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FOSTERING DIGITAL TRANSFORMATIONS IN MILITARY ENGINEERING EDUCATION: INTRODUCTION OF A TECHNOLOGY-ENHANCED LEARNING ENVIRONMENT

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Abstract

Digital tools have become integral to training military engineers, and the introduction of a technology-enhanced learning environment may improve the educational process at higher military educational institutions. This study explores the impact of digital transformations in military engineering education through a technology-enhanced learning environment. To answer the research questions, mixed methodology was used, which involved integration and data triangulation matrices. The survey included 17 experts who possess the competences to evaluate the integration of technology into the learning environment. The results showed that a positive technology-enhanced learning environment is represented through ICT-supported learning, e-learning, blended learning, and virtual learning environments. The researchers distinguished groups of digital tools used at higher military educational institutions (communication tools, content creation tools, Learning Management Systems, collaboration tools, assessment tools, simulation and modelling, and adaptive learning tools). The impact of digital tools applied for the formation of professional competence among future military engineers was evaluated. Then, the algorithm for creating and developing a positive technology-enhanced learning environment was explained as the set of systematic measures used to design and implement a learning environment that integrates technology. The measures to be taken to foster digital technologies while training future military engineers were described during the study. The outcomes can be used to improve the existing system of military engineering education at the Ukrainian military institutions and to maximize the professional training at the active military units.
Keywords: *digital tools, higher military educational institution, learning environment, professional competence, technology-enhanced learning*

Introduction

The era of digitalization poses significant challenges for education due to the rapid technological changes, requiring constant adaptation of teaching methods and resources. Modern universities have been incorporating new paradigms for sustainability through digital transformations that aim to integrate information and communication technologies (ICTs), computing, and connectivity technologies within the learning environment (Mondragon-Estrada et al., 2023). At the same time, higher educational institutions are pivotal players in producing essential knowledge for innovations, consequently enhancing the process of future professionals' training to meet the demands of tomorrow's workforce and adapt to new digital trends. Considering a number of emerging threats, the role of military education is increasing since it is oriented toward strengthening national security efforts and building military leadership able to operate in a dynamic setting and make strategic decisions under pressure (Bhinder, 2022). The primary mission of military engineering education is to prepare cadets to be technically proficient, innovative, and adaptable professionals who can address complex

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challenges using digital technologies (Kompan & Hrnčiar, 2022). However, higher military educational institutions (HMEIs) are greatly influenced by digital transformations, creating a more realistic, accessible, and effective learning environment (Barreiros dos Santos et al., 2019).

The use of technology in higher education was intensified by the recent COVID-19 pandemic (Bularca et al., 2024). In Ukraine, during the war, technology-enhanced learning contributes significantly to ensuring the continuity of education and creating safe and equal opportunities to access education (Nychkalo et al., 2022). Additionally, according to Galynska and Bilous (2022), using e-learning demonstrated that digital tools are capable of delivering education to the areas wrecked by war. The training of future military engineers usually involves various digital tools, platforms, and resources to increase their learning experience (Torichnyi & Bhinder, 2019). Today, many engineering programs use simulations and virtual laboratories (Maistrenko et al., 2020), artificial intelligence (AI) (Hadlington et al., 2023), online learning platforms, and learning management systems (LMS) (Bularca et al., 2024), computer-aided software, gamification (Kozubtsov & Nesterov, 2024), and data analysis tools (Kaluzny, 2021). Some findings showed that Virtual Reality (VR) and Augmented Reality (AR) technologies have been applied to interact with 3D models (Ocaña et al., 2023). Obviously, technology-enhanced learning provides opportunities to improve the quality and effectiveness of military engineering education by implementing a number of digital tools and resources.

Given that technology is an essential component of the training of future military engineers, this current study was aimed at discovering digital transformations at the HMEIs and describing a technology-enhanced learning environment for military engineering education. On the one hand, technology has enabled access to resources, fostering a more comprehensive and engaging learning experience (Miron & Gherman, 2022). Moreover, it facilitates personalized learning tailoring to cadets' individual needs (Xue-jun et al., 2021). On the other hand, technology has equipped future military engineers with the necessary digital skills (Pinchuk & Prokopenko, 2021) since digitally competent officers drive technological innovation, developing advanced weapons systems, surveillance and communication technologies, as well as command and control systems.

Literature Review

Digitalization in Military Engineering Education: Practices, Challenges, and Opportunities

In education, the definition of digitalization varies depending on pedagogical approaches, technological infrastructures, and curriculum objectives. Generally, digitalization refers to the use of digital technologies to enhance the educational process (Pettersson, 2021), and it includes the integration of digital tools and resources into curriculum design, classroom instruction, and educational administration (Fernández-Sánchez et al., 2022). Recent studies showed that digitalization is responsible for integral and holistic transformations of the educational process (McCarthy et al., 2023). At the same time, digitalization introduces the mechanisms and strategies of modernization of an educational institution to update the existing infrastructure and to improve the efficiency of the learning environment. In the context of military engineering education, digitalization has been implemented through the principles of accessibility (Spridzāns, 2023), flexibility (Holth & Boe, 2019), interactivity (Silfverskiöld et al., 2011), collaboration (Davidson-Shivers & Rand, 2023), data-driven culture and innovation (Barreiros dos Santos et al., 2019). Apparently, digital transformations provide access to the educational process, overcome geographical barriers, create customized learning paths, offer collaborative tools and software, and suggest using innovative and creative approaches to teaching.

According to Kamalov et al. (2023), to transform the learning environment, a commitment to adapt to rapid changes and flexibility is essential. HMEIs, as a rule, recognize the strict hierarchical structure, emphasize the importance of tradition, and adhere to the established protocols (Spridzāns, 2023). Military training focuses on discipline, cohesion within the organization, and precise regulations governing every aspect of the educational process. Often, military organizations can be resistant to change (Holmberg & Alvinius, 2019), particularly when it comes to the established training methods and practices. This resistance to change originated from a desire to maintain the effectiveness and integrity of military training. But, while military training may be conservative in many aspects, it also incorporates innovations to ensure that military units remain effective and capable in a changing world.

The professional training of future officers at the HMEIs is considered to be an intricate process that comprises both an academic component and a military training component (Urych, 2018). Due to the complexity of the military profession and its importance, the practical part of the training is essential, and it must be supported by both specialized knowledge and specific military skills (Bularca et al., 2024). Digital tools have become integral to training military engineers because they largely facilitate practical skill development and enhance cadets' learning experiences (Chen et al., 2019). Additionally, digital tools enable remote and flexible learning and connect the process of military education with real-life practices and technological advancements (Garlinska et al., 2023). According to Pinchuk & Prokopenko (2021), these tools play a crucial role in preparing military engineers to carry out complex professional and combat tasks as well as remain competitive in a rapidly evolving technological landscape of military activities. It is worth mentioning that the COVID-19 pandemic has forced HMEIs, similar to civilian educational institutions, to transform their teaching approaches and launch a digitalization process for the continuity of education (Bhinder, 2022). Bularca et al. (2024) thought that it resulted in the emergence of a new phenomenon called "crises-military e-learning (cmel)".

Two years of the full-scale war in Ukraine have further emphasized the critical role of digital tools within the educational process at the HMEIs since these instruments contributed to the sustainable development of the military education system during the war by providing continuity, facilitating access to learning resources, and introducing innovative approaches. During emergencies, digital tools are viewed through their possibilities to focus on the interaction between social and technical aspects of military education (Martínez-Cerdá et al., 2020). According to the practice-based approach, training is a social process taking place while participating in practical activities (Barreiros dos Santos et al., 2019). As a result, digital tools enhance the educational process and create a landscape favorable for collaboration, sharing knowledge, and developing innovative teaching. Moreover, digital tools assist in building resilience in the education system by enabling continuity of learning during emergencies and supporting its post-crisis recovery (Kirchner & Yelich Biniecki, 2022). Importantly, many studies have dealt with the question of digitalization in engineering education (Gumaelius et al., 2023; Teplická et al., 2022). The findings showed that digital tools implemented within military engineering training vary depending on the purpose of their use. Table 1 shows the classification of digital tools used in military engineering training.

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Table 1
Classification of Digital Tools Used in Military Engineering Training

Type of digital tools	Description of functions	Examples
Communication tools (Miron & Gherman, 2022; Porancea-Răulea et al., 2023; Ramesh, 2023)	Organization of general communication; facilitation of peer-to-peer interaction; establishment of remote mode communication	E-mail, online discussion boards, video conferencing tools (Zoom, Microsoft Teams, or Google Meet), instant messaging platforms, Google Docs, virtual labs, social media, interactive whiteboards, blogs
Content creation tools (Banday et al., 2014; Udeozor et al., 2023)	Delivering instructional materials; creation of content; integration of multimedia elements; providing real-time interaction with content	Presentation software (Microsoft PowerPoint, Google Slides), simulation software (MATLAB/Simulink), video editing software, graphic design software
LMS (Bradley, 2021; Vakaliuk, 2021)	Facilitating the creation, delivery, and management of online courses and learning materials; assessment of learning outcomes	Course management tools (Moodle, Canvas), assessment tools (ExamSoft, Respondus, Proctorio), analytics and reporting tools (Google Data Studio), feedback tools (SurveyMonkey, Google Forms)
Collaboration tools (Ramesh, 2023; Udeozor et al., 2023)	Facilitating teamwork, communication, and project management; organization of tasks	Google Workspace, Microsoft Teams, messaging platforms, control and collaboration platform (GitHub), online whiteboard platform
Assessment tools (Farzana, 2023; Porancea-Răulea et al., 2023)	Evaluation of cadets' ability to apply theoretical knowledge to real-life problems and combat tasks	Online quizzes (Kahoot!, Quizlet), laboratory reports tools (Google Docs, LabArchives), peer assessment tools (Peerceptiv, Peergrade), portfolios, concept maps, rubrics (Google Sheets, Quick Rubric)
Simulation and modelling tools (Chen, 2021; Coman et al., 2021)	Creation of immersive virtual environments; simulation of future officers' real-life behavior and analyzing their performance	Simulation and gaming platforms (SimScale, AnyLogic), modeling and simulation software (MATLAB, LabVIEW), 3D modeling software (AutoCAD, Blender), VR and AR tools
Adaptive learning tools (Barto & Daly, 2021; Duzhyi & Derkach, 2024)	Personalization of the learning experience; assessment of cadets' knowledge and skills, identifying areas for improvement; creation of personalized learning paths	Adaptive learning platforms (Smart Sparrow, DreamBox), real-time feedback tools, adaptive assessments tools, data analytics tools (Google Data Studio), content customization tools (Adobe Captivate)

Considerable research work is devoted to the analysis of the advantages of digitalization in military engineering education. To date, digital tools are found to provide access to a wide range of resources to build interactive learning through simulations, virtual labs, or engagement platforms. Barto and Daly (2021) emphasized that digital tools create personalized learning experiences and enhance the flexibility of the learning environment. Also, digital tools contribute to making lessons more engaging and interactive, as well as increasing motivation. Digital tools can collect and analyze the data on cadets' performance, engagement, and learning outcomes (Xu et al., 2022). Moreover, digitalization often reflects the tools and technologies used during professional or combat activities (Torichnyi & Bhinder, 2019). Using these tools in the educational process, future military engineers can gain valuable skills and experiences that will prepare them to carry out professional tasks efficiently.

At the same time, digitalization in military engineering education brings several challenges. Above all, there are concerns about the privacy and security of cadets' data since some information used at the HMEIs has limited access (Holth & Boe, 2019). Urych (2018) and Fernández-Sánchez et al. (2022) considered that integration of new digital tools into the existing curricula can be challenging. And sometimes, lecturers require additional training to use these tools effectively within the learning environment. Not all cadets are proficient in using digital tools and technologies, and their digital literacy needs to be improved (Pinchuk & Prokopenko, 2021). Other challenges include technical such as connectivity problems or software failures. It is possible that addressing these challenges will make digital transformations in military engineering education effective and sustainable and, therefore, will build a positive technology-enhanced learning environment at the HMEIs.

Creation and Development of Technology-Enhanced Learning Environments in the HMEIs

Implementation of educational technologies in higher education is becoming increasingly popular as a way to improve learning and teaching. ICTs, being flexible, accessible, and affordable, have been interpreted as a fundamental component of the learning environment (Garay et al., 2018) due to their ability to enhance the educational experience by providing tools and resources that facilitate effective learning and skill development. Technologies also have a profound impact on pedagogy, enabling learner-centered approaches (Bremner, 2019), personalized learning experiences (Xue-jun et al., 2021), promoting active learning strategies (Silfverskiöld et al., 2011), and facilitating collaboration between the participants of the educational process (Ramesh, 2023). Technologies allow for the integration of multimedia elements (Abdulrahaman et al., 2021), increasing cadets' motivation to learn and bringing positive learning outcomes (Barreiros dos Santos et al., 2019; Pinchuk & Prokopenko, 2021). Accordingly, technology-enhanced learning is the term used to refer to the benefits of utilizing ICTs in learning and teaching (Shen & Ho, 2020). Schweighofer et al. (2019) described technology-enhanced learning as a pedagogical approach that includes all technologies to make learning more effective, efficient, and enjoyable.

In the context of engineering education, technology-enhanced learning has opened up opportunities for the advancement of the educational process, enabling learners to engage with complex practical experiences in innovative ways (Rehman, 2023). Efficient technology-enhanced learning has demonstrated its capacity to improve training in technical competence, personal development, and contextual intelligence (Licciardello et al., 2021). At the same time, technology-enhanced learning is increasingly changing due to rapid advancements (Grassini, 2023) and improvements in pedagogical approaches (Fowler et al., 2022). A significant shift in technology-enhanced learning occurred when different, more intelligent, adaptive, and personalized educational systems were implemented (Ivanović et al., 2018).

The comprehensive critical literature review on technology-enhanced learning in military engineering education was presented in the works of Kyva and Koshlan (2022), Miron & Gherman (2022), and Pinchuk & Prokopenko (2021). The researchers focused on examining how technology-enhanced learning was understood and how it was developed. Special attention was paid to increasing the digital competence of future officers (Pinchuk & Prokopenko, 2021). Besides, it was stated that digital tools are responsible for the development of various professional areas of competence in the HMEIs subjects (Kyva & Koshlan, 2022). Spridzāns (2023) confirmed that focusing on the skillful and effective use of digital technologies promotes more personalized, flexible, learner-centered, and collaborative learning at the HMEIs.

At the same time, a number of findings showed success stories of the creation of a technology-enhanced learning environment at the HMEIs and presented digital practices in military engineering education (Porancea-Răulea et al., 2023; Xue-jun et al., 2021). To clarify these points, it is worth noting that HMEIs have been gradually and purposefully developing, and the increase in technology is inevitably going to happen (Spridzāns, 2023). Other works described teaching the disciplines for military purposes through digital tools. Thus, Miron and Gherman (2022) insisted that some disciplines use various digital tools while teaching. Their findings proved that these disciplines are related to measurement in telecommunications, databases, war gaming, information warfare, unmanned aircraft systems, electronic warfare, air defense systems, and radar fundamentals. According to Juninhu and Fathurrahman (2022), digital tools cultivate competencies in the mechanical, electrical, telecom, and ballistics disciplines.

Technology-enhanced learning environment refers to a setting where digital tools are used to deliver and facilitate teaching activities and resources (Rehman, 2023). Additionally, this environment combines traditional teaching with digital practices, and technology is used to supplement the traditional classroom, providing cadets with more flexibility and personalized learning opportunities. A number of studies (Fowler et al., 2023; Ivanović et al., 2018; Schweighofer et al., 2019) were devoted to a positive technology-enhanced learning environment. For instance, Bustamante-Mora et al. (2023) insisted that it is an engaging landscape, capturing learners' interest and motivating them to participate actively. Other qualities include accessibility (Spridzāns, 2023), flexibility, and interactivity (Smith et al., 2021). A technology-enhanced learning environment is positive when it provides constructive feedback (Gogoulou & Grigoriadou, 2021). Besides, the environment should be supportive and adaptable (Rehman, 2023). Fowler et al. (2022) and Torres-Díaz et al. (2022) stated that technology should integrate with pedagogical practices and ensure the security of future officers' data. According to Tan and Wong (2020), digital tools are characterized by teacher support, cooperation, learners' involvement, and real-life task orientation.

To disclose the mechanisms of creation and development of a technology-enhanced learning environment in the HMEIs, it is necessary to describe its classification and peculiarities. The findings show that a technology-enhanced learning environment is divided into several types. The first type, an ICT-supported learning environment, concerns a learning environment where ICT tools and resources are extensively used (Tan & Wong, 2020). This environment provides opportunities for interactive and collaborative learning, personalized teaching, and access to a wide range of educational resources and materials (Garay et al., 2018; Ramesh, 2023). The application of an ICT-pedagogy enables a learner-centered learning environment where the lecturer's role has changed from instructivist to constructivist (Bremner, 2019). E-learning environment, meanwhile, means that learning uses electronic technologies (Banday et al., 2014). This environment encompasses various tools, platforms, and resources that facilitate teaching, such as online courses, LMS, virtual classrooms, collaboration and assessment tools, mobile learning, etc. (Abdulrahaman, 2022). In the study of Vakaliuk (2021), an e-learning environment focuses on the use of electronic technologies for the delivery and administration of educational content, whereas an ICT-supported learning environment requires the effective use of ICTs to assist teaching and learning.

A blended learning environment combines traditional face-to-face classroom teaching with online learning activities (Jones & Chew, 2015). Here, learners engage in a mix of in-person interactions with lecturers or peers and online learning activities that are often self-paced and can be completed remotely (Vodovozov et al., 2022). Serhiienko and Samoilova (2022) explain the peculiarities of training in professional military educational institutions and emphasize that blended learning suggests combining synchronous and asynchronous formats and provides flexibility. It is important to add that the exact blend of online and face-to-face activities can vary depending on the course (Jones & Chew, 2015). At the same time, blended courses are developed to form soft skills among the military and improve their combat readiness (Bučka & Andrassy, 2017).

A virtual learning environment is a digital platform that facilitates the delivery of educational courses to learners (Torres-Díaz et al., 2022). It provides a centralized hub where course materials can be accessed, and cadets are able to participate in discussions, submit assignments, and communicate with lecturers and peers. At the HMEIs, a virtual learning environment creates real-life simulations and provides learners with experiential learning opportunities in a safe and controlled setting (Chen, 2021; Maistrenko et al., 2020). Regarding military conditioning, cadets use a variety of equipment like head-mounted displays (or eyewear), VT helmets, or gloves that simulate environments similar to those that soldiers will face in real life (Ocaña et al., 2023). Some scholars described the introduction of VR technologies for teaching driving and vehicle maintenance (Pinto et al., 2008), piloting (Saastamoinen & Maunula, 2021), tactical medicine (Friedl & O'Neil, 2013), or creating realistic battle conditions (Harris et al., 2023).

Obviously, technology-enhanced learning is an important aspect of military engineering education due to its potential to simulate real-life scenarios, facilitate practical learning, and enhance understanding of complex engineering concepts. When technologies such as simulations, virtual labs, and computer-aided tools are implemented into the curriculum, cadets can develop the professional competencies needed to succeed in their military careers and contribute to the development of advancements in weapons and technology.

Research Problem

A technology-enhanced learning environment has been considered an important scientific problem in the context of military engineering education. Because this environment was understood as a structure that provided a more dynamic and adaptable approach to teaching activities (Fowler et al., 2023), it was important for the potential to facilitate collaboration among the participants of the educational process (Davidson-Shivers & Rand, 2023) and incorporate interactive and multimedia elements (Abdulrahaman et al., 2021). Fowler et al. (2023) distinguished a technology-enhanced learning environment from conventional training and highlighted what advantages it possesses for the formation of professional competencies among learners. The researchers pointed out that technology-enhanced learning involves the extensive use of technology to augment the teaching and learning experience. A technology-enhanced learning environment is created within the HMEI and implements engaging and interactive teaching and learning through ICT and digital technologies, which are unable to perform tasks or enhance the effectiveness of the educational process. Therefore, the study of the impact of a technology-enhanced learning environment and the introduction of subsequent digital transformations in military engineering education will solve a significant pedagogical task related to the modernization of the educational process at the HMEI and the improvement of professional training of future military engineers.

Research Focus

The empirical reconstruction of a technology-enhanced learning environment focuses on solving the urgent problem of fostering digital transformations at the HMEIs to improve the professional training of future military engineers and prepare them to perform a variety of tasks, including combat engineering, demolitions, logistics management, etc. The creation of a positive technology-enhanced learning environment and the description of its strengths and weaknesses will modernize the educational process at the HMEIs and help refocus the training of future military engineers on the formation of their professional competencies in view of functioning the institutions during the war. Despite the growing popularity of technology-enhanced learning, a comprehensive analysis of its trends and benefits in military engineering education and digital transformations is still needed. Hence, the efforts of Ukrainian HMEIs are oriented toward careful evaluation of the impact of digital transformations applied for the training of future military engineers and understanding the factors influencing the creation and development of a technology-enhanced learning environment in military engineering education.

Research Aim and Research Questions

The research aimed to study the impact of digital transformations in military engineering education by introducing ICT-supported learning, e-learning, virtual learning, and blended learning environments. Concretely, the following research questions have been formulated:

RQ1: What are the criteria for the creation of positive technology-enhanced learning environments at the HMEIs? What are the strengths and challenges of a technology-enhanced learning environment?

RQ2: What digital tools are applied for the formation of professional competence among future military engineers? And how effective are they, according to experts' estimations?

RQ3: What is the algorithm for the creation and development of a positive technology-enhanced learning environment at the HMEIs? What measures should be taken to foster digital technologies while training future military engineers?

Research Methodology

General Background

The study was carried out at the department of engineering and technical support of Bohdan Khmelnytskyi National Academy of the State Border Service of Ukraine, which is responsible for the development and implementation of the educational program "Organization of activities of engineering and technical units of the State Border Guard Service of Ukraine". It was conducted in three stages (planning and design, data collection, and data analysis and interpretation) during the first semester of the 2023-2024 academic year. In order to answer the research questions, two research lines were represented. The first research line outlined the criteria for the creation of a technology-enhanced environment at the HMEIs and revealed the potential of digital transformations for military engineering education. To implement the first research line, a representative sample involved 17 lecturers of Bohdan Khmelnytskyi National Academy of the State Border Service of Ukraine involved in training future military engineers. The optimal criteria for the creation of a technology-enhanced environment were identified, and the lecturers' perceptions of different types of technology-enhanced environments were determined.

The second research line analyzed the application of digital tools for the formation of professional competence among future military engineers. It focused on addressing the practical problems of a technology-enhanced learning environment in the context of military engineering education. As practical research, it was concerned with finding solutions to the optimization of the educational process at the HMEIs through various digital tools. The lecturers involved in the research collaborated closely to evaluate the application of digital tools based on the type of lesson. Additionally, the line described the challenges faced when introducing a technology-enhanced learning environment at the HMEIs identify the areas for improvement of the educational process.

To gain a more comprehensive understanding of the research problem, a mixed methodology was used, which involved two matrices: integration (Fetters et al., 2013) and data triangulation (Fielding, 2012). The integration matrix organized the integration of qualitative and quantitative data collection and analysis. At the same time, the data triangulation matrix generated data from multiple sources methods to enhance the reliability of the findings. It helped compare data collected to identify patterns typical for military education and provide a deeper understanding of algorithms for the creation and development of technology-enhanced environments at the HMEIs.

Sample

The survey included a panel of 17 experts to present diverse perspectives on the research problem and ensure its comprehensive understanding through both theory and practice. The experts served as lecturers from Bohdan Khmelnytskyi National Academy of the State Border Guard Service of Ukraine and, therefore, were involved in the process of training future military engineers. When selecting the experts, six specific criteria were considered to show that participants have the necessary skills and expertise to objectively evaluate the integration of technology into the learning environment. These criteria included: (1) involvement in training future military engineers; (2) strong pedagogical knowledge and understanding of the teaching practices for working in the technology-enhanced learning environment; (3) technology proficiency; (4) experience with online teaching; (5) research experience in the field of technology-enhanced learning; (6) commitment to continuous learning and professional development in the field of technology-enhanced learning; (7) extensive experience in teachers' training. Moreover, all the experts were leaders of course development units or coordinators of teachers' training groups at the Academy. Using the criteria mentioned above, we identified experts who are well-equipped to effectively integrate technology into the learning process and contribute to the modernization of professional training of future military engineers at the HMEIs through the implementation of technology-enhanced learning courseware and curricular materials. All individuals were informed about the research and participated voluntarily. The research was conducted according to the Code of academic virtue and ethics of academic relations adopted at Bohdan Khmelnytskyi National Academy of the State Border Guard Service of Ukraine and ensured the honor, dignity, mutual respect, and confidentiality of all participants. The results were assessed objectively and impartially to reflect the research objectives accurately.

Instrument and Procedures

To study digital transformations in military engineering education through the introduction of a technology-enhanced learning environment, the mixed methodology approach was applied. Firstly, a questionnaire was organized into four different sections: (1) positive technology-enhanced learning environment at the HMEIs; (2) application of digital tools for the formation of professional competence among future military engineers; (3) challenges faced when introducing a technology-enhanced learning environment at the HMEIs; (4) practical measures to introduce a positive technology-enhanced learning environment. The questionnaire was designed according to the research objectives and the specific aspects of the use of digital technologies in military engineering education. Previously, a literature review was conducted to identify relevant theories, concepts, and previous research findings related to the use of digital technologies in military engineering education that has become a basis for the development of close-open-ended questions. These questions helped researchers gather quantitative and qualitative data that offered a more comprehensive understanding of the research problem, contextualization, complementarity, and enhanced validity (Dawadi et al., 2021; Fàbregues et al., 2023).

Secondly, to evaluate the impact of digital technologies within the educational environment of HMEIs, the SAMR framework was used (Blundell et al., 2022; de Morais Bicalho et al., 2023). The framework analyzed the efficiency of digital technologies according to four components: S or substitution means a direct substitute of a traditional tool for digital technology with no functional change; A or augmentation concerns functional improvement over traditional tools, enhancing learning tasks; M or modification is related to significant task redesign, leading to the formation of new learning experiences that were previously not possible;

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and R or redefinition enables the creation of new tasks that were previously inconceivable, fundamentally changing the educational process at the HMEIs. The efficiency of a digital tool was calculated on the basis of four components indices added up by the experts, where 5 = a digital technology is extremely efficient in improving cadets' learning outcomes and reshaping the educational process; 4 = a digital technology is very efficient and contributed to the increase of learning educational outcomes; 3 = a digital technology is moderately efficient and supports the creation of a technology-enhanced learning environment; 2 = a digital technology is slightly efficient within the educational process; and 1 = a digital technology is not efficient and does not improve cadets' learning outcomes.

Thirdly, to support the findings, classroom observations were used where the experts filled in a structured observation protocol and outlined the descriptors of digital technologies, including frequency of application, reliability, validity, and accessibility. This also involved using a digital recording device. Afterward, the reports were prepared in a clear and concise manner, which included a description of the observation methodology, key findings, advantages for military engineering education, and challenges the lecturers are facing while creating a technology-enhanced learning environment.

Data Analysis

The data was analyzed according to the following key principles: data quality, transparency, reliability, and contextual understanding. Importantly, data analysis was guided by clear research questions that the study aims to address and the standardized SAMR framework to evaluate the efficiency of digital technologies used within the educational process of HMEIs. The research adhered to the principles above-mentioned, which gave us the possibility to achieve meaningful and impactful research findings. To gather the data and their interpretations, the experts' estimations method was used. It enabled us to provide the judgments, opinions, and perceptions of the experienced individuals involved in creating a technology-enhanced learning environment and participating in teachers' training. The experts' estimations identified the common patterns and trends of using digital technologies at the HMEIs and helped reveal the algorithm for the creation and development of a technology-enhanced learning environment applicable to the formation of future military engineers' professional competence. The Analysis of the experts' opinions and perceptions contributed to drawing the conclusions or making the recommendations for HMEIs. Additionally, the experts served as peer reviewers during the research, providing structured feedback on the methodology used in the classroom of the HMEIs around the strengths and challenges of digital technologies. It is important to note that then peer review was used in a supportive manner to extend the existing findings collected when the questionnaires or SAMR framework were applied.

Research Results

Creation of Positive Technology-Enhanced Learning Environments at the HMEIs

The results showed that a positive technology-enhanced learning environment at the HMEIs is characterized by a number of criteria. The biggest number of experts enumerated the following criteria: orientation towards the formation of professional skills and attitudes (16 experts), data protection, and interactivity among cadets through multimedia content, simulations, and interactive exercises (15 experts each). 14 experts considered accessibility to all cadets and the facilitation of communication within the learning environment. Other criteria included: the availability of reliable technical infrastructure at the HMEI (13 experts), flexibility enabling the incorporation of different learning styles within the educational process

(12 experts), use of digital pedagogy (12 experts), mechanisms for objective assessment of cadets' learning outcomes (11 experts) and providing feedback (10 experts). Also, 10 experts insisted that the learning environment should integrate with other tools and resources used in engineering training, such as textbooks, software applications, and laboratory equipment. Table 2 shows the criteria for the creation of a positive technology-enhanced learning environment at the HMEIs according to experts' estimations.

Table 2
Criteria for the Creation of a Positive Technology-Enhanced Learning Environment at the HMEIs

Criteria	Agree	Disagree
Orientation toward skills formation	16	1
Accessibility	14	3
Interactivity	16	2
Communication	14	3
Assessment	11	6
Feedback	10	7
Integration with other tools	10	7
Reliable technical infrastructure	13	4
Data protection	15	2
Use of digital pedagogy	12	5

The findings showed that a technology-enhanced learning environment offers numerous strengths, including the formation of practical skills, increased accessibility, flexibility, and engagement for future military engineers. This environment also provides personalized learning experiences and facilitates collaboration within the educational process. However, a technology-enhanced learning environment faces challenges such as technical issues, the potential for social isolation, and the necessity for additional training. The choice of a technology-enhanced learning environment depends on various factors, including the educational objectives, the needs and preferences of the cadets, and the availability of digital tools. Lecturers carefully considered these factors when selecting a type of technology-enhanced learning environment in the process of professional training of future military engineers. Table 3 presents the analysis of strengths and challenges of technology-enhanced learning environments according to experts.

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Table 3
Estimations of Technology-Enhanced Learning Environments

Type of technology-enhanced environment	Advantages	Quantity	Disadvantages	Quantity
ICT-supported learning environment	Increased access to educational resources	4	Depends on the infrastructure of the HMEIs	2
	Flexibility of course delivery	3	Possible technical issues	5
	Enhancement of cadets' engagement and motivation	5	Ensuring that high-quality educational content	3
	Increased collaboration	3	Limited interaction	3
	Building personalized learning experiences	2	Necessity to possess digital literacy skills	4
	TOTALLY	17	TOTALLY	17
e-learning environment	Providing immediate feedback to learners	1	Limited practical learning	5
	Data collection and analysis	3	Security concerns	5
	Reducing the need for paper-based materials	5	Limited personalization	3
	Providing supporting teaching tools and resources	6	Limited access to resources	2
	Easy integration with other tools and technologies	2	Resistance to change	2
	TOTALLY	17	TOTALLY	17
Blended learning environment	Increased lecturer-cadet interaction	5	Necessity for balancing online and in-person activities	7
	Integration of traditional and innovative teaching technologies	6	Necessity to design effective blended learning activities	6
	Preparation for future learning	2	Training to effectively use the digital tools	1
	Formation of soft skills	2	Ongoing maintenance and updates of courseware	2
	Improved cadets' learning outcomes	2	Assessment challenges	1
	TOTALLY	17	TOTALLY	17
Virtual learning environment	Safe conditions	7	Limited lecturers' support	2
	Increased engagement and incorporation of interactive elements	5	Security concerns	5
	Real-time assessment	2	Dependence on technology	6
	Multimedia content integration	1	Costly maintenance	2
	Adaptation to new content, technologies, and teaching methods	2	Excessive screen time	2
	TOTALLY	17	TOTALLY	17

Then, digital tools applied to the formation of professional competence among future military engineers were analyzed, and their efficiency was assessed.

Efficiency of Digital Tools Applied for Formation of Professional Competence among Future Military Engineers

The results proved that seven groups of digital tools are used within the educational process: communication tools, content creation tools, LMS, collaboration tools, assessment tools, simulation and modelling, and adaptive learning tools. These tools offer various functions to enhance professional competence among future military engineers. According to respondents, each tool has its own efficiency, depending on the educational objectives. For instance, LMS like Moodle are used to deliver course content, manage assignments, and facilitate discussions. On the other hand, content creation tools, particularly presentation software, are effective in delivering engaging lectures and visual presentations. Assessment tools, such as online quizzes, provide an opportunity to assess cadets' understanding and gather feedback. Collaboration tools (Google Docs or Microsoft Teams) enable future officers to work on projects, promoting their teamwork and communication skills.

During the survey, the efficiency of digital tools applied for the formation of professional competence among future military engineers was evaluated on the basis of the SAMR framework (table 4). The findings show that 10 most efficient digital tools are the following: simulation and gaming (334 points), modelling (332 points), VR and AR tools (331 points), instant messaging (326 points), adaptive assessments (323 points), presentation software (319 points), online quizzes (315 points), Microsoft Teams (306 points), video conferencing (304 points), content customization (303 points). Such cumulative index demonstrates that these digital tools are characterized by substitution potential, augmentation, modification, and redefinition, and their application significantly enhances the educational process at the HMEIs. At the same time, blogs (217 points), graphic design (209), and video editing software (193) were considered less effective for the formation of professional competence of future military officers.

Table 4
Estimations of Digital Tools Used in Military Engineering Training

Digital tools applied	Experts' estimations																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Σ	№
Communication tools																				
E-mail	15	14	12	15	17	18	16	15	14	12	11	11	17	12	12	15	18	14	258	22
Online discussion	12	13	16	15	14	18	19	17	18	15	16	11	12	19	17	16	15	13	276	17
Video conferencing	16	17	17	19	17	18	15	16	20	19	18	19	17	16	12	17	15	16	304	9
Instant messaging	14	13	16	18	18	17	16	19	18	17	20	20	12	15	14	16	17	12	292	14
Google Docs	15	15	17	18	19	19	20	19	19	18	20	17	18	19	20	18	18	17	326	4
Social media	11	12	11	11	14	15	11	17	18	11	12	10	9	11	15	11	12	17	246	24
Interactive whiteboard	15	14	13	12	11	11	14	15	15	18	12	17	14	15	12	16	11	10	245	25
Blog	11	9	11	10	12	13	10	9	11	15	16	12	17	11	12	14	13	11	217	31
Content creation tools																				
Presentation software	15	16	17	15	16	18	15	19	19	20	20	18	18	17	20	19	17	20	319	6
Simulation software	12	13	13	12	11	11	11	14	17	19	12	16	15	13	16	13	12	13	243	26

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Video editing software	11	12	9	8	11	10	9	12	8	9	11	12	12	13	11	9	14	12	193	33
Graphic design software	9	11	12	15	11	18	12	13	9	10	11	10	12	13	14	8	10	11	209	32
LMS																				
Course management	15	16	17	14	16	14	18	18	19	16	17	14	18	19	20	17	16	16	300	11
Assessment tools	16	15	17	18	19	15	12	19	19	15	16	19	13	14	17	18	19	15	296	13
Analytics / reporting tools	14	15	17	14	18	14	12	14	15	16	17	13	15	16	12	16	17	14	269	20
Feedback tools	13	14	16	19	12	15	16	17	18	12	13	11	10	12	16	14	15	13	256	23
Collaboration tools																				
Google Workspace	12	16	18	16	15	19	15	14	19	13	12	18	19	10	20	12	18	15	281	16
Microsoft Teams	13	16	17	18	17	16	16	16	17	15	18	19	20	20	16	17	18	17	306	8
Messaging platforms	12	14	15	17	12	12	11	17	16	15	12	11	13	11	12	13	12	16	241	27
Control and collaboration platform	12	13	11	11	10	9	11	12	11	14	15	17	12	11	13	14	12	11	219	30
Online whiteboard	12	14	15	16	12	17	17	13	18	19	12	16	15	15	14	18	13	19	275	19
Assessment tools																				
Online quizzes	13	16	17	19	19	20	20	16	18	19	20	18	12	17	19	18	20	14	315	7
Laboratory reports tools	11	13	17	15	19	12	11	12	13	12	17	11	13	11	10	16	18	12	243	25
Peer assessment tools	10	11	12	11	15	17	12	13	14	17	12	11	12	14	12	12	16	12	233	28
Portfolios	12	13	11	12	15	17	12	10	12	11	13	11	14	11	11	15	13	16	229	29
concept maps	13	14	15	16	16	13	15	14	18	12	14	15	15	15	14	15	16	12	262	21
Rubrics	14	18	17	14	17	17	18	14	15	16	17	18	17	17	15	16	13	12	285	16
Simulation and modelling tools																				
Simulation and gaming	19	20	20	20	19	19	17	20	18	17	20	14	17	19	18	20	18	19	334	1
Modelling	17	18	17	19	19	20	18	17	19	19	20	17	20	18	19	20	17	16	332	2
3D modeling	11	12	17	16	15	14	17	18	19	16	17	13	19	17	15	14	15	16	281	17
VR and AR	17	18	19	19	20	18	17	16	18	19	20	19	18	19	18	19	17	20	331	3
Adaptive learning tools																				
Adaptive learning platforms	17	15	16	17	18	19	18	17	19	18	19	20	16	18	19	16	16	18	286	15
Real-time feedback	15	14	16	18	15	17	16	17	18	19	19	18	17	18	17	14	16	15	299	12
Adaptive assessments	14	16	17	18	17	18	19	18	20	18	18	17	19	19	20	20	18	17	323	5
Data analytics	12	14	16	15	17	18	19	17	18	12	13	14	15	16	16	14	12	16	276	18
Content customization	15	16	17	15	16	17	14	13	17	18	19	19	18	19	18	15	19	18	303	10

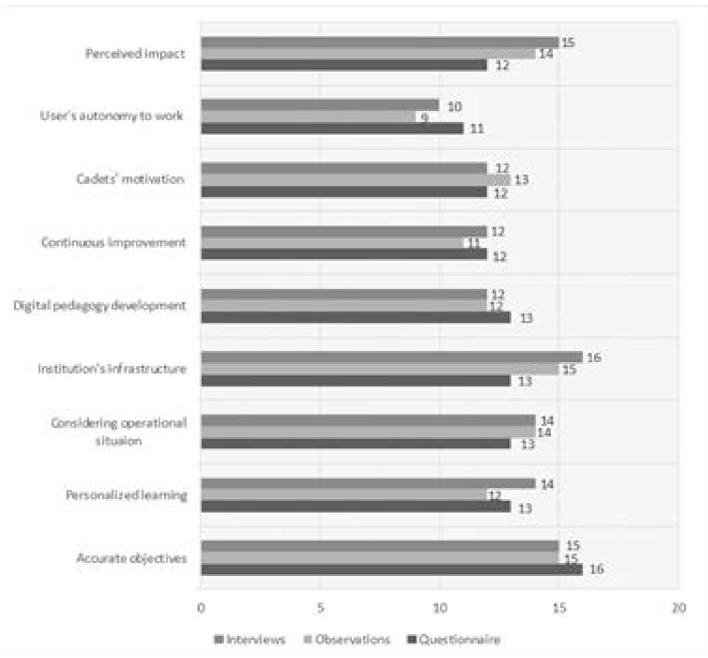
The findings related to types of technology-enhanced learning environments at the HMEIs, their advantages and disadvantages, as well as the data on the efficiency of digital tools applied within the educational process, were used to create and develop a positive technology-enhanced learning environment within the frames of military engineering education.

Algorithm of Creation and Development of Positive Technology-Enhanced Learning Environment

Then, the experts explained the algorithm for the creation and development of a positive technology-enhanced learning environment at the HMEIs as the set of systematic measures used to design and implement a learning environment integrating technologies. According to the experts' estimations, a positive technology-enhanced learning environment was designed through: (1) identification of educational objectives; (2) selection of appropriate technology; (3) development of educational content and incorporating of appropriate learning activities.

The findings showed that a technology-enhanced learning environment is used for different lesson formats and activities. Thus, ICT-supported learning is effective during lectures, assessments, presentations, and collaborative learning. Also, ICT enables the creation of online course content, delivers it, and helps instructors assess cadets' progress. Based on experts' answers, ICT is effective for organizing self-work among future military engineers. The E-learning environment is effective during lectures, seminars, assessment lessons, and online courses. The findings show that e-learning provides material delivery, video demonstration, group projects, and online discussion. The experts emphasized that a quiz is a learning activity and a type of lesson in the context of e-learning, and it is used to assess learners' understanding of the material as well as identify areas where cadets need support. Importantly, quizzes create a sense of urgency and simulate real-life scenarios requiring quick decision-making. E-learning enables the use of adaptive quizzes that are based on cadets' responses, providing a more personalized learning experience.

Figure 1
Measures to Create and Develop a Positive Technology-Enhanced Learning Environment



The survey described a virtual learning environment as effective when visualization activities, online courses, virtual laboratories, and interactive lessons are used. The experts paid special attention to the lessons where simulations were introduced. These are powerful tools within the process of professional training of future military engineers, which engage in realistic combat scenarios and increase necessary practical skills in a safe and controlled setting. Simulations are also found effective for collaborative learning, where cadets work together to solve complicated military engineering tasks. A blended learning environment is effective for interactive lessons, workshops, lectures, and seminars. In the system of military engineering education, a blended learning environment includes online modules that cadets can access independently. Blended learning platforms offer adaptive learning technologies and use data analytics to provide personalized recommendations for additional resources.

Studying the measures to be taken to foster digital technologies while training future military engineers, the results were calculated on the basis of questionnaires, classroom observations, and face-to-face interviews with experts. It was found that these measures include the following: defining accurate educational objectives, examination of cadets' needs and orientation towards personalized learning; considering operational situations and battlefield experience that can change the military engineering practice, presence of developed institutions' digital infrastructure, digital pedagogy developments and instructors' readiness to implement innovative digital tools, continuous improvement of digital technologies and orientation on their usefulness, cadets' motivation to learning and future professional activities, users' autonomy to work, and positive perceived impact of digital transformations in military engineering education. Figure 1 shows the experts' quantitative perceptions of the relevant measures to create and develop a positive technology-enhanced learning environment in military engineering education.

The reported outcomes confirmed that digital transformations in military engineering education are important since they are aimed at the enhancement of the educational process and allow for more practical training to form professional competence among future military engineers. The study found that digital transformations are introduced through a technology-enhanced learning environment, particularly an ICT-supported learning environment, e-learning environment, virtual learning environment, and blended learning environment. These findings proved the thesis that the choice of a technology-enhanced learning environment depends on the educational objectives, the needs and preferences of the cadets, and the availability of digital tools. When choosing an environment type, instructors carefully consider the strengths and challenges of digital tools. The results demonstrate that using a technology-enhanced learning environment at the HMEIs significantly contributes to the formation of professional competence among future military engineers.

Discussion

The research showed the importance of digital transformations within the educational process at the HMEIs. Also, the quantitative and qualitative analysis revealed that the introduction of ICT-supported, electronic, virtual, and blended learning environments positively affects military engineering education and increases training effectiveness, cadets' performance, and resource utilization. The research supported the previous findings, showing that technology-enhanced learning creates opportunities for the improvement of the educational process and the development of learners' practical skills (Rehman, 2023). It was found that positive technology-enhanced learning provides cadets with flexibility and makes learning more personalized (Ivanović et al., 2018). Bustamante-Mora et al. (2023) stated that using a technology-enhanced learning environment in military engineering education contributes to the increase of learners' interest and motivation to professional activities. Spridzāns (2023) and Smith et al. (2021) insisted that digital technologies facilitate cadets' collaboration and make the educational process interactive. The recent findings (Fowler et al., 2022; Torres-Díaz et al., 2022) showed technology should ensure the safety and security of future officers' data. Special attention was paid to the role of digital technologies in the emergence. Bularca et al. (2024) described the contribution of digitalization to the sustainable development of military education during war. At the same time, during the survey, it was decided that technology-enhanced learning faces challenges such as technical issues, the potential for social isolation, and the necessity for additional training. Therefore, these arguments described the importance of a technology-enhanced learning environment but reported that it is required to approach its creation thoughtfully and responsibly.

According to the theoretical analysis of the research problem, it was found that a technology-enhanced learning environment is realized through four different types. They are concerned primarily with ICT-supported learning environments (Garay et al., 2018; Ramesh, 2023; Tan & Wong, 2020). Banday et al. (2014) and Abdulrahaman (2022) differentiated e-learning environments that suggest extensive use of electronic technologies. Other types included blended learning environments (Jones & Chew, 2015) and virtual learning environments (Torres-Díaz et al., 2022). The experts estimating the strengths and challenges of technology-enhanced environments decided that ICT increases access to educational resources and facilitates collaboration among cadets, but, at the same time, it is characterized by limited interaction with instructors and peers. E-learning provides supporting teaching tools and easily integrates with other tools and technologies. Some experts admitted that e-learning has limited personalization and does not contribute to the formation of practical skills. Blended learning increases lecturer-cadet interaction but requires balancing online and in-person activities. A virtual learning environment facilitates the formation of practical skills in safe conditions and suggests increased engagement and incorporation of interactive elements. In addition, the implementation and maintenance of a virtual learning environment can be costly.

The findings showed that digital tools implemented within military engineering training vary depending on the purpose of their use. The literature review revealed that digital tools used in military engineering training include communication tools (Miron & Gherman, 2022; Porancea-Răulea et al., 2023; Ramesh, 2023); content creation tools (Banday et al., 2014; Chen et al., 2019; Udeozor et al., 2023); LMS (Bradley, 2021; Vakaliuk, 2021); collaboration tools (Ramesh, 2023; Udeozor et al., 2023); assessment tools (Farzana, 2023; Porancea-Răulea et al., 2023); simulation and modelling tools (Chen, 2021; Coman et al., 2021); and adaptive learning tools (Barto & Daly, 2021; Duzhyi & Derkach, 2024). Considerable research work was paid towards the analysis of the effectiveness of digital tools (Chen et al., 2019; Spridzāns, 2023). The survey results proved that these tools offer various functionalities to enhance the formation of professional competence among future military engineers. According to the experts, each tool has its own efficiency, depending on the specific educational objectives. On the basis of the SAMR framework, the efficiency of digital tools was evaluated, and it was found that simulation and gaming, modelling, VR and AR tools, instant messaging, adaptive assessments, presentation software, and online quizzes are the most efficient ones.

During the research, it was found that certain measures need to be taken to foster digital technologies while training future military engineers. Firstly, it requires defining accurate educational objectives and examining cadets' needs to design training programs that can help them acquire the knowledge and skills they need in their professional activities. In this regard, it should be noted that the effectiveness of a technology-enhanced learning environment is achieved through personalized learning (Xue-jun et al., 2021). Secondly, it is important to consider operational situations and battlefield experience because future officers become prepared for the real-life context and understand the practical application of their skills. Thirdly, the creation of a positive technology-enhanced learning environment demands developed institutions' digital infrastructure and application of digital pedagogy. The studies of Bremner (2019) were directed toward confirming this conclusion and show that digital pedagogy enables a learner-centered approach to teaching (active engagement, individualization, and real-life relevance). Other measures include continuous improvement of digital technologies, increase of cadets' motivation, and positive perceived impact of digital transformations in military engineering education.

The research was considered relevant in several ways. Most importantly, the problem of the introduction of a technology-enhanced learning environment in military engineering education offered valuable benefits that enhance the quality, accessibility, and effectiveness of training of future military officers. Improving the educational process at the HMEIs through digital transformations contributed to the formation of integrated professional competence among cadets and prepared them to carry out operational tasks since digitalization has reshaped technical proficiency, cyber skills, data analysis, interoperability, adaptability, problem-solving, and leadership of future military professionals. The study further suggested that the focus should be paid to creating and developing a positive technology-enhanced learning environment at the HMEIs, considering its strengths and challenges.

Although this research thoroughly explained the fostering of digital transformations in military engineering education through the introduction of a technology-enhanced learning environment, it addresses several limitations. Definitely assessing the impact of technology-enhanced learning environments can be complex, requiring the development of reliable measures for different engineering specialties. Besides, the researchers may face challenges in developing appropriate tools that assess the full range of characteristics of technology-enhanced learning environments. Additionally, the research involving the creation and development of a technology-enhanced learning environment at the HMEIs may raise some ethical considerations, particularly regarding data privacy and the use of sensitive information related to the content of the courses. This means that the researchers cannot describe some parts of the curriculum, especially those related to the disciplines that have limited access.

Conclusions and Implications

During the research, it was found that digital tools, which constitute a technology-enhanced learning environment, largely facilitate practical skill development and enhance cadets' learning experiences as well as prepare future military engineers to carry out complex professional and combat tasks as well as remain competitive in a rapidly evolving technological landscape of military activities. It was concluded that the creation and development of a positive technology-enhanced learning environment require certain measures, including defining accurate educational objectives, examination of cadets' needs; considering the operational situation; the presence of developed digital infrastructure using digital pedagogy; continuous improvement of digital technologies; cadets' motivation to learning and future career; and positive perceived impact of digital transformations in military engineering education.

The research outcomes can be used to improve the existing system of military engineering education at the Ukrainian HMEIs through digital transformations. Also, the results will be useful when developing the curriculum for training future military professionals oriented toward forming their digital competence. The findings can also be implemented within the officers' professional development system at the active military units to organize the continuity of training and maximize the educational process in emergencies.

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Declaration of Interest

Authors declare no competing interest.

References

Abdulrahaman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V., Imam-Fulani, Y. O., Fahm, A. O., & Azeez, A. L. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon, 6*(1), Article e05312. https://doi.org/10.1016/j.heliyon.2020.e05312

Banday, M. T., Ahmed, M., Jan, T. R. (2014). Applications of e-learning in engineering education: A case study. *Procedia – Social and Behavioral Sciences, 123*, 406–413. https://doi.org/10.1016/j.sbspro.2014.01.1439

Barreiros dos Santos, L. A., Loureiro, N. A. R. S., do Vale Lima, J. M. M., de Sousa Silveira, J. A., & da Silva Grilo, R. J. (2019). Military higher education teaching and learning methodologies: An approach to the introduction of technologies in the classroom. *Security and Defence Quarterly, 24*(2), 123–154. https://doi.org/10.35467/sdq/108668

Barto, J., & Daly, T. (2021). Designing adaptive blended learning experiences for military formal school Courses. In R. A. Sottilare & J. Schwarz (Eds), *Adaptive Instructional Systems. Design and Evaluation. HCII 2021. Lecture Notes in Computer Science*. Springer. https://doi.org/10.1007/978-3-030-77857-6_2

Bhinder, N. (2022). The Reshaping of Professional Discourse among Young Military Leaders during the COVID-19 Pandemic in Ukraine. *Arab World English Journal. 2nd Special Issue on Covid 19 Challenges, 2*, 85–103. https://dx.doi.org/10.24093/awej/covid2.6

Blundell, C. N., Mukherjee, M., & Nykvist, S. (2022). A scoping review of the application of the SAMR model in research. *Computers and Education Open, 3*, Article 100093. https://doi.org/10.1016/j.caeo.2022.100093

Bradley, V. M. (2021). Learning management system (LMS) use with online instruction. *International Journal of Technology in Education, 4*(1), 68-92. https://doi.org/10.46328/ijte.36

Bremner, N. (2019). From learner-centred to learning-centred: Becoming a ‘hybrid’ practitioner. *International Journal of Educational Research, 97*, 53–64. https://doi.org/10.1016/j.ijer.2019.06.012

Bučka, P., & Andrassy, V. (2017). Military education and training supported by blended simulation. *Knowledge-based organization. Proceedings of the 23rd international conference, 23*(1), 61–65. https://doi.org/10.1515/kbo-2017-0009

Bularca, M. C., Bumbuc, S., Barsan, G., Coman, C., Bucoi, A., Hertanu, A., Netedu, A., & Aron, I. (2024). The influence of COVID-19 on the learning and developing processes of practical skills in military educational institutions. *Frontiers in education, 9*, Article 1332850. https://doi.org/10.3389/feduc.2024.1332850

Bustamante-Mora, A., Diéguez-Rebolledo, M., Hormazábal, Y., Valdés, Y., & Cadena, R. (2023). Learning models for higher education in engineering: Motivation, self-determination, and the role of information and communication technologies. *Sustainability, 15*(17), Article 12869. https://doi.org/10.3390/su151712869

Chen, Y. (2021). Application of simulation technology in military education. *Journal of Contemporary Educational Research, 5*(9), 121–123. http://ojs.bbwpublisher.com/index.php/JCER

Chen, Y., Huang, S., Fu, P., Zhou, H., & Xue, W. (2019). Exploration of practical teaching with digital technology for industrial engineering education in local universities of China. *Creative Education, 10*, 2082–2100. https://doi.org/10.4236/ce.2019.1010151

Coman, M., Bârsan, G., & Piele, C. (2021). Modelling and simulation as a service – an emergent concept that supports the military education and training process continuity. *Knowledge-based organization: Proceedings of the 27th international conference, 27*(3), 7–14. https://doi.org/10.2478/kbo-2021-0082

Davidson-Shivers, G., & Rand, A. (2023). Asynchronous tools for interaction and collaboration. In O. Zawacki-Richter & I. Jung, I. (Eds), *Handbook of Open, Distance and Digital Education* (pp. 1003–1020). Springer. https://doi.org/10.1007/978-981-19-2080-6_56

Dawadi, S., Shrestha, S., & Giri, R. A. (2021). Mixed-methods research: A discussion on its types, challenges, and criticisms. *Journal of Practical Studies in Education, 2*(2), 25–36. https://doi.org/10.46809/jpse.v2i2.20

de Morais Bicalho, R. N., Coll, C., Engel, A., & de Oliveira, M. C. S. L. (2023). Integration of ICTs in teaching practices: Propositions to the SAMR model. *Educational technology research and development, 71*, 563–578. https://doi.org/10.1007/s11423-022-10169-x

Duzhyi, R. V., & Derkach, T. M. (2024). Learning styles of the Armed Forces of Ukraine personnel undergoing English language courses. *Educational Technology Quarterly, 2024*(1), 97–119. https://doi.org/10.55056/etq.659

Fàbregues, S., Sáinz, M., Romano, M. J., Escalante-Barrios, E. L., Younas, A., & López-Pérez, B. S. (2023). Use of mixed methods research in intervention studies to increase young people's interest in STEM: A systematic methodological review. *Frontiers in Psychology, 13*, Article 956300. https://doi.org/10.3389/fpsyg.2022.956300

Farzana, T. (2023). The standard measurement in online learning: a rubric as a focus on teaching-learning practices to move up quality education. *EIKI Journal of Effective Teaching Methods, 1*(3). https://doi.org/10.59652/jetm.v1i3.37

Fernández-Sánchez, M. R., Garrido-Arroyo, M. del C., & Porras-Masero, I. (2022). Curricular integration of digital technologies in teaching processes. *Frontiers in Education, 7,* Article 1005499. https://doi.org/10.3389/feduc.2022.1005499

Fetters, M. D., Curry, L. A., & Creswell, J. W. (2013). Achieving integration in mixed methods designs-principles and practices. *Health services research, 48*(6Pt2), 2134–2156. https://doi.org/10.1111/1475-6773.12117

Fielding, N. G. (2012). Triangulation and mixed methods designs: Data integration with new research technologies. *Journal of Mixed Methods Research, 6*(2), 124–136. https://doi.org/10.1177/1558689812437101

Fowler, S., Cutting, C., Kennedy, J., Leonard, S. N., Gabriel, F., & Jaeschke, W. (2022). Technology enhanced learning environments and the potential for enhancing spatial reasoning: a mixed methods study. *Mathematics Education Research Journal, 34*(4), 887–910. https://doi.org/10.1007/s13394-021-00368-9

Friedl, K. E., & O'Neil, H. F. (2013). Designing and using computer simulations in medical education and training: An introduction. *Military Medicine, 178*(10), 1–6. https://doi.org/10.7205/MILMED-D-13-00209

Galynska, O., & Bilous, S. (2022). Remote learning during the war: challenges for higher education in Ukraine. *International Science Journal of Education & Linguistics, 1*(5), 1–6. https://doi.org/10.46299/j.isjel.20220105.01

Garay, F., Morillo, G., & Guarda, T. (2018). ICT Integration in Ecuador's Military Education: Going Beyond PowerPoint. In A. Rocha & T. Guarda (Eds), *Developments and Advances in Defense and Security. MICRADS 2018. Smart Innovation, Systems and Technologies* (pp. 337–350). Springer. https://doi.org/10.1007/978-3-319-78605-6_29

Garlinska, M., Osial, M., Proniewska, K., & Pregowska, A. (2023). The influence of emerging technologies on distance education. *Electronics, 12*(7), Article 1550. https://doi.org/10.3390/electronics12071550

Gogoulou A., & Grigoriadou, M. (2021). Educating students in technology enhanced learning design by interweaving instruction and assessment. *Informatics in Education Journal, 20*(3). https://doi.org/10.15388/infedu.2021.17

Grassini, S. (2023). Shaping the future of education: Exploring the potential and consequences of AI and ChatGPT in educational settings. *Education Sciences, 13*(7), Article 692. https://doi.org/10.3390/educsci13070692

Gumaelius, L., Skogh, I-B., Matthíasdóttir, Á., & Pantzos, P. (2023). Engineering education in change. A case study on the impact of digital transformation on content and teaching methods in different engineering disciplines. *European Journal of Engineering Education, 49*(1), 1–24. https://doi.org/10.1080/03043797.2023.2285794

Hadlington, L., Binder, J., Gardner, S., Karanika-Murray, M., & Knight, S. (2023). The use of artificial intelligence in a military context: development of the attitudes toward AI in defense (AAID) scale. *Frontiers in psychology, 14*, Article 1164810. https://doi.org/10.3389/fpsyg.2023.1164810

Harris, D. J., Arthur, T., Kearse, J., Olonilua, M., Hassan, E. K., De Burgh, T. C., Wilson, M. R., & Vine, S. J. (2023). Exploring the role of virtual reality in military decision training. *Frontiers in Virtual Reality, 4,* Article 1165030. https://doi.org/10.3389/frvir.2023.1165030

Holmberg, A., & Alvinius, A. (2019) How pressure for change challenge military organizational characteristics. *Defence Studies, 19*(2), 130–148. https://doi.org/10.1080/14702436.2019.1575698

Holth, T., & Boe, O. (2019). Lost in transition: The dissemination of digitization and the challenges of leading in the military educational organization. *Frontiers in psychology, 10*, Article 2049. https://doi.org/10.3389/fpsyg.2019.02049

Ivanović, M., Milićević, A. K., Aleksić, V., Bratić, B., & Mandić, M. (2018). Experiences and perspectives of Technology-enhanced learning and teaching in higher education – Serbian case. *Procedia Computer Science, 126*, 1351–1359. https://doi.org/10.1016/j.procs.2018.08.086

Jones, L. J. N., & Chew, E. (2015). Blended Learning in Engineering Education: Curriculum Redesign and Development. In S. Tang & L. Logonnathan (Eds), *Taylor's 7th Teaching and Learning Conference 2014 Proceedings* (pp. 441–448). Springer. https://doi.org/10.1007/978-981-287-399-6_40

Juninhu, D., & Fathurrahman, R. (2022). The urgency of adaptive performance in supporting the transformation of military educational institutions in the digital age: A case study of army polytechnics. *Budapest International Research and Critics Institute-Journal, 5*(2), 14803–14812. https://doi.org/10.33258/birci.v5i2.5357

Kaluzny, B. L. (2021). Data analytics in military human performance: Getting in the game. Summary of a keynote address. *Journal of Science and Medicine in Sport, 24*(10), 970–974. https://doi.org/10.1016/j.jsams.2021.04.003

Kamalov, F., Santandreu Calonge, D., & Gurrib, I. (2023). New era of artificial intelligence in education: towards a sustainable multifaceted revolution. *Sustainability, 15*(16), Article 12451. https://doi.org/10.3390/su151612451

Kirchner, M. J., & Yelich Biniecki, S. (2022). Learning to navigate a global pandemic from military training. *New Horizons in Adult Education and Human Resource Development, 34*(2), 16–26. https://doi.org/10.1002/nha3.20356

Kompan, J., & Hrnčiar, M. (2022). Harmonisation via education of engineering officers' competencies with demands of contemporary operating environment. *INTED2022 Proceedings* (pp. 1886–1892). https://doi.org/10.21125/inted.2022.0554

Kozubtsov, I., & Nesterov, O. (2024). The conceptual view of the department of combat use of communication units on the creation of a training game complex for training military specialists on the basis of leadership. *IgMin Research, 2*(2), 48–58. https://doi.org/10.61927/igmin145

Kyva, V., & Koshlan, O. (2022). Library digitalization as a strategic goal of higher military educational institution. *ΛΌГОΣ*, 230–232. https://doi.org/10.36074/logos-20.05.2022.070

Licciardello, F., Consoli, S., Cirelli, G., Castillo, C., Fernández-Ahumada, E., Montejo-Gámez, J., & Taguas, E. V. (2021). Technology-enhanced learning for promoting technical and social competences in hydrological science. *Technology, Knowledge and Learning, 26*, 985–997. https://doi.org/10.1007/s10758-021-09510-9

Maistrenko, O. V., Bubenshchykov, R. V., & Stetsiv, S. V. (2020). The use of simulation modelling tools in a practical training for the prospective officers of the Armed Forces of Ukraine. *Information Technologies and Learning Tools, 75*(1), 186–201. https://doi.org/10.33407/itlt.v75i1.2676

Martínez-Cerdá, J.-F., Torrent-Sellens, J., & González-González, I. (2020). Socio-technical e-learning innovation and ways of learning in the ICT-space-time continuum to improve the employability skills of adults. *Computers in Human Behavior, 107*, Article 105753. https://doi.org/10.1016/j.chb.2018.10.019

McCarthy, A. M., Maor, D., McConney, A., & Cavanaugh, C. (2023). Digital transformation in education: Critical components for leaders of system change. *Social Sciences & Humanities Open, 8*(11), Article 100479. https://doi.org/10.1016/j.ssaho.2023.100479

Miron, E. L., & Gherman, L. (2022). A new age in the Air Force: The digitalization of military higher education. *Scientific research and education in the Air Force – AFASES 2022* (pp. 99–102). https://doi.org/10.19062/2247-3173.2022.23.14

Mondragon-Estrada, E., Kirschning, I., Nolazco-Flores, J. A., & Camacho-Zuñiga, C. (2023). Fostering digital transformation in education: technology enhanced learning from professors' experiences in emergency remote teaching. *Frontiers in Education, 8,* Article 1250461. https://doi.org/10.3389/feduc.2023.1250461

Nychkalo, N., Ovcharuk, O., HordiienkoV., & Ivanyuk, I. (2022). Ukrainian education in the conditions of the Russian war^ trials, new experiences, prospects. *UNESCO Chair Journal Lifelong Professional Education in the XXI Century, 1*(5), 7–39. https://doi.org/10.35387/ucj.1(5).2022.7-39

Ocaña, M., Luna, A., Jeada, V. Y., Carrillo, H. C., Alvear, F., & Rosales, M. (2023). Are VR and AR really viable in military education? A position paper. In Á. Rocha, C. H. Fajardo-Toro, & J. M. Riola (Eds), *Developments and Advances in Defense and Security. Smart Innovation, Systems and Technologies* (pp. 165–177). Springer. https://doi.org/10.1007/978-981-19-7689-6_15

Pettersson, F. (2021). Understanding digitalization and educational change in school by means of activity theory and the levels of learning concept. *Education and Information Technologies, 26*, 187–204. https://doi.org/10.1007/s10639-020-10239-8

Pinchuk, O., & Prokopenko, A. (2021). Actual areas of development of digital competence of officers of the Armed Forces of Ukraine. *Educational Dimension, 5*, 89–108. https://doi.org/10.31812/educdim.4720

Pinto, M., Cavallo, V., & Ohlmann, T. (2008). The development of driving simulators: toward a multisensory solution. *Le travail humain, 71*, 62–95. https://doi.org/10.3917/th.711.0062

Porancea-Răulea, A., Bătușaru, C., & Rădoiu, A. (2023). Conscious or indifferent – concerns on digitalization and sustainability of the military higher education institution. *Knowledge-based organization: Proceedings of the 29th international conference, 29*(1), 152–157. https://doi.org/10.2478/kbo-2023-0023

Ramesh, N. (2023). Designing remedial course in English for engineering students from non-English medium background. *EIKI Journal of Effective Teaching Methods, 1*(2). https://doi.org/10.59652/jetm.v1i2.17

Rehman, ur Z. (2023). Trends and challenges of technology-enhanced learning in geotechnical engineering education. *Sustainability, 15*(10), Article 7972. https://doi.org/10.3390/su15107972

Saastamoinen, K., & Maunula, K. (2021). Usefulness of flight simulator as a part of military pilots training – case study: Grob G 115E. *Procedia Computer Science, 192*, 1670–1676. https://doi.org/10.1016/j.procs.2021.08.171

Schweighofer, P., Weitlaner, D., Ebner, M., & Rothe, H. (2019). Influential factors for technology-enhanced learning: professionals' views. *Journal of Research in Innovative Teaching & Learning, 12*(3), 268–294. https://doi.org/10.1108/JRIT-09-2017-0023

Serhiienko, T., & Samoilova, Y. (2022). Synchronous and asynchronous format of blended learning as a way of English language training in professional military education institutions and higher education institutions with specific study conditions. *Scientific Collection «InterConf+», 20*(105), 129–136. https://doi.org/10.51582/interconf.19-20.04.2022.011

Shen, C.-w., & Ho, J.-t. (2020). Technology-enhanced learning in higher education: A bibliometric analysis with latent semantic approach. *Computers in Human Behavior, 104*, Article 106177. https://doi.org/10.1016/j.chb.2019.106177

Silfverskiöld, S., Norsell, M., Bull, P., & Fransson, T. (2011). Interactive teaching of military-technology: A pilot study of implementation. *Stockholm Contributions in Military-Technology. 2010* (1st ed., pp. 141–150). https://www.diva-portal.org/smash/get/diva2:391582/FULLTEXT01.pdf

Smith, C., Onofre-Martínez, K., Contrino, M. F., & Membrillo-Hernández, J. (2021). Course design process in a technology-enhanced learning environment. *Computers & Electrical Engineering, 93*, Article 107263. https://doi.org/10.1016/j.compeleceng.2021.107263

Spridzāns, M. (2023). Perspectives of developing digital education in military institutions. *Society. Integration. Education: Proceedings of the International Scientific Conference, I*, 318–328. https://doi.org/10.17770/sie2023vol1.7141

Tan, B. S., & Wong, S. L. (2020). Learning principles of accounting in ICT-supported learning environments of Malaysian secondary schools: future-oriented approach. *Research and Practice in Technology Enhanced Learning, 15*, Article 1. https://doi.org/10.1186/s41039-020-00128-6

Teplická, K., Kádárová, J. & Hurná, S. (2022). The new model of the engineering education using digitalization and innovative methods. *Management Systems in Production Engineering, 30*(3), 207-213. https://doi.org/10.2478/mspe-2022-0026

Torichnyi, O., & Bhinder, N. (2019). Organizational methods of formation of military and special competence in future border guard officers in the continuing education process. *Revista Romaneasca Pentru Educatie Multidimensionala, 11*(4Sup1), 278–301. https://doi.org/10.18662/rrem/190

Torres-Díaz, J. C., Rivera-Rogel, D., Beltrán-Flandoli, A. M., & Andrade-Vargas, L. (2022). Effects of COVID-19 on the perception of virtual education in university students in Ecuador; technical and methodological principles at the Universidad Técnica Particular de Loja. *Sustainability, 14*(6), Article 3204. https://doi.org/10.3390/su14063204

Udeozor, C., Toyoda, R., Abegão, F. R., & Glassey, J. (2023). Digital games in engineering education: systematic review and future trends. *European Journal of Engineering Education, 48*(2), 321–339. https://doi.org/10.1080/03043797.2022.2093168

Urych, I. (2018). Students' opinion on the academic curriculum in military classes. *Security and Defence Quarterly, 18*(1), 26–44. https://doi.org/10.5604/01.3001.0011.8324

Vakaliuk, T. (2021). Structural model of a cloud-based learning environment for bachelors in software engineering. *Educational Technology Quarterly, 2*, 257–273. https://doi.org/10.55056/etq.17

Vodovozov, V., Raud, Z., & Petlenkov, E. (2022). Active blended learning engineering students: A case study. *Education Sciences, 12*(5), 344. https://doi.org/10.3390/educsci12050344

Xu, L., Zhang, J., Ding, Y., Sun, G., Zhang, W., Philbin, S. P., & Guo, B. H. W. (2022). Assessing the impact of digital education and the role of the big data analytics course to enhance the skills and employability of engineering students. *Frontiers in psychology, 13*, Article 974574. https://doi.org/10.3389/fpsyg.2022.974574

Xue-jun, R., Ya-ni, Z., Xiao-shuang, W., & Zheng-kang, Z. (2021). Design of Personalized Learning System for Military Vocational Education Based on Big Data. *Proceedings of 2nd International Conference on Artificial Intelligence and Education* (pp. 440–443). https://doi.org/10.1109/ICAIE53562.2021.00097

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