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Research article

AI in the Higher Military Institutions: Challenges and Perspectives for Military Engineering Training

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Abstract

Recognizing the peculiarities of the current system of military education and considering the necessity of rapid modernization of military engineering training, HMIs need to implement innovative technologies to enhance the educational process. The purpose was to present a detailed analysis of the implementation of AI technologies while training future military engineering officers, to outline the existing strategies, and to develop possible strategies to enhance the educational process through AI technologies. To achieve the research purpose, we conducted open and closed-ended surveys among 154 instructors through five questionnaires to address the research questions. The answers were studied using conventional content analysis and statistical data processing. The results revealed basic directions for using AI in military engineering training and possible AI applications for the formation of professional competencies among future military engineering officers. But, meanwhile, the findings indicate that the process of military engineering training is facing several challenges complicating the implementation of AI-driven transformations. To overcome the existing challenges of AI and elaborate the applicable recommendations for the implementation of AI in the HMIs, we outlined the strategies for the enhancement of military engineering training through AI technologies.

Keywords*:* AI, higher military institution (HMI), military engineering training, AI technology, application, AI-based methodology.

SUSTAINABLE DEVELOPMENT GOALS **Better Education**

1. Introduction.

Currently, AI in education has been rapidly increasing and demonstrating promising potential for individualized instruction, and improved assessment practices, to facilitate meaningful communication and collaboration between teachers and students (Zhang & Aslan, 2021). Also,

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scholars report that the benefits of incorporating AI in the classroom include the prediction of academic outcomes (Chatterjee & Bhattacharjee, 2020), enhancement of students' engagement (Ayala-Pazmiño, 2023), educational management (Igbokwe, 2023), interactive feedback (Harry, 2023), creation of high-quality learning materials (Seo et al., 2021).

The use of AI is not a new concept for modern pedagogy but its implementation within the educational process was of a fragmentary character before the COVID-19 pandemic. A global public health emergency, self-isolation, and strict lockdown caused a hard time for education. Such a situation forced educators to seek innovative approaches and methods to make education available, accessible, and adaptable (Goel, 2020). We recognize that AI technologies certainly move towards the revolution of the education system and assist in the achievement of positive educational outcomes. At the same time, AI tools and platforms modernize higher education and contribute significantly to the training of students in the intensive digital environment.

Military education aims to prepare highly qualified personnel to act in situations of risk and uncertainty specific to the missions of the defense and security forces in response to internal and external threats (Barreiros dos Santos et al., 2019). Existing security threats have exacerbated the problem of intensive modernization and digitalization of the system of military education in the world. Today, the process of training officers of the new generation is one of the most important issues of army transformation along with technological developments of weapons and equipment for any country.

2. Background

2.1 AI Innovations in Military Education.

The functioning of the security sector is impossible without the efficient system of training of officers for military units and law-enforcement agencies since military education as a concept has been considered the basis for strengthening the national defense and an essential tool for military personnel modernization strategy (Ya-Honga et al., 2020). Currently, the key challenges for military education are the creation of an innovative environment, extensive implementation of information and communication technologies, and the building of a new training paradigm aimed at the comprehensive development of a future officer's personality (Perminova et al., 2017).

AI, which refers to computing systems capable of engaging in human-like processes such as adapting, learning, synthesizing, correcting, and using various data to perform complex tasks (Chatterjee & Bhattacharjee, 2020), affects education considerably offering incredible potential for making the educational environment more knowledgeable, productive, adaptive, personalized and effective (Guan et al., 2020). AI is increasingly adopted by institutions to innovate in the digital age as it creates both qualitative and quantitative transformations within the educational process (Mariani et al., 2023). New AI technologies help with the emergence of technological developments and new approaches to computing. And then we obtain an education environment in a completely new context.

The analysis of the theoretical framework of AI innovations in military education requires the description of basic characteristics of educational innovations to prove that AI-driven changes are

fundamental tools and contribute to strengthening the support for effective modifications while training future military officers. Such characteristics relate to the following statements: (a) education innovation concern changes increasing the quality of education (Guan et al., 2020; Romanovskyi et al., 2020; Vincent-Lancrin, 2021); (b) educational innovations possess specific qualities (Vincent-Lancrin, 2021); (c) educational innovations may be initiated at any level (Romanovskyi et al., 2020); (d) educational innovations must be realized through operation or thinking activity (Mykhailyshyn et al., 2019); (f) educational innovations are implemented continuously (Guan et al., 2020); (g) introduction of educational innovations depends on the participants' readiness and the institution possibilities (Mykhailyshyn et al., 2019); (h) educational innovations are implemented through educational forms and methods (Blanco et al., 2020); (i) educational innovations are based upon certain theoretical concepts (Vincent-Lancrin, 2021); (j) educational innovations are manageable elements (Blanco et al., 2020).

The study of educational innovations contributed to building the paradigm of AI-driven transformations and further understanding how they enhance the quality of military education. According to Meshko and Tarabara (2012), the pedagogical paradigm of transformations is related to their typological peculiarities and semantic structure within the educational process. Consequently, it establishes several specific characteristics that correlate with AI-driven transformations. Table 1 shows the paradigmatic analysis of AI-driven transformations and thoroughly substantiates the validity of the role of AI in the enhancement of contemporary military education.

Table 1: Paradigmatic analysis of AI-driven transformations in the context of military education.

Basic characteristics of educational innovations	Characteristics of AI-driven transformations
Educational innovation as a targeted change	Concentration for enhancement (Ali Alnaqbi, 2020)
Possession of specific qualities	Rapidly evolving qualities (Wasilow & Thorpe, 2019); Innovative environment (Ustun et al., 2020)
Initiation at any level of the education system	Implementation of AI within various training programs (Ali Alnaqbi & Md Yassin, 2021)
Realization through operation or thinking activity	Interdependence between the use of AI technology and education quality (Ali Alnaqbi & Md Yassin, 2021)
Innovation as a continuous process	Development of scenarios for military training (Chuang & Cheng, 2022; Roberson et al., 2022); Legal and ethical requirements (Roberson et al., 2022; Sachdev, 2021)
Participants' readiness and institution possibilities	Ai literacy in defence (Ali Alnaqbi & Md Yassin, 2021; Hadlington et al., 2023);

Implementation through forms and methods	Innovative pedagogical technologies (Kim, 2021; Sachdev, 2021); Introduction of adaptive training (Meerveld et al., 2023; Spain et al., 2012); Use of games and simulators (Goecks et al., 2022); Incorporation of AI-based methodology (Gluck et al., 2020)
Orientation toward pedagogical objectives	Purpose-oriented environment (Özdemir, 2019); Maximization of AI impacts (Araya & King, 2022)
Monitoring, evaluation, variability, and improvement	Integration of AI technologies (Ali Alnaqbi & Md Yassin, 2021); Evaluation of AI-driven transformations (Hadlington et al., 2023; Roberson et al., 2022).

Military education whose primary objective is to train highly qualified and motivated officers, requires the implementation and purposeful use of digital tools and innovative education practices (Barreiros dos Santos et al., 2019). Since AI is moving fast, it is forcing us to rethink the system of military education and is facilitating new attributes of the educational environment in the HMIs.

2.2 Applications of AI for military engineering training.

When considering applications of AI in the educational process, it is important to indicate that a significant number of scientific studies are devoted to the enhancement of personalized learning and the construction of individual educational trajectories (Guan et al., 2020; Harry, 2023; Zhang & Aslan, 2021). Other findings show that AI is used in online learning supporting interaction (Seo et al., 2021), improving self-regulated learning, and boosting learners' engagement (Ayala-Pazmiño, 2023) or offering dynamic assessments (Zhang & Aslan, 2021). Several studies address the use of AI for the creation of learning materials and automatic content generation (Diwan et al., 2023; Seo et al., 2021; Yu & Chen, 2018). Besides, recent research effort concerns smart classroom incorporating AI-powered learning management systems including tutoring and assessment tools, data analysis, and control over virtual learning environment (Igbokwe, 2023). Other findings (Zhang & Aslan, 2021) reveal what advantages AI brings to improve assessment techniques. Thus, AI technologies contribute to automated assessment, peer assessment, writing analytics, electronic assessment platforms, and stealth assessment through digital games.

Some scientists imply that the publications concerning AI in education have a specific interest in administration processes (de Souza Zanirato Maia et al., 2023), intelligent data analysis (Yufeia et al., 2020), knowledge revision (Yufeia et al., 2020), visualizations and virtual learning environments (Zhang & Aslan, 2021). In addition, the recent AI-driven transformations in education cannot appropriately happen without considering the challenges or vulnerabilities. Recent findings highlighted social and juridical problems with the implementation of AI technologies in education (Perc et al., 2019).

In addition, certain studies have been oriented toward AI techniques used for military education and military engineering training in particular. Table 2 shows a detailed and comprehensive analysis of AI applications for military engineering training and the possibilities they offer for the educational process. These findings can be used to facilitate further research on AI in HMIs as they clearly demonstrate the benefits it may potentially bring to the system of military education.

Table 2: Analysis of AI applications for military engineering training.

Application	Possibilities for the educational process	Source
Games and simulations	to simulate military missions; to aid military planning; to generate expert-level decisions; to provide algorithms to support command and control; to randomize environment conditions; to execute complex scenarios; to analyse large data sets; and to practice specific skills.	Alhumaida et al., 2022; Araya & King, 2022; Gluck et al., 2020; Goecks et al., 2022; Hadlington et al., 2023; Sachdev, 2021; Zentner, 2022
Map development	to identify terrain features; approximate the area of operation; compute battle outcomes; and integrate sensors and maps.	Goecks et al., 2022; Sachdev, 2021
Tool for designing battle plans	to process input and output data; to develop a map-based interface; and to provide the best engineering choice.	Kott et al., 2002
Human-AI teaming	to form decision-making skills; to improve planning and avoid errors; to generate valuable knowledge; to process relevant data in a limited amount of time; and to understand possible perspectives and calculations.	Araya & King, 2022; Meerveld et al., 2023; Özdemir, 2019; Sachdev, 2021
e-learning	to implement personalized learning; to improve learning management; to provide virtual lecturers or individualized tutors; to create interactive courses; and to incorporate gamification.	Ali Alnaqbi & Md Yassin, 2021; Lakshmi et al., 2023; Zentner, 2022
Behavior models	to create a better training experience; enhance simulations; utilize learning algorithms; and develop autonomous activities.	Ustun et al., 2020
Machine Learning and Deep Learning	to facilitate cognitive processes; to enhance data integrity; to carry out engineering works; to support decisions; to provide intelligence analytics; to implement deep learning systems; to improve assessments; to identify and monitor hazards; to teach language; and to improve feedback.	Alhumaida et al., 2022; Araya & King, 2022; Hadlington et al., 2023; Kim, 2021; Özdemir, 2019; Sachdev, 2021; Szabadföldi, 2021
Big Data technology	to process and modify data; to develop virtual models of a weapons system; to detect threats; to advance mapping; to optimize management; to improve assessments; and to organize reskilling.	Araya & King, 2022; Kim, 2021; Özdemir, 2019
Communication systems	to improve communication; enhance personnel management; evaluate information; shape relevant communication strategies; and improve discourse.	Hadlington et al., 2023
Virtual Reality	to provide visualization; to make learning more flexible and dynamic; to increase knowledge	Lakshmi et al., 2023

	retention; to develop professional competencies; and to create complex test scenarios.	
Conversational agents or chatbots	to teach foreign languages; generate innovative ideas; summarize teaching materials; improve task-oriented communication skills; to analyze information.	Alhumaida et al., 2022; Chuang & Cheng, 2022; Zentner, 2022
Learning management systems	to create an effective learning environment; manage students' data; improve assessments; plan schedules; generate reports; and develop and deliver training materials.	Alhumaida et al., 2022; Zentner, 2022
Personalized learning	to develop individual educational trajectories; enhance instruction; provide feedback; to integrate technology and educational data.	Zentner, 2022

3. Purpose of the study.

The general objective of the present research was to present a detailed analysis of the implementation of AI technologies in Ukrainian military institutions while training future military engineering officers. The recent research (Barreiros dos Santos et al., 2019) demonstrated that the role of military training has been increasing and, as a result, the high demands for experienced military professionals during uncertain times. To reveal this issue, some scientists, particularly those who are involved in military education research (Ali Alnaqbi, 2020; Goecks et al., 2022), insist on comprehensive modernization of the educational process and extensive implementation of AI technologies. To explain the challenges and perspectives of using AI in military engineering training we considered the peculiarities of the existing system of military education in Ukraine along with the study of requirements for military engineering officers.

Overall, we address the following research questions:

1) What are the basic directions of military engineering training where AI technologies are introduced?
2) What are the possibilities of application of AI for the formation of professional competencies of future military engineering officers? How do HMIs use these opportunities to enhance military engineering training?
3) What are the challenges of AI-driven transformations in military engineering training? And what are the key factors for the improvement of military engineering training through AI applications?

4. Materials and methods.

The implementation of AI technologies for military engineering education was analyzed in 5 departments of the Bohdan Khmelnytskyi National Academy of the State Border Guard Service of Ukraine where future bachelor in the educational and professional program "Organization of activities of engineering and Technical Units of the State Border Guard Service of Ukraine" are trained. Also, the survey was conducted in three HMIs under the Ministry of Defence of Ukraine

(educational and professional programs "Electric power industry, electric equipment, and electric mechanics", "Armament and military equipment", "Automobile transport") and two HMIs under the Ministry of Internal Affairs of Ukraine (educational and professional programs "Armament and military equipment" and "Automobile transport").

4.1 Participants.

The survey was conducted among 154 participants in 6 HMIs of Ukraine which train future military engineering officers. They included the following professionals: chief of the department, professor, associate professor, senior instructor, methodologist, and head of laboratory. They had different teaching experiences and educational backgrounds and were involved in the teaching of various subjects. Also, we regarded gender, military status, previous experience of using AI technologies, and the type of lessons they conduct. Table 3 represents the descriptive profiles of survey respondents.

Table 3: Descriptive profiles of survey respondents.

Respondents' characteristics		Quantity (%)
Teaching experience		
	Under 10 years	13,0
	10-20 years	19,6
	21-30 years	33,5
	31-40 years	25,4
	Over 40 years	8,5
Gender		
	Male	76,2
	Female	23,8
Military status		
	Officer	63,2
	Civilian	25,1
	Retired	11,7
Educational background		
	Master	25,7
	PhD	59,5
	Doctor of Science	14,8
Position		
	Chief of the department	5,6
	Professor	11,2
	Associate Professor	22,4
	Senior Instructor	31,0
	Instructor	22,4
	Methodologist	3,7
	Head of the laboratory	3,7
Previous experience of using AI		
	Yes	23,2
	No	76,8
Subjects		
	General technical	17,2
	Special technical	16,4

	General Military	22,8
	Special military	24,9
	Humanities or Social sciences	18,7
Lessons		
	Lectures	25,9
	Seminars	16,3
	Practical session	30,7
	Laboratory	12,1
	Individual classes	6,4
	Group or individual consultations	8,6

4.2 Procedure.

We used five questionnaires to address the research questions. One form concerned basic directions of military engineering training where AI technologies are introduced; two forms were used to describe the possibilities of application of AI for the formation of professional competencies of future military engineering officers; one questionnaire was applied to assess the enhancement of military engineering training; and one form validated the challenges of AI-driven transformations (Table 4).

Table 4: Instruments of the survey.

Research question	**Instrument**	**Method**
What are the basic directions of military engineering training where AI technologies are introduced?	Questionnaire "Basic directions of AI application for military engineering training"	Closed survey including multiple choice and ranking questions
What are the possibilities of AI application for the formation of professional competencies of future military engineering officers? How do HMIs enhance military engineering training?	2 questionnaires "Possible applications of AI" Questionnaire "Impact of using AI in the process of training of future military engineering officers"	Analysing online survey data with closed and open-ended questions
What are the challenges of AI-driven transformations? What are the key factors for the improvement of military engineering training?	Questionnaire "Possible challenges of AI-driven transformations in military engineering training" Questionnaire "Strategies for enhancement of military engineering training through AI technologies"	Multiple choice form Expert reviews Open-ended items that allow the respondents to provide their responses Cognitive interview

The interview was conducted online through the circulation of Google Forms. The answers were analysed using conventional content analysis and statistical data processing. All the staff members

participated in the survey voluntarily and, in advance, they were informed about the research objectives and procedures.

4.3 Data analysis.

After surveying the scientific and pedagogical staff on clearly targeted questions, the results were analysed using methods of statistical data processing which converted the information into the assigned numeric values to facilitate educational research. Before processing the results of the survey, it is obligatory to guarantee that the data are collected without errors and the participants answered objectively and unbiasedly.

The data processing required the application of the following methods: descriptive statistical analysis to reduce large volumes of information concerning the use of AI in education and its possible impact upon improvement of the educational process, to represent and interpret the numbers collected during the survey; predictive analysis to evaluate future pedagogical changing strategies based on the research outcomes through predictive modelling; data interpretation to provide conclusive results and to answer the research questions. To ensure accuracy, all the data were verified by two experts with extensive experience in organizing quantitative education research. All the findings were then implemented to improve military engineering training through AI-driven transformation in the HMIs

5. Results.

5.1 Basic directions of AI application for military engineering training.

The respondents were involved in a closed survey where multiple-choice and ranking questions were applied. The findings showed that instructors consider five basic directions of AI application within the educational process. They are the following: personalized learning and building individual trajectories, learning management systems, assessment, data analysis, and intelligent tutoring systems (Figure 1). At the same time, most respondents (27,3 %) think that learning management systems are the most applicable for military engineering training as they help optimize teachers' efforts, manage time, and improve the planning process. As a rule, the teachers use AI technology to make schedules, evaluate possible classroom activities, record attendance, or make the necessary changes in lesson plans.

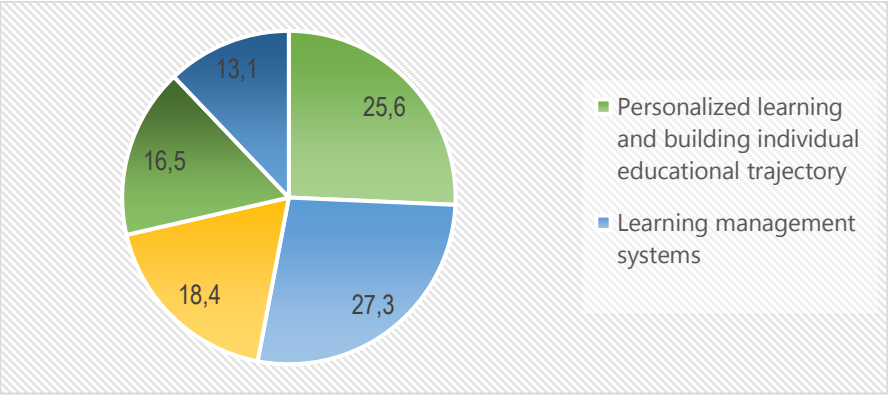

Figure 1: Basic directions of AI application for military engineering training.

A rather large number of staff members (25,7 %) regard personalized learning and building individual trajectories as the main direction of AI applications. 18,4 % of respondents are sure that the implementation of AI technology may be useful for the improvement of assessment since it makes it possible to obtain instant results and analyse errors. Other participants indicate the data analysis (16,5 %) and intelligent tutoring systems (13,1 %) belong to basic directions of AI application for military engineering training. The findings suggest that the staff members understand the increasing role of AI technology in military education and focus on its adequate use in the HMIs to ensure maximum effect.

5.2 Possible applications of AI.

The findings showed that actually, a small number of instructors apply AI technologies within the educational process despite their possible positive impact. As manifested in Table 5, most respondents use AI-based tools like conversational agents or chatbots, personalized learning systems, e-learning, games and simulation, assessment, administration processes, and learning management.

Table 5: Possible applications of AI (by frequency).

Possible applications of AI	Quantity (%)				
	Regularly	Often	Sometimes	Rarely	Never
Personalized learning systems	2,4	7,8	28,6	38,9	22,3
Learning management systems	2,3	6,7	20,6	32,1	38,3
e-learning	4,2	9,8	15,6	45,8	24,6
Games and simulations	7,2	13,4	22,9	29,8	26,7
Assessment tools	6,3	15,6	18,8	31,4	27,9
Data analysis	1,1	4,3	11,9	29,6	53,1
Big Data technology	0,0	1,2	9,6	16,7	72,5
Map development	0,6	0,6	2,4	8,1	88,3
Tool for designing battle plans	0,0	0,0	0,6	1,8	97,6
Human-AI teaming	0,0	0,0	0,0	1,2	98,8
Machine Learning and Deep Learning	1,2	3,5	13,4	23,8	58,1
Virtual Reality	0,6	2,4	3,8	11,5	81,7
Boosting cadets' engagement	1,3	1,8	4,5	15,6	76,8

Behavior models	0,8	2,3	6,3	12,1	78,5
Communication systems	0,4	2,8	9,1	14,7	73,0
Administration processes	5,8	11,9	15,4	31,8	35,1
Conversational agents or chatbots	11,4	20,5	23,9	38,3	5,9
Knowledge revision	1,2	2,8	8,7	13,3	74,0

The analysis of the personal data of respondents demonstrates that using AI technologies is comfortable for those instructors who have a technical or military educational background, used AI previously in their professional activities and underwent advanced training in AI-based methodology, or experienced AI-driven transformations while taking internships in the HMIs abroad where AI tools are more applicable.

Studying AI applications, we concluded that they vary depending on the subjects as some instructors diversify educational technologies and consider the use of AI tools an essential condition to enhance the quality of the educational process (Table 6). To estimate the possible AI applications for military engineering training we chose a 5-point scale, where 5 points mean that 100-90 % of instructors use the particular technology and it is applied regularly, 4 points = 89-65 %, 3 points = 64-45 %, 2 points = 44-25 %, 1 = 24 % and less. If some technologies are introduced during the course, we summed up the points.

Table 6: Possible application of AI (by subjects).

Subject	AI applications	Frequency
Engineering Graphics	Learning management systems	3
	e-learning	2
	total	5
Machinery Parts	Data analysis	3
	Knowledge revision	2
	total	5
Standardization and Technical Measurement	Administration processes	2
	total	2
Physics	e-learning	1
	Data analysis	1

	total	2
Heat Engineering	Administration processes	2
	total	2
Work of Heat Engine	Learning management systems	1
	total	1
Applied Mechanics	Learning management systems	2
	e-learning	2
	total	4
Theory of Technical Systems	Administration processes	2
	total	2
Strength of Materials	Knowledge revision	1
	total	1
System Analysis	Administration processes	1
	total	1
Mathematics Programming	Assessment tools	2
	Data analysis	2
	Big Data technology	1
	total	5
Processing of Materials	Assessment tools	2
	total	2
Chemistry	e-learning	3
	total	3
Materials Science	Machine Learning and Deep Learning	1
	total	1
Hydraulics	e-learning	1

	total	1
Occupational Health	Learning management systems	2
	Games and simulations	2
	total	4
Engineering Structures	Machine Learning and Deep Learning	1
	total	1
Engineering Armament	Learning management systems	2
	total	2
Automobile Engines	Knowledge revision	2
	total	2
Autotechnical Expertise	Games and simulations	3
	total	3
Electrical Engineering	Learning management systems	2
	total	2
Operations of Engineering Units	Adaptive and personalized learning systems	2
	Games and simulations	3
	Boosting cadets' engagement in the classroom	2
	total	7
Mine Safety	Learning management systems	2
	Games and simulations	2
	total	4
Intelligence Training	Adaptive and personalized learning systems	3
	total	3
Tactical Training	Adaptive and personalized learning systems	3
	Learning management systems	3

	Games and simulations	4
	Map development	3
	Tool for designing battle plans	2
	Virtual Reality and the creation of a virtual learning environment	2
	total	17
Weapons Training	Adaptive and personalized learning systems	2
	total	2
Art of war	Games and simulations	3
	Conversational agents or chatbots	2
	total	5
Border Control	Learning management systems	3
	Games and simulations	3
	total	6
Technical Means for Border Defence	Assessment tools	2
	total	2
Basics of Survival	Games and simulations	3
	total	3
Information Security	Machine Learning and Deep Learning	1
	total	1
Technical Cybernetics of Transport	Assessment tools	2
	Administration processes	1
	total	3
Military Law	Conversational agents or chatbots	2
	total	2
Logistics	Learning management systems	2

	Map development	2
	Data analysis	1
	total	5
Technical Maintenance	e-learning	3
	Assessment tools	3
	Data analysis	2
	Machine Learning and Deep Learning	1
	Virtual Reality	2
	Games and simulations	4
	total	15
Driving Instruction	Personalized learning systems	2
	Map development	3
	Games and simulations	4
	total	9
Philosophy	Conversational agents or chatbots	2
	total	2
Sociology	Data analysis	2
	total	2
Data Processing	Learning management systems	2
	Assessment tools	1
	total	3
Psychology and Pedagogics	Personalized learning systems	2
	Conversational agents or chatbots	2
	total	4
Foreign Language	Adaptive and personalized learning systems	3

	e-learning	4
	Games and simulations	3
	Assessment tools	3
	Conversational agents or chatbots	2
	Administration processes	2
	Machine Learning and Deep Learning	1
	Boosting cadets' engagement in the classroom	2
	total	20
Physical Training	Adaptive and personalized learning systems	3
	total	3
Moral and Psychological Support	Assessment tools	2
	Games and Simulation	2
	Conversational agents or chatbots	2
	Human-AI teaming	1
	total	7
Military Leadership	Personalized learning systems	2
	Behavior models	1
	total	3
Communications	e-learning	3
	total	3

The findings show that the following subjects are usually taught with the use of artificial technology: Tactical Training, Technical Maintenance, Driving Instruction, and Foreign Language. Several subjects are taught using minimal AI technology. They include Physics, Work of Heat Engine, Strength of Materials, System Analysis, Materials Science, Hydraulics, and Engineering Structures.

5.3 Impact of using AI in the process of training future military engineering officers.

The respondents were asked through a multichoice online test. Table 7 shows that the staff members admit, that when used correctly, AI technology may improve the educational process and affect the educational environment positively.

Table 7: Impact of using AI in the process of training of future military engineering officers

Impact of using AI	Quantity (%)				
	Regularly	Often	Sometimes	Rarely	Never
Improvement of interaction	3,5	8,1	14,0	29,5	44,9
Objective assessment	1,2	12,8	15,4	31,9	38,7
Optimization of instructor's work	4,1	13,9	17,6	44,1	20,3
Implementation of innovative teaching technologies	5,6	12,6	23,0	37,4	21,4
Enhancement of cadets' motivation	3,2	11,7	20,8	28,4	35,9
Building of professional competencies	2,4	18,6	23,4	25,8	29,8
Accurate interpretation of data	1,4	5,9	18,6	28,0	46,1
Identification of possible problems	0,6	2,8	15,7	19,4	38,5
Formation of deep knowledge	0,6	3,7	9,2	32,1	54,4
Constant feedback	1,2	5,3	7,7	26,3	59,5
Entertainment	3,2	18,5	21,9	30,1	26,3
Task automation	1,4	5,8	13,3	21,6	57,9
Development of learning materials	3,0	7,6	19,8	27,3	42,3
Preparing cadets to work in a digital environment	5,5	12,8	24,9	30,2	26,6
Formation of information literacy	3,4	11,5	17,6	27,1	40,4
Building of practical skills	2,1	8,3	9,5	14,8	65,3
Increasing educational quality	9,5	14,7	20,3	40,1	15,4
Lowing human errors	2,3	17,8	19,4	29,3	31,2

The solution to complex problems	3,1	9,3	17,2	31,0	39,4
Fostering peer learning	0,6	3,7	14,5	20,9	60,3
Increasing productivity	2,3	7,8	9,6	19,5	39,2
Time management	1,2	8,1	12,5	24,3	53,9
Development of creativity	0,6	7,3	14,6	19,0	58,5
Formation of decision-making	0,8	11,5	30,1	32,9	24,7
Improvement of cognitive flexibility	1,2	18,5	14,5	28,8	37,0

To investigate the reasons for such views among staff members we interviewed them through open-ended questions in the survey about the possible challenges of AI-driven transformations in military engineering training.

5.4 Possible challenges of AI-driven transformations in military engineering training.

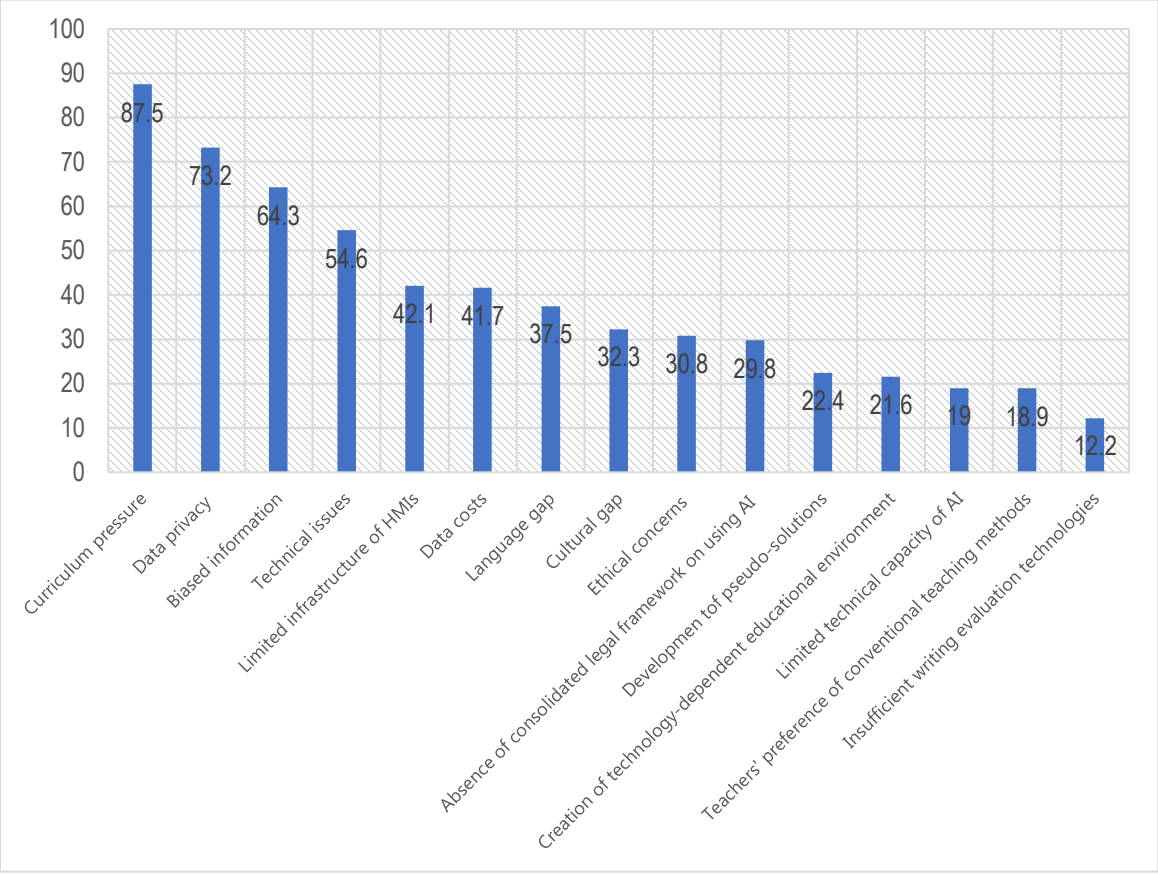

Figure 2: Challenges of AI-driven transformations in military engineering training.

Figure 2 shows that the instructors note several challenges that complicate the process of implementation of AI-driven transformations. 87,5 % of respondents stated that they cannot apply

AI technologies regularly as they are facing curriculum pressure. 73,2 % of staff members worry about data privacy while using AI tools since HMIs are establishments with restricted access to service information. Other major challenges are related to technical issues, data costs, language gaps, lack of certain skills, or teachers' preference to use conventional teaching methods.

5.5 Strategies for enhancement of military engineering training through AI technologies

To overcome the existing challenges and elaborate the applicable recommendations for the implementation of AI in HMIs, we studied the strategies for the enhancement of military engineering training through AI technologies (Figure 3). The findings showed that the staff members suggested introducing five strategies, in particular incorporation of AI in the curriculum, development of AI digital literacy among the participants of the educational process, development of regulations when using AI, development of AI-based methodology, and increasing of teachers' innovative competency which suggests using innovative teaching methods and making AI a teaching mode in HMIs.

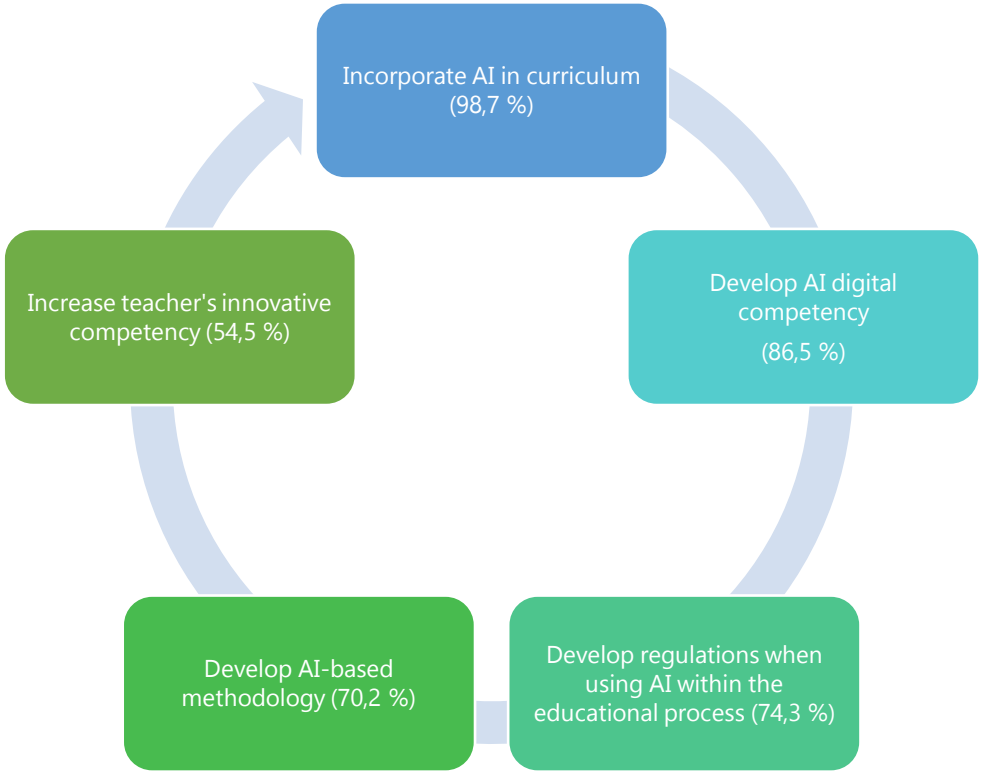

Figure 3: Strategies for enhancement of military engineering training through AI technologies.

6. Discussions.

Based on the survey results, five strategies for the enhancement of military engineering training through AI technologies may be taken into consideration.

First, the training of future military engineering officers effectively and data privacy control requires the development of a legal framework for using AI. Especially it is essential for HMIs where there is restricted access to information. Since all Ukrainian educational institutions function

on the principles of harmonization of Ukrainian legislation with European Union (EU) law under the EU-Ukraine Association Agreement, the proposed EU AI law (European Commission, 2021) becomes the basis for the design of AI regulations. Meanwhile, HMIs approximate their educational process to the North Atlantic Treaty Organization (NATO) standards, and they are obliged to apply AI policies at NATO (Stanley-Lockman & Christie, 2021). Institution-specific regulations may help teachers deal with contextualized situations and address risks specifically created by AI applications. Also, the official guidelines include a list of high-risk applications that cannot be used in the HMIs and define specific obligations for AI users, both instructors and cadets. We expect that the development of a legal framework for using AI will facilitate the educational process and enable the participants to benefit from several innovative technologies that already exist.

Second, the incorporation of AI in the curriculum concerns the accommodation of AI principles, ethics, regulations, and basic functions into the courses taught in the HMIs as well as the creation of integrated courses with the use of AI tools. The strategy is oriented on the efficient application of AI tools in the process of training future military engineering officers and is available for the formation of AI literacy, and digital competency. Moreover, such implications may be helpful to extend the possibilities of operation of engineering units and increase the productivity of professional activity of future military engineering officers. The incorporation of AI in the curriculum is an essential condition for the development of instructor's and cadets' adaptability to innovative digital educational environments within HMIs. Thus, modification of the existing curriculum will create a stable position for the correct and ethical use of AI in military engineering training.

Third, a high level of AI digital competency among the participants of the educational process means they are ready to work with AI tools correctly, able to process big volumes of information from different sources, and understand the necessity of digital transformation within a professional military activity (Ng et al., 2023). The development of AI digital competency requires the introduction of special courses for instructors and cadets to teach how to operate in the digital environment and how to avoid possible errors. AI digital competency is essential for the optimization of educational processes, work in the online environment, improvement of visual perception of learning materials, creation of high-quality content using AI tools, collection and systematization of data, development of AI-based projects, positive online communication, improvement of teaching practices, efficient classroom management.

Fourth, the enhancement of military engineering training through AI technology requires the development of a specific methodology aimed at the selection of teaching methods and activities to make the educational process efficient. Appropriate methodology allows the instructors to use learning material appropriately, to form deep knowledge and skills among cadets, and to train future military engineering officers to continuous learning. Currently, teaching subjects at the HMIs is facing rapid transformations as we observe the transfer from conventional teaching methods to personalized learning and interactive teaching styles. On the one hand, AI tools, like behavior models, data analysis, and learning management systems, contribute to the modernization of military education and form effective customized learning. On the other hand, the use of AI tools demands using specific teaching methods considering the subjects being taught and educational objectives.

Fifth, increasing teachers' innovative competency contributes to the wide use of innovative teaching methods and makes AI a teaching mode in HMIs. The strategy helps develop learners' cognitive potential, develop interesting and aesthetic learning materials, provide adaptive or differentiated learning, and, as a result, increase the volume of information taught during the lesson. Implementation of innovative teaching methods positively affects cadets' motivation and, therefore, leads to productivity enhancement and the creation of inner wishes to work and apply new technologies.

It is noteworthy that the implementation of AI technologies for military engineering training plays an important role and may lead to the enhancement of the educational process in the HMIs and the improvement of professional competencies among future military engineering officers. The current educational and professional programmes in the HMIs in Ukraine suggest a number of obligatory and elective courses that allow using AI tools and the content is adjusted to the existing conditions of professional military activity as well as digital transformation and technological advances.

7. Conclusions.

The research aimed at surveying the current aspects of using AI for military engineering training in the HMIs, its challenges, and perspectives, presents a detailed analysis of AI technologies as instruments of comprehensive modernization of the educational process and investigates the strategies for enhancement of military engineering training. Currently, the system of military education focuses on modernization changes and transfer to an innovative pedagogical paradigm. Consequently, it possesses specific characteristics that correlate with AI-driven transformations and highlight the role of AI in the enhancement of the educational process.

The survey indicates that AI technologies in military engineering training are introduced in five basic directions they include the following: personalized learning and building individual educational trajectories, learning management systems, assessment, data analysis, and intelligent tutoring systems. The findings show that the most common AI applications used in the educational process in HMIs are conversational agents or chatbots, personalized learning systems, e-learning, games and simulation, assessment, administration processes, and learning management. At the same time, AI applications vary depending on the subjects since not all instructors decide to use innovative technologies considering the absence of a legal framework and AI-based methodology. If AI tools are implemented, they contribute to the diversification of educational technologies in the classroom and enhance the quality of the educational process. According to the survey outcomes, Tactical Training, Technical Maintenance, Driving Instruction, and Foreign Language are the subjects that are taught with the use of AI.

We found that AI technology may affect the educational process positively if used correctly. As manifested in the survey, the technology improves cadet-instructor interaction, provides objective assessment, optimizes instructor's work, enhances cadets' motivation, helps interpret the data, establishes interactive feedback, and contributes to the development of learning materials and task automation. Also, AI tools are used to increase educational quality, lower human errors, and form professional competencies among cadets. But, meanwhile, the process of military

engineering training is facing several challenges. They include curriculum pressure, data privacy, biased information, technical issues, the limited infrastructure of HMIs, data costs, language gaps, ethical and legal concerns, and low levels of AI digital competencies among instructors.

To overcome the existing challenges of AI and elaborate the applicable recommendations for the implementation of AI in HMIs, we studied the strategies for the enhancement of military engineering training through AI technologies. They are oriented towards the development of regulations when using AI, incorporation of AI in curriculum, development of AI digital competency among the participants of the educational process, development of AI-based methodology, and increasing of teachers' innovative competency.

The study, therefore, proves that AI-driven changes are fundamental tools and contribute to strengthening the support for effective modifications while training future military engineering officers.

Declaration of Conflicts of Interests

The authors declared no potential conflicts of interest.

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