobile platforms, digital resilience, Ukraine

## 1. Introduction

### *1.1 Introduce the Problem*

The full-scale war in Ukraine has put the higher education system in exceptionally difficult conditions. In particular, the long-term risks of air strikes, the forced relocation of institutions and students, the instability of power supply and Internet connectivity have influenced the need to find innovative solutions to support the educational process (Yuryk et al., 2024; Ober et al., 2025). Traditional approaches to the use of digital technologies, in particular learning management systems (LMS) or video conferencing, are no longer sufficient today (Ma et al., 2022). It played the role of basic infrastructure but did not provide the adaptability and flexibility required by modern critical situations. Problems such as the instability of infrastructure, mass migration of students and teachers, and the psychological pressure of military events increased the use of more new innovations that determine the competitiveness of Ukrainian higher education institutions in the modern academic space (Zhyhora et al., 2024; Zayachuk, 2024).

However, despite the large number of studies describing the features of using standard digital tools (videoconferencing, LMS, electronic textbooks), there is currently a lack of attention to less common but potentially effective technologies that can function in resource-limited and crisis situations. There is a noticeable interest in the analysis of adaptive

educational platforms (Londar & Pietsch, 2023; Zakhozhai et al., 2024). Some scientists have drawn attention to the importance of microlearning technologies, VR/AR education, and the integration of artificial intelligence into learning (Hunko et al., 2024; Kalashnikova & Lytovchenko, 2024). At the same time, studies by other scientists focus on problematic aspects of the digitalization of education and the use of online platforms, digital resources, and cloud technologies in crisis conditions (Havryliuk et al., 2024; Kuzheliev et al., 2023). Galynska and Bilous (2022) highlighted aspects of distance learning during wartime, while Tarasenko et al. (2024) discussed effective educational systems both during and after conflict. Kibenko and Popadych (2024) noted that higher education institutions adapted through organizational flexibility, shifting to distance formats, and adopting new quality assurance methods under martial law. To support these points, Lugovyi et al. (2023) recognized the impact of war on the network of higher education institutions, admission campaigns, QA procedures and international support. Additionally, the need for structural reforms and targeted digital transformation tools has been highlighted by Prykhodko et al. (2025) and Orzhel et al. (2023). These conclusions form the "background" for our hypothesis about the feasibility of such technologies as edge/fog, low-resource AI and blockchain). Also important are the results of scientists who indicated that in wartime conditions students prefer media-oriented and interactive learning formats (Bondarchuk et al., 2024; Tsekhmister, 2024). For this reason, most modern scientists have considered the role of digitalization in ensuring the sustainable development of Ukraine (Marhasova et al., 2023; Mohylna, 2022). For these authors, education was a determinant of competitiveness and sustainability, and blended/distance formats were important platforms for scaling access (Mazur et al., 2025; Orzhel, 2022). However, in modern scientific discourse there is practically no comprehensive work devoted to the features of using decentralized educational clouds (edge/fog computing) to overcome infrastructure barriers, using low-resource AI tutors for regions with limited access to the Internet, implementing energy-efficient mobile educational solutions adapted to frequent power outages, and operating blockchain registries to preserve academic data in wartime conditions. Thus, there is an important research gap in current scientific discourse, which is associated with the lack of analysis of these technologies that can ensure the sustainability of the educational process, even in such crisis conditions as wars.

The purpose of the study is to determine the potential of little-studied innovative technologies in supporting and developing the educational process of Ukrainian higher education institutions during wartime, as well as to analyze effective implementation in practice.

Research questions:

1. What innovative technologies (edge/fog computing, AR, low-resource AI, energy-efficient mobile platforms, blockchain) are the most effective for supporting the educational process of Ukrainian higher education institutions during the war?

2. What factors influence the readiness of students, teachers, and administration to implement these technologies?

3. What barriers and opportunities do different participants in the educational process see in the application of these technologies, and how can quantitative and qualitative results be integrated to build a holistic model of their implementation?

## 2. Method

### *2.1 Research Design*

This study is based on a mixed approach, which involves the synthesis of quantitative and qualitative data collection methods. This choice is due to the complexity of the subject: innovative technologies in wartime conditions affect both the technical side of the educational process and psychological perception, organizational practices and pedagogical strategies.

The quantitative stage (questionnaire) made it possible to form a generalized picture of the level of awareness, use and attitude towards innovative technologies in education. It provided the opportunity to statistically assess the differences between groups of participants. At the same time, the qualitative stage (semi-structured interviews and expert survey) influenced the identification of the main barriers and hidden factors of the implementation of new technologies in higher education. The combination of such approaches ensured triangulation and increased the reliability of the results.

### *2.2 Participants*

The study involved 189 respondents, divided into three key categories of the educational process:

1. Students of higher education institutions ($n \approx 110$)

The sample included undergraduate and graduate students of various specialties (humanities, technical, pedagogical and medical fields).

2. University teachers ($n \approx 55$)

Representatives of various faculties and departments who have experience in using digital tools during the war. Teachers have become key technology providers, as they are the ones who integrate innovative tools into the educational process.

3. Administrative and technical staff of higher education institutions (n ≈ 24)

This group consisted of representatives of the administration, employees of digitalization departments and IT specialists. It was the administration that made strategic decisions on the implementation of technologies, and technical staff were responsible for their configuration and support.

The sample was formed on the principle of purposeful stratification using elements of regional and profile characteristics.

The triangle "students - teachers - administration" made it possible to determine and evaluate the educational process, identify consistency and gaps in the attitude towards innovative technologies between different levels of the educational ecosystem.

*2.3 Plan for the Implementation of Innovative Technologies*

The developed plan was based on the principle of adaptability, that is, each technology had to be implemented considering crisis conditions, including factors such as:

1. Unstable Internet.

2. Power outages.

3. The lack of equipment for some students was considered.

Iinnovative but less researched technologies were selected that have the potential to compensate for these challenges.

1. Edge/Fog Computing

These technologies involved the implementation of local servers or mini clouds located closer to students (for example, on the university grounds or in shelters). These technologies made it possible to work with educational materials even with limited access to the global network.

Main tools and infrastructure:

- Open platforms for deploying local servers (e.g., Nextcloud, ownCloud);
- Mini-server devices (e.g., Raspberry Pi or local NAS systems).

Implementation methods:

- Teachers upload educational materials to the local cloud environment;
- Students access the materials via a local Wi-Fi network without the need for a stable Internet connection.

Methods for assessing effectiveness:

- Questionnaires administered to teachers and students;
- Monitoring of usage statistics (e.g., number of downloads, frequency of access, user activity).

2. Augmented reality (AR) for asynchronous learning

These technologies involved the use of AR applications that made it possible to study complex topics (anatomy, engineering models, and architecture) via smartphones without the need for expensive VR helmets.

The main tools consisted of applications: ARKit (Apple), ARCore (Google) for creating mobile applications. Ready-made platforms: Zappar, Assemblr EDU.

Implementation methods included the use of interactive 3D models in laboratory work and the development of educational “AR-cards”.

Methods for assessing effectiveness included student surveys on clarity and practical utility and comparative analysis of test results

3. Low-resource AI Tutors

This category included the implementation of offline algorithms based on machine learning that can work even with weak or no Internet.

The main tools consisted of applications: TensorFlow Lite, PyTorch Mobile for mobile AI applications. Chat bots in Telegram or Viber with built-in learning scenarios.

These technologies involved the use of a student's "digital assistant" to train skills (tests, practical tasks). An important task was also the formation of personalized tips based on the student's progress.

Methods for assessing effectiveness consisted of analyzing the frequency of use of the AI tutor, the average interaction time, and student feedback on the convenience and usefulness of learning.

4. Energy-efficient mobile educational platforms

These platforms consisted of applications with minimal battery consumption, optimized for unstable power supply.

Key tools and applications:

- Lightweight versions of learning management platforms (e.g., Moodle Lite, Google Classroom Go);
- Educational applications with offline access (e.g., Khan Academy Lite, Kolibri).

Implementation scheme:

- Teachers download educational materials into lightweight applications;
- Students complete tests and assignments offline;
- Data synchronization occurs automatically when an Internet connection becomes available.

The methods of assessing effectiveness included the use of resource consumption statistics (smartphone battery life) and analysis of student feedback on the convenience of the mode.

5. Blockchain registers of educational achievements

The study included the inclusion of a system for storing student results and certificates in the blockchain to protect against data loss in wartime. Such resources as OpenCerts, Blockcert and pilot educational blockchain platforms (EduCTX) were used. For this, student results were registered in the blockchain network. The assessment of effectiveness was based on an analysis of the security and reliability of data storage and a survey of the administration on the convenience of maintaining registers.

Instruments

The main tool in the study was a questionnaire developed in Google Forms and LimeSurvey.

Questionnaire structure:

Block 1. Socio-demographic data (age, gender, region, specialty, role in higher education institution).

Block 2. Level of awareness of innovative technologies (Edge/Fog computing, AR, low-resource AI, mobile offline platforms, blockchain).

Block 3. Experience of use (yes/no, frequency of use, convenience assessment).

Block 4. Attitude and readiness for implementation (Likert scales 1–5).

Block 5. Open questions for expressing opinions and suggestions (See Appendix 1).

Semi-structured interviews were also conducted based on the use of Google Meet resource. These meetings lasted an average of 30–45 minutes.

The main thematic blocks concerned the following aspects:

Experience of using innovative technologies during the war.

Main barriers to implementation (technical, organizational, psychological).

Advantages and disadvantages of using under-researched tools.

Expectations for their further development (See Appendix 2).

The data collection process consisted of a preparatory stage, where the questionnaire and interview guides were developed. This was followed by pilot testing of the questionnaire on a small group (10 people) to check the validity of the questions.

In particular, the content validity was checked using expert assessment. This involved considering the opinions of 3 teachers with experience in the field of educational technologies.

The content validity index (CVI), calculated as the percentage of questions that received a score of "relevant" or "very relevant", was 0.87 (with a recommended minimum of 0.80). Preliminary factor analysis confirmed the logical structure of three main blocks: "Awareness", "Experience", "Readiness to use". The questions correlated with each other within the expected subscales ($r = 0.42–0.68$). In addition, Cronbach's α coefficient was calculated for the key blocks:

"Awareness of technology" – $\alpha = 0.81$

"Experience of use" – α = 0.78

"Readiness to implement" – α = 0.84

All values exceed the threshold value of 0.70, which determined sufficient internal consistency.

The stage of collecting questionnaire data involved distributing online questionnaires among students, teachers and administrative staff. The duration of the collection was 3–4 weeks. Accordingly, 189 complete questionnaires were received during this time.

The next stage involved conducting interviews. The selection of participants was carried out on the principle of representativeness — different regions and profiles of HEIs. The interviews were conducted online and were recorded with the consent of the participants for the purpose of further analysis.

The expert survey involved the selection of experts through professional networks (in particular, Erasmus+ alumni, members of educational technology associations). This survey was conducted in the form of a combined questionnaire and short interviews.

*2.4 Data Analysis*

Statistical methods were used to process the questionnaire data, in particular, frequency analysis of responses (number and percentage), mean values (M), standard deviation (SD), median (Me) were calculated. At the same time, the internal consistency of the questionnaire blocks was checked using Cronbach's α ($\alpha \geq 0.70$ is considered acceptable). Correlation analysis (Pearson's method (r) to check the relationship between the level of awareness and Spearman's method (ρ) for ordinal variables) was also conducted. Student's t-test and Pearson's $\chi^2$-criterion were used to analyze associations between categorical variables. Regression and factor analyses were also conducted. Table 1 lists the main methods, formulas, and short variable designations.

Table 1. Methods, formulas, and variable designations

| Method | Formula name | Formula (text notation) | Variable notation |
|---|---|---|---|
| Correlation | Pearson's correlation coefficient | $r = \Sigma[(X_i - \bar{X})(Y_i - \bar{Y})] / \sqrt{(\Sigma(X_i - \bar{X})^2 \cdot \Sigma(Y_i - \bar{Y})^2)}$ | X – awareness; Y – readiness; n – number of observations. |
| Correlation | Spearman's rank correlation coefficient | $\rho = 1 - (6 \cdot \Sigma d_i^2) / [n(n^2 - 1)]$ | $d_i$ is the difference between the ranks of $X_i$ and $Y_i$; n is the number of pairs. |
| Regression | Linear regression (2 predictors) | $Y = \beta_0 + \beta_1 X + \beta_2 Z + \varepsilon$ | Y – readiness; X – awareness; Z – experience; ε – error. |
| Regression | Multiple regression (with covariates) | $Y = \beta_0 + \beta_1 X + \beta_2 Z + \beta_3 Age + \beta_4 Gender + \beta_5 Region + \beta_6 Role + \varepsilon$ | Age, Gender, Region, Role – control variables. |

Source: Author's development

## 3. Results

Participants rated the promise of each technology on a 5-point scale (1 = not at all promising, 5 = very promising) (See Appendix 3). Energy-efficient mobile platforms received the highest average score (M=4.34, SD=0.71). This indicated the importance of their perception as a key tool for supporting learning in crisis conditions. Low-resource AI tutors (M=4.18, SD=0.77) also showed high values, which determined a positive attitude towards personalized automated learning systems. Edge/Fog computing (M=4.02, SD=0.83) ranks third, confirming its strategic value. AR received average scores (M=3.67, SD=0.93), while blockchain ledgers (M=3.21, SD=0.98) remain the least supported technology (See Table 2).

Table 2. Prospects of innovative technologies according to participants' assessments (n=189)

| **Technology** | M | SD | Me | 95% CI | % Marks «4–5» |
|---|---|---|---|---|---|
| **Energy-efficient mobile platforms** | **4.34** | 0.71 | 4.0 | [4.24; 4.44] | **82%** |
| **Low-resource AI tutors** | 4.18 | 0.77 | 4.0 | [4.07; 4.29] | 76% |
| **Edge/Fog computing** | 4.02 | 0.83 | 4.0 | [3.90; 4.14] | 71% |
| **AR (asynchronous learning)** | 3.67 | 0.93 | 4.0 | [3.54; 3.80] | 58% |
| **Blockchain ledgers** | 3.21 | 0.98 | 3.0 | [3.07; 3.35] | 42% |

Analysis of variance (ANOVA) showed statistically significant differences between students, teachers and administration in three cases: Edge/Fog computing: administration rated the technology significantly higher than students ($F(2,186)=6.12$, $p=0.003$). At the same time, AR indicated that students showed more interest than administration ($F(2,186)=4.01$, $p=0.020$). Administration showed higher ratings of blockchain compared to students and teachers ($F(2,186)=9.04$, $p<0.001$). For energy-efficient platforms and Low-resource AI, intergroup differences were insignificant ($p>0.10$). This indicated a consensus of all categories of participants.

Correlation analysis revealed positive and statistically significant relationships between the level of awareness and willingness to use technologies. The strongest correlations were found for Low-resource AI ($r=0.51$, $p<0.001$) and Edge/Fog computing ($r=0.46$, $p<0.01$). For AR, the correlation is also significant ($r=0.42$, $p<0.01$). For blockchain, the relationship is weaker ($r=0.29$, $p=0.04$). Thus, knowledgeable participants rate the technology's potential higher. The regression model for willingness to implement low-resource AI showed that awareness ($\beta=0.33$, $p<0.001$) and experience in use ($\beta=0.38$, $p<0.001$) are the strongest predictors. Age had a weak negative effect ($\beta=-0.11$, $p=0.048$). (See Table 3).

Table 3. Correlations between awareness, experience, and readiness

| **Technologies** | Variables | Awareness | Experience | Readiness |
|---|---|---|---|---|
| **Energy-efficient platforms** | Awareness | 1 | 0.41** | 0.38** |
| | Experience | 0.41** | 1 | 0.44** |
| | Readiness | 0.38** | 0.44** | 1 |
| **Low-resource AI** | Awareness | 1 | 0.47** | 0.51*** |
| | Experience | 0.47** | 1 | 0.55*** |
| | Readiness | 0.51*** | 0.55*** | 1 |
| **Edge/Fog computing** | Awareness | 1 | 0.36** | 0.46** |
| | Experience | 0.36** | 1 | 0.41** |
| | Readiness | 0.46** | 0.41** | 1 |
| **AR** | Awareness | 1 | 0.33* | 0.42** |
| | Experience | 0.33* | 1 | 0.36* |
| | Readiness | 0.42** | 0.36* | 1 |
| **Blockchain** | Awareness | 1 | 0.27* | 0.29* |
| | Experience | 0.27* | 1 | 0.31* |
| | Readiness | 0.29* | 0.31* | 1 |

Note: *p<0.05, **p<0.01, ***p<0.001

Factor analysis, in particular PCA results (KMO=0.74, Bartlett test $\chi^2=146.3$, $p<0.001$) showed a two-factor structure. Factor 1 (practical efficiency) indicated energy-efficient platforms (0.78), Low-resource AI (0.74), Edge/Fog (0.66). (See Appendix 4). At the same time, Factor 2 (innovation/long-term) showed that AR - 0.71, blockchain -0.68. Thus, respondents divide technologies into those that can be applied immediately and those that have strategic importance. Table 4 presents the results of multiple regression.

Table 4. Multiple regression results (readiness for Low-resource AI, n=189)

| Predictor | **β** | **SE** | **t** | **p** |
|---|---|---|---|---|
| Awareness | 0.33 | 0.08 | 4.21 | <0.001 |
| Experience | 0.38 | 0.07 | 5.04 | <0.001 |
| Age | -0.11 | 0.05 | -1.99 | 0.048 |
| Gender | 0.04 | 0.06 | 0.66 | 0.51 |
| Region | 0.09 | 0.07 | 1.28 | 0.20 |
| Role in HEI | 0.07 | 0.05 | 1.42 | 0.16 |

Note: $R^2 = 0.42$, $F(6,182)=22.1$, $p<0.001$.

The strongest predictors are for awareness ($\beta=0.33$) and experience ($\beta=0.38$). At the same time, age has a small negative effect (older respondents are slightly less prepared). However, factors such as gender, region and role in the higher education institution are statistically insignificant.

## 4. Discussion

Analysis of qualitative data (in particular, open-ended questions of the questionnaire and semi-structured interviews) indicated 4 main groups of barriers and 3 groups of opportunities. Among the main problems, there are technical limitations. Student A indicated that "there is no stable internet in the dormitory, edge/fog would look ideal, but we do not have the equipment". The frequency of mentioning these difficulties is 68% of respondents. Financial costs were most often associated with AR and blockchain. Teacher B indicated that "in order for AR to work, you need

high-quality tools or at least modern smartphones". The frequency of mentions of this problem is 52%. The challenge of regulatory uncertainty is also serious. Teacher A indicated that "there are currently no clear instructions on how to legalize a blockchain diploma register." The frequency of mentions of this problem is 41%. The problem of cultural and pedagogical resistance is also serious. Teachers pointed to the problems of integrating new technologies into traditional approaches ("AI cannot replace a live mentor"). The frequency of mentions of this problem was 36%. However, opportunities were also noted. They were combined into 3 groups: continuity, personalization, data protection and trust. In particular, the continuity of the educational process was expressed in the fact that the selected mobile platforms provided access to materials during outages. This aspect was mentioned by 61% of respondents. At the same time, personalization of learning was expressed in the fact that low-resource AI tutors made it possible to adapt courses to a specific student (mentioned by 57%). At the same time, 44% of the teachers surveyed and administrators indicated that blockchain is perceived to increase the transparency of diplomas and certificates. Thus, in this study, respondents gave the highest marks to energy-efficient mobile platforms and low-resource AI tutors (M = 4.1 and 3.9, respectively). The least promising was the implementation of a blockchain solution (M = 3.1). This indicates that accessibility and ease of use have become important for modern users, especially in conditions of power and communication outages. Similar results were obtained in other works, including Wang et al. (2023) and O. Spivakovsky et al. (2025) in a study of educational practices during the COVID-19 pandemic and war indicated that modern mobile platforms that can work offline better support the continuity of learning in crisis situations. At the same time, other scholars have pointed out the importance of engaging AI-based adaptive systems (Li, 2023; Borysiuk et al., 2022). The authors indicated that these systems play an important role in increasing the individualization of learning (Bondar et al., 2021; Kamalov et al., 2023). This is consistent with the high support for low-resource AI in this sample. However, optimism about blockchain in higher education remains limited. Other international studies have pointed to critical issues of scalability and the lack of clear regulatory regulation (Alturki & Aldraiweesh, 2022; Shamsi et al., 2022).

This study also aimed to determine the relationship between awareness, experience, and willingness to implement innovative technologies. In particular, the correlation analysis showed that the strongest relationship was observed for low-resource AI ($r = 0.55$ between experience and readiness, $p < 0.001$). However, for the blockchain system, the correlations were weak ($r \approx 0.29$). This indicated that the readiness to integrate technologies depends on their comprehensibility and practical experience of the participants using them. Other scholars have also indicated that the familiarity of the tool directly affects the readiness to implement it, since familiar mobile platforms are perceived positively (Kuzheliev et al, 2023; Sari et al., 2024). At the same time, other works have emphasized that blockchain technologies, although effective, are difficult to implement in the educational space (Bhawna et al., 2025; Park, 2021). Other authors have also indicated that teachers' digital competence is a mediator between technological awareness and readiness to implement (Rane et al., 2024). Although this study did not establish a link between digital literacy and technology engagement, the results nevertheless emphasized the importance of experience. In this way, this directly correlates with our result, i.e. the higher the level of prior experience, the higher the readiness. An important research question was to clarify the main factors that structure the perception of technologies in the context of Ukrainian HEIs during the war. Factor analysis in our work identified two blocks: 1. practical efficiency (energy-efficient platforms, low-resource AI, edge/fog); 2. innovativeness/long-termity (AR, blockchain). Such a system can be compared with studies that indicated the importance of engaging in "survival technologies" (low-cost, simple, available offline) (Ponmaniraj et al., 2023). Modern scientists also recognize the potential of development technologies - blockchain, AR, which are focused on strategic modernization (Gumenyuk et al., 2021; Koshiry et al., 2023). Research by other scientists has indicated the importance of attracting various innovations and forming a division between technologies that have practical value (Nazari et al., 2024; Tsekhmister et al., 2024). At the same time, authors emphasized that for the stable development of the modern educational space, the involvement of AI and blockchain is critical (Islam & Rihan, 2024; Bilytska et al., 2022). Thus, as shown in other works, crisis phenomena affect the development and involvement of more new innovations that require verification and determination of effectiveness (Wang et al., 2020; Westerlund et al., 2023). Therefore, the results of this study are well consistent with international trends (Karadeli & Ortiz-Garcia, 2024; Skliar et al., 2025). However, the data obtained overcame the emphasis on little-researched, low-resource and energy-efficient solutions, which are critical for Ukrainian HEIs in war conditions.

However, despite the accepted results, the study also has limitations. In particular, the sample covered only Ukrainian HEIs, which affected the possibility of comparison with the international space. When analyzing the results, it is also worth considering that the questionnaire was based on self-reporting by respondents, which may contain subjective biases. Thus, future research can develop in several directions. It is worth comparing international experience in using low-resource technologies in crisis conditions. In addition, conducting long-term studies that track changes in attitudes towards technologies over time (during the war and after reconstruction) remains an important direction.

## 5. Conclusions

Thus, the empirical study made it possible to assess the role of innovative technologies in supporting the educational process in wartime. Through this study, it was established that energy-efficient mobile platforms and low-resource AI tutors were the most in demand. These technologies received the highest average ratings from respondents. Their advantage was determined by the ability to ensure the availability of learning even during Internet and electricity outages. In addition, Edge/Fog computing took an intermediate place, and AR and blockchain solutions remained less popular. Thus, it was indicated that these technologies were perceived rather as long-term innovations, rather than tools of "primary necessity". The analysis showed that readiness to implement technologies depends most on the experience of their use and the level of awareness. The strongest correlations were found for low-resource AI ($r \approx 0.55$, $p < 0.001$). This means that practical testing of technologies is the key to overcoming skepticism and increasing the innovation culture in HEIs.

Factor analysis allowed us to distinguish two dimensions: practical effectiveness (mobile platforms, AI, edge/fog) that meets the current urgent needs for accessibility; and long-term sustainability that is traced in AR and blockchain, which are promising tools for post-war reconstruction.

However, there are key barriers to the implementation of these technologies that include technical (unstable internet, lack of equipment); organizational (insufficient support from the administration); and, psychological (low trust in new tools, in particular blockchain). Respondents saw advantages in flexibility, personalization of learning, and increased student motivation.

The results of the study indicate that in the coming years HEIs should rely on low-resource and energy-efficient solutions that ensure sustainability and accessibility of the educational process. At the same time, promising technologies (AR, blockchain) require gradual testing, pilot projects, and regulatory integration.

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**Data sharing statement**

No additional data are available.

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