

OPERATIONAL AGILITY IN DUAL-USE EDUCATION: A STUDY OF AI, CRITICAL THINKING AND VIRTUAL RESOURCE MANAGEMENT

Adrian-Paul SINGHEORGHE

National University of Science and Technology Politehnica Bucharest, Romania
adrian.singheorghe@gmail.com

Mihai-Virgil NICHITA

National University of Science and Technology Politehnica Bucharest, Romania
mihai_nichita9@yahoo.com (corresponding author)

Andreea BARBU

National University of Science and Technology Politehnica Bucharest, Romania
andreea.barbu2901@upb.ro

Dana Corina DESELCU

National University of Science and Technology Politehnica Bucharest, Romania
d_deselnicu@yahoo.com

ABSTRACT

This paper analysed the role of critical thinking and artificial intelligence in optimizing operational agility in the context of the use of emerging and disruptive dual-use technologies, from the perspective of civil and military technical education. The accelerated development of artificial intelligence, autonomous systems and digital infrastructures generated complex and uncertain operational environments, which exceed the limits of traditional decision-making models. The research had a qualitative exploratory-analytical approach, based on the analysis of the specialized literature. The comparative civil-military analysis highlighted the convergence of the skills necessary for the use of dual-use technologies in maintaining cognitive control over technologically assisted decisions. Operational agility should not depend exclusively on technology, but on its integration with advanced cognitive skills. Critical thinking supports the contextual interpretation of information, the management of technological risks and human responsibility in decisions with an impact on security. The paper proposes an integrative conceptual framework and strategic recommendations for educational policies and civil-military cooperation.

KEYWORDS: agents, agility, critical thinking, management

**Submission Received: 06 April 2026; Revised: 25 April 2026;
Accepted: 04 May 2026; Published: June 2026**

1. Introduction

This work considered one of the major strategic challenges of the contemporary security and technological development environment: how technical education can

support the optimization of operational agility in a context dominated by emerging and disruptive dual-use technologies, in both civilian and military environments.

The accelerated evolution of emerging and disruptive technologies represents one of the most profound structural transformations of contemporary society, with a direct impact on the way in which civil and military activities are conceived, organized and executed. In line with the work of the Organisation for Economic Co-operation and Development (OECD, 2021), on education at a glance and the North Atlantic Treaty Organization (NATO, 2026), on emerging and disruptive technologies, it can be stated that artificial intelligence, autonomous systems, big data analysis, quantum technologies, advanced communications and collaborative robotics can no longer be analysed exclusively from a sectoral perspective, as they operate in a dual-use regime, in which the boundary between civil and military applications is becoming increasingly diffuse.

According to Bennett and Lemoine (2014), this technological convergence generates an operational environment characterized by high complexity, decisional uncertainty, systemic interdependence and accelerated dynamics of change, phenomena frequently described in the specialized literature through concepts such as Volatility, Uncertainty, Complexity and Ambiguity (VUCA) or, more recently, Brittle, Anxious, Non-linear, Incomprehensible (BANI). In this context, being in line with the work of NATO (2024) on cognitive warfare, traditional planning and control cycles become insufficient and rigid organizational models are progressively replaced by adaptive and distributed architectures.

In both the civilian and military sectors and in accordance with Alberts and Hayes (2006) work about understanding command and control, a paradigm shift is emerging: strategic advantage is no longer determined exclusively by technological superiority, but by the ability of organizations to integrate technology into rapid, informed and accountable decision-

making processes that support the quality of AI-enabled decisions, human resource cognitive workload reduction and human control over them. Consequently, operational agility is becoming a fundamental requirement for the efficient functioning of complex socio-technical systems.

The purpose of the paper is to highlight the role of critical thinking in the use of artificial intelligence to improve operational agility, in the context of emerging dual-use technologies, from the perspective of civilian and military education.

The paper is structured in five main sections, starting with the introduction, followed by the analysis of dual-use technologies and their impact, a discussion on the civil-military implications of critical thinking, the role of artificial intelligence in information processing, and, finally, the conclusions of the study.

The literature review was conducted using a structured search of peer-reviewed journal articles, academic books and policy reports published in English between 2010 and 2024 from BDI indexed databases. Google Scholar platform was used using combinations of keywords including “critical thinking”, “artificial intelligence”, “operational agility”, “dual-use technologies” and “civil-military education”. Sources were selected based on relevance to the intersection of AI, cognitive skills and civil-military educational contexts, methodological transparency and citation impact. The analysis employed an exploratory-analytical framework, combining thematic content analysis with a comparative civil-military lens to identify convergent topics and to develop an integrative conceptual model linking critical thinking, AI integration and operational agility.

2. Dual-Use Technologies and Their Impact on Education and Operations

Blockchain and related data security technologies have applications in finance, digital identity and trusted infrastructures, as well as in protecting military communications, supply chains and operational information integrity. IoT, edge computing and distributed architectures are also used to optimize complex civil systems, as well as to manage the resilience of critical systems and tactical operations in contested environments. These technological developments are deeply disruptive not only from a technical point of view, but also from an organizational and cognitive perspective. The literature, such as Brundage et al. (2018) work on malicious use of AI, highlights that technology, in the absence of adequate cognitive skills, can amplify systemic risks, vulnerabilities and decision-making errors, especially in contexts characterized by time pressure and information ambiguity.

The technological transformations described above are exerting significant pressure on technical education systems, both civilian and military. Traditional training models, focused on the transmission of specialized knowledge and standardized procedures, are increasingly inadequate for preparing professionals who must operate in dynamic and interconnected technological ecosystems characterized by rapid change and systemic complexity.

Technical education in civilian contexts must prepare specialists to manage complex digital systems, analyse large data sets and make decisions under uncertainty. In the military sphere, it focuses on operating autonomous systems, AI-supported command structures and agile communications. Despite different traditions, both systems are converging, emphasizing shared skills like critical thinking, adaptability and contextual judgment, especially important for civil-military collaboration in innovation and technology transfer.

In line with work of Facione et al. (2011), critical thinking is defined as a complex cognitive process that involves the analysis, evaluation and synthesis of information in order to formulate rational judgments and make informed decisions. In the context of emerging and disruptive technologies, this competence gains strategic importance, becoming a fundamental mechanism for mediating between humans and technology.

Numerous studies show that systems based on artificial intelligence and Big Data can introduce biases, interpretation errors and ethical risks, especially when decisions are automated or semi-automated. In this context and in agreement with the work of Floridi et al. (2018), critical thinking allows users to assess the quality of data, correctly interpret algorithmic results and identify the limits of technological autonomy. In the military environment, these issues are particularly sensitive in the context of autonomous weapons, multi-domain operations and real-time AI-assisted decisions, where human accountability and compliance with the international legal framework remain indispensable. In the civilian environment, the implications are similar, especially in areas such as critical infrastructure, intelligent transport and cybersecurity.

Operational agility is the ability to quickly adapt, learn and adjust strategies. In complex tech environments, it depends on integrating technology into decisions and operations. This includes agile communications, spectrum management, unmanned systems and AI support aligned with human reasoning. Critical thinking supports this synchronization, providing the cognitive framework necessary to assess complex situations and adapt strategies in real time. Given the above, the main purpose of this research was to analyse how the development of critical thinking within civil and military technical education can contribute to optimizing operational agility in contexts dominated by emerging and

disruptive dual-use technologies. Furthermore, the paper promoted the use of AI agents, virtual resources of an organization, in applications such as individual practice for the purpose of continuous practice to sediment information.

3. Analysis and Discussion: Civil-Military Implications of Critical Thinking in the Context of Emerging Technologies

3.1. The Impact of Disruptive Technologies in Civilian and Military Environments

In the civil environment, emerging and disruptive technologies were integrated into a variety of domains, such as energy infrastructure, smart transport, financial systems, digital health and public administration. Artificial intelligence, Big Data, IoT and advanced digital platforms allowed for process optimization, cost reduction and increased speed of reaction to changes in the external environment.

However, as McAfee and Brynjolfsson (2017) state in the literature review, the mere adoption of technology did not automatically lead to increased operational agility. On the contrary, civil organizations that implemented advanced technological solutions without developing adequate cognitive skills at the staff level often faced problems such as overreliance on algorithms, erroneous interpretation of data or the rigidity of decision-making processes.

In this context, it can be said that critical thinking plays a fundamental role in mediating the relationship between technology and decision-making. Organizational practices that encourage critical analysis of the results generated by automated systems allow for a more flexible and responsible use of emerging technologies, thus contributing to a real increase in operational agility.

From an educational perspective, these findings support the need to integrate critical thinking into civil engineering

education, not as an isolated discipline, but as a transversal competence applied to the use of technology.

In the military environment, the impact of emerging technologies was amplified by the critical nature of decisions and their potentially irreversible consequences. Autonomous systems, unmanned platforms, AI-assisted command and control architectures and real-time analytics capabilities were profoundly transforming the way operations are planned and conducted.

Analysis of NATO documents, such as NATO (2024) and NATO (2025) and specialized literature highlighted that technology allows for the expansion of operational capabilities and the reduction of risks for human personnel, but at the same time introduces new cognitive and organizational vulnerabilities. Excessive automation can lead to a decrease in situational awareness, a loss of critical assessment capacity and the implicit delegation of responsibility to technical systems.

In this context, critical thinking is fundamental for maintaining human control over the decision-making process, especially in situations characterized by ambiguity, time pressure and incomplete information. The literature on autonomous weapons consistently emphasizes the need to retain meaningful human intervention in potentially lethal decisions.

Therefore, military education must go beyond strictly procedural training and include the systematic development of critical thinking as a central element of leadership and responsible decision-making.

Naturally, the civilian and military environments may highlight a number of significant convergences in terms of the use of emerging technologies and the need to develop advanced cognitive skills. In both environments, dual-use technologies are integrated into complex, interconnected and

data-dependent systems, where decisions must be made quickly and under conditions of uncertainty.

The differences, as D'Alessio, Aitella, Giannini and Burrai (2024) say, mainly arise at the level of the decision-making context and the consequences of decisions. In the military environment, risks are often immediate and existential in nature, which requires a stricter framework of accountability and control. In the civilian environment, the consequences are usually more diffuse, but can have long-term systemic impact, especially in the case of critical infrastructures.

However, recent literature, such as Enstad and Hagen (2026), argues that these differences do not justify completely separate educational approaches, but on the contrary, indicate the need for a common core of cognitive skills, focused on critical thinking, contextual judgment and adaptability.

The results of theoretical and documentary analysis indicate that critical thinking contributes to operational agility through several complementary mechanisms. First, it facilitates the contextualized interpretation of information, avoiding automatic reactions based solely on technological indicators.

Second, critical thinking may support organizational learning, allowing the evaluation of previous decisions and the adaptation of strategies according to the feedback obtained. In civilian and military environments, this capacity is fundamental for maintaining operational relevance in a context of rapid change.

Third, critical thinking may function as a mechanism for managing technological risks, contributing to identifying the limits of autonomous systems and integrating ethical and legal considerations into the decision-making process.

From an educational perspective and in accordance with the work of Mena-Guacas, López-Catalán, Bernal-Bravo and

Ballesteros-Regaña (2025), the analysis highlights the need for a reconfiguration of the technical curriculum, both in the civilian and military environment. Critical thinking should not be treated as a generic competence, but as a skill directly applied to the use of emerging technologies.

Integrating critical thinking into technical training means using real civilian and military case studies, leveraging technology-assisted decision-making tools and evaluating not just technical solutions but also the reasoning behind them. These approaches are supported by the recommendations of international organizations on education for the digital age and technological security.

3.2. Defence Related Initiative

In reference with work of Seol (2024), Joint All-Domain Command and Control (JADC2) is the U.S. Department of Defence's strategic initiative to integrate command and control capabilities across all operational domains (land, air, maritime, space, cyber and information) into a unified architecture based on data networks, artificial intelligence and real-time processing.

The goal of JADC2 is to reduce decision latency and increase decision advantage by integrating data from distributed sensors, automatically correlating information and providing AI decision-making options to the human factor.

Although the JADC2 architecture demonstrates superior technological performance, defence departments' doctrinal exercises and analyses have highlighted associated risks such as overconfidence in AI-generated recommendations (automation bias), difficulties in understanding algorithmic assumptions, increased time pressure on human decision-makers or risk of implicit delegation of decision-making, especially in contexts with a large volume of data, an incomplete information or a contested environment (electromagnetic and cyber).

This situation may highlight the fact that technological superiority does not guarantee decision-making superiority, in the absence of adequate cognitive skills.

The use case proposed integrating critical thinking into the training of military personnel who operate or supervise JADC2 systems by incorporating real ABMS-based scenario analysis, exercises in interpreting AI outputs and assessing algorithmic limits, decision simulations requiring justified choices among AI-generated options and the integration of legal, ethical and strategic constraints into the decision-making process.

Implementing this type of training helps maintain meaningful human control within C2 architectures, reduces the risk of systemic errors in AI-assisted decision-making, enhances operational agility through fast and accountable decisions based on accurate information and strengthens cognitive interoperability across domains and organizational structures.

Although JADC2 is a military concept, the logic of this use case is transferable to civilian domains such as critical infrastructure management, intelligent transportation systems, emergency command centres and energy and communication networks.

In all these areas, AI supports decision-making, but cannot substitute it and critical thinking remains the controlling factor.

3.3. Civilian Related Initiatives

According to Troitiño (2025), Estonia is internationally recognized as a leading country in digitalization, e-government and digital education. The national strategy on artificial intelligence and technological education is coordinated by state entities such as Government, Ministry of Education and Research or Information System Authority.

The stated strategic goal is to develop the cognitive and digital skills necessary for the responsible use of AI in administration,

economy and education, not just the adoption of the technology as such. Implementation in education requires schools to have access to advanced digital infrastructure such as high-speed internet and e-learning platforms, students to be introduced to computational thinking, AI and data analysis at the secondary level and teachers to be trained in digital competencies and technology-oriented pedagogy. In the educational public sector, AI can be used to personalize learning, predict school dropout risks and support policy decision-making, provided that the human-in-the-loop principle is explicitly maintained in administrative processes.

Public institutions must analyse and highlight that the use of AI in education and administration increases efficiency, but can introduce algorithmic biases, overreliance on automated proposals or opaque decisions. What is more, without critical thinking, users (students, teachers, civil servants) tend to accept AI results without evaluation or underestimate the limits of data and models. The use case highlights the integration of applied critical thinking into technical and digital education through AI modules focused on interpreting algorithmic results and understanding their limits and societal impact, real case studies from digital public administration and decision-making exercises where AI provides recommendations but the final, justified decision remains with the human.

The implementation of this approach may lead to increased public trust in digital systems, reduced the risk of uncontrolled automated decisions and development of an organizational culture oriented towards accountability, transparency and adaptability.

A central aspect of the discussion concerns the inherent limitations of emerging technologies. While AI and autonomous systems can process large volumes of data and identify complex patterns, they remain dependent on data quality and design assumptions. However,

digital assisted learning might be a key solution in the way someone can learn. Few

benefits of AI assisted learning are depicted in Figure no. 1.

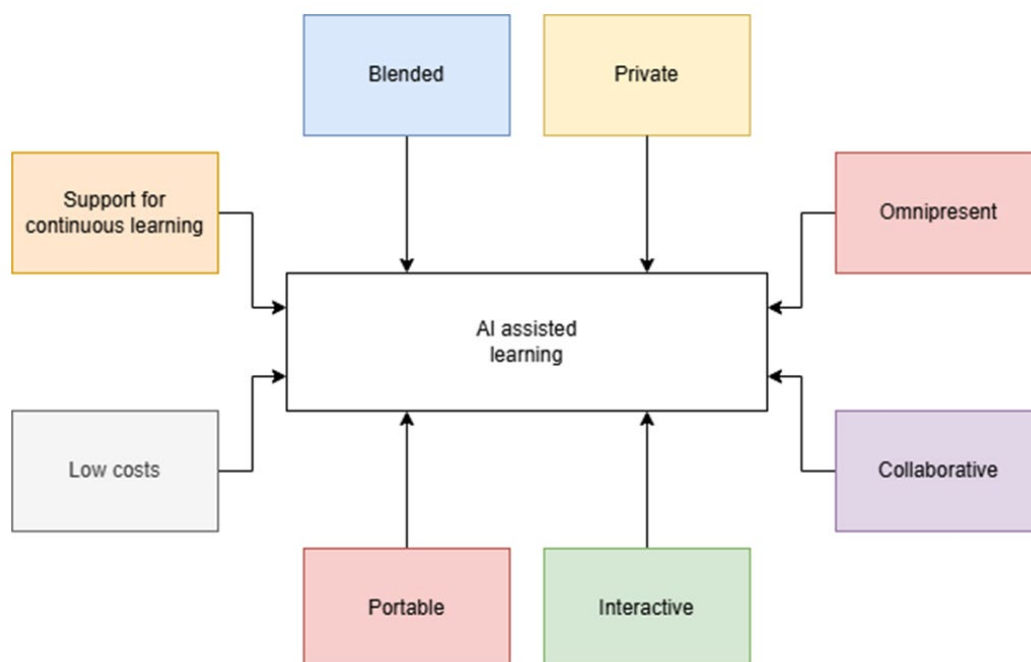


Figure no. 1: *Benefits of AI assisted learning*
(Source: Authors' own contribution)

In accordance with the work of Li and Tian (2026), in the absence of critical thinking, there is a risk that technology will become an apparent substitute for human reasoning, which can lead to erroneous or unethical decisions, especially in high-stakes contexts. The literature emphasized that real agility does not derive from automation per se, but from the balanced interaction between humans and technology, within socio-technical systems that maintain human control, responsibility and adaptability in decision-making processes.

This analysis did not advocate a rejection of automation or artificial intelligence, but rather highlighted the need to integrate them into a cognitive and educational framework that prevents the substitution of human reasoning.

4. Artificial Intelligence as an Agent for Information Sedimentation

Emerging dual-use technologies created operational settings that are marked

by high information density, rapid decision cycles and unpredictability, as the preceding chapters have shown. In these situations, operational agility is more dependent on the capacity to analyse, filter and modify information.

However, repeated cognitive engagement is how critical thinking is developed rather than just being exposed to knowledge.

There is little chance of ongoing individual cognitive training outside of formal instruction because traditional educational organizations, both civilian and military, are still primarily episodic and instructor-centred. As a result, there is a discrepancy between how frequently cognitive adaptation is needed in contemporary operational situations and how regularly directed practice can really be provided by education.

Persistent personalized guidance is made possible by artificial intelligence systems, especially conversational agents.

An AI agent is able to perform mimic dialogic learning, offer instant feedback and modify explanations based on the learner's current comprehension, in contrast to static digital learning systems. This may facilitate information sedimentation, a process of progressive accumulation of knowledge from a pedagogical standpoint. Therefore, artificial intelligence can be viewed as a cognitive training tool intended to maintain ongoing practice and strengthen critical thinking skills necessary by dual-use technological environments, rather than only as a technological topic within education. It can also be viewed as a resource for a virtual state of an organization, in positions where it can make a considerable contribution in processing large data, providing clues in complex situations, etc.

The study suggests and assesses an AI-agent-based educational application meant to facilitate individual practice and long-term information consolidation in order to investigate this role. A software tool that could offer ongoing, personalized interaction and instant feedback was

needed to operationalize the previously mentioned instructional method. This implementation's goal was to create an experimental setting where the information sedimentation process could be studied, not to demonstrate technology. Thus, as a cognitive training tool, an educational application based on AI agents was created. The approach was created to mimic guided practice by giving the student the opportunity to come up with answers, get flexible explanations and go over ideas again during several exchanges.

The application served as an experimental mediator between the learner and the information in this study, allowing for the monitoring of repetitive reasoning processes as opposed to performance in a single moment. As a result, rather than being solely technical, its architecture respects instructional requirements, such as feedback creation, repetition and incremental clarification. Figure no. 2 shows the main layout of the suggested system.

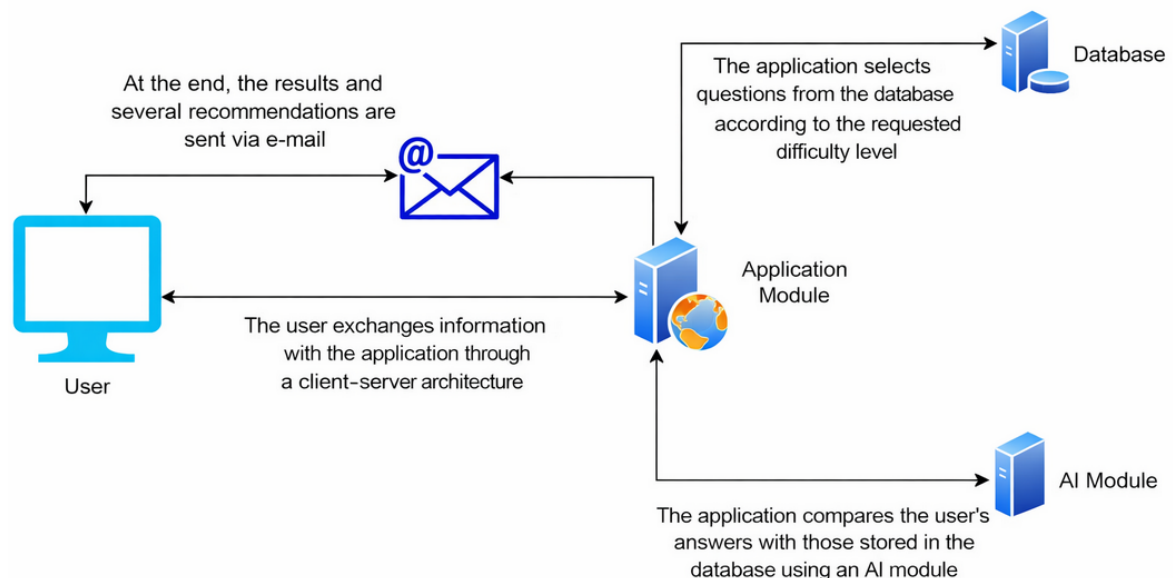


Figure no. 2: *Topology of the proposed software application*
(Source: Authors' own contribution)

The client-server architecture-based topology of the suggested software application is depicted in Figure no. 2.

For practicing and solidifying knowledge, the system was made to enable constant communication between the user and an artificial intelligence based module.

The model used in this application is “all-mpnet-base-v2” and is a transformer model specialized in generating dense semantic representations for sentences and phrases. It is developed based on the Masked and Permuted Pre-training for Language Understanding (MPNet) architecture, a high-performance model that combines the advantages of BERT and XLNet-type permutation, thus being able to more efficiently capture subtle meanings in text. In the context of the designed architecture, this model can be used to compare two text strings, one representing the correct answer that the application has in the database and the other being a variant provided by the user. By converting both strings into a common semantic vector space, the model allows the calculation of a cosine similarity between the two semantic representations, a value that expresses how close they are in terms of meaning. Thus, if a user formulates a correct answer, but expressed differently, the agent will recognize this semantic equivalence and return a high similarity score.

From a resource point of view, “all-mpnet-base-v2” is quite efficient, having a good balance between model size and performance, being able to run on CPU architectures for small applications or on GPUs for production applications with higher traffic.

The user engaged with the program interface to start the procedure. The application module, which controlled the educational logic and synchronized the data flow amongst the system components, received requests from the user via it. To choose activities or questions that matched the selected difficulty level, the application

module made use of the database, which also represented the agent’s knowledge memory. As a result, the information offered was dynamic and changed according to the needs of the user and the phases of the learning process.

The artificial intelligence module received the user’s response. The AI module performed a semantic evaluation and provided feedback after analysing the response and compared it with the data in the database. The user then received the feedback back in the form of clarifications or recommendations for changes via the application module.

In order to provide a method that helped user to keep the recommendations, an e-mail was sent to personal address with the findings and suggestions at the conclusion of the session. This facilitated a subsequent assessment of the concepts and supported the distributed review process. This structure allowed the program to serve as both an interactive learning environment and a testing tool. Contextual evaluation and adaptive guiding were made possible by the AI module’s integration, which promoted recurrent contact and information consolidation, the two important components for building the cognitive abilities required in ever-changing technology contexts.

In addition to facilitating information access, the design presented aimed to support guided iterative interaction, a particular kind of instructional interaction.

According to this approach, the AI agent’s job was to maintain the user’s cognitive process through requests, explanations and adaptive feedback rather than to give definitive answers.

As a result, the application served as an ongoing cognitive training environment where learning was based on repeating the cycle of trial, feedback, reformulation and future return rather than on the timely accumulation of knowledge.

This mechanism sought to turn declarative knowledge into a stable operational scheme (sedimentation). Thus, an educational system based on guided iterative engagement is implemented by the application. The AI agent did not provide the final solution. Instead, it offered tailored explanatory feedback based on the user's answer or hypothesis.

The concepts were then reiterated in comparable contexts once the interaction proceeds through reformulation and explanation. This iterative cycle of try, feedback, correction and return promoted the process of information sedimentation and helped turn information into stable knowledge.

As for the role of the AI agent in developing critical thinking, the AI agent did not deliver answers, it served as a cognitive facilitator. By encouraging comparison, verification and reformulation in place of procedural memorization, the user developed the cognitive autonomy and critical thinking skills required in fast-paced technological environments.

Thus, referring to the implications for operational agility, the AI agent's supported for ongoing cognitive training helped to increase situational flexibility and decreased dependence on set processes.

The user could make decisions in uncertain situations and perceive unknown contexts more rapidly by fortifying reasoning strategies rather than just knowledge. The suggested instructional methodology thus facilitated the growth of operational agility required to engage with new dual-use technologies.

A questionnaire was designed to systematically assess both the functionality

and overall usability of the application, with emphasis on its accessibility and intuitiveness for end users. The study sample included 32 participants aged between 14 and 35 years, drawn from a larger group of over 150 individuals who attended an educational promotion event organized at UNSTPB in May 2025. The selection of participants was based on a convenience sampling method, as only those who voluntarily expressed interest in testing the application were included. This approach was suitable considering the exploratory nature of the research and the logistical constraints.

The 32 participants did not represent the total number of individuals who could potentially use the application, but rather a subset of engaged users who actively participated in the testing phase. The application was made available online for one week, during which participants interacted with it frequently, as Figure no. 4 shows. Their involvement consisted of repeated use in real conditions, allowing for relevant and experience-based feedback.

Data analysis indicated that the application was accessed consistently throughout the testing period, with most users engaging multiple times per week. Session durations typically ranged between 15 and 30 minutes, suggesting an optimal balance between content delivery and user attention. Participants, pupils or students, came from diverse backgrounds, including both civilian and military sectors, with varied occupations. This heterogeneity contributed to the validity of the findings, supporting the identification of usability aspects applicable across different user categories.

How easy is the application to use?
32 responses

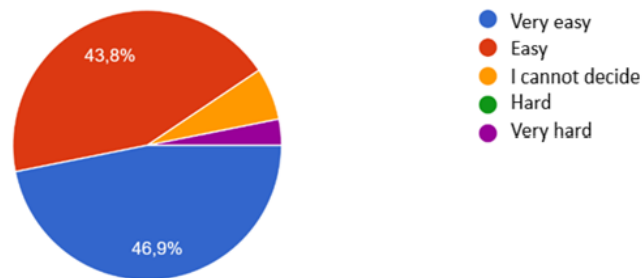


Figure no. 3: *The ease of using the application*
(Source: Authors' own contribution)

How often did you use the app during the test week?
32 responses

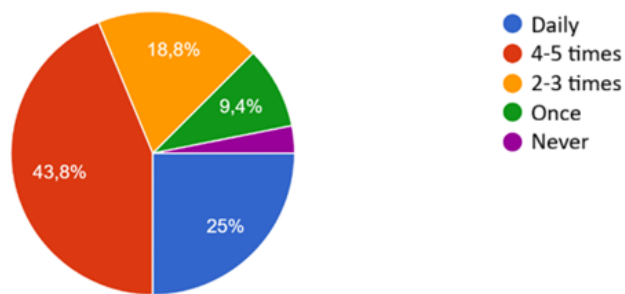


Figure no. 4: *Frequency of use of the application by volunteers*
(Source: Authors' own contribution)

How useful did you find the AI component in the learning process?
32 responses

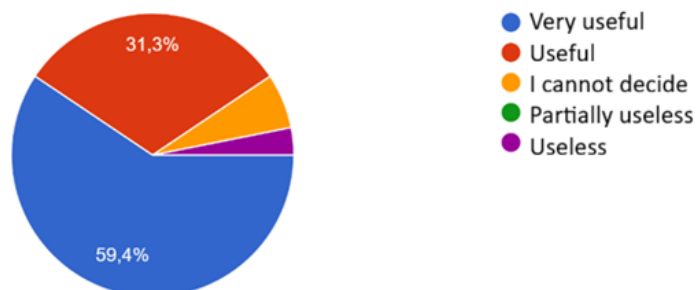


Figure no. 5: *The usefulness of the AI component in the learning process*
(Source: Authors' own contribution)

How natural was the interaction with the AI component?
32 responses

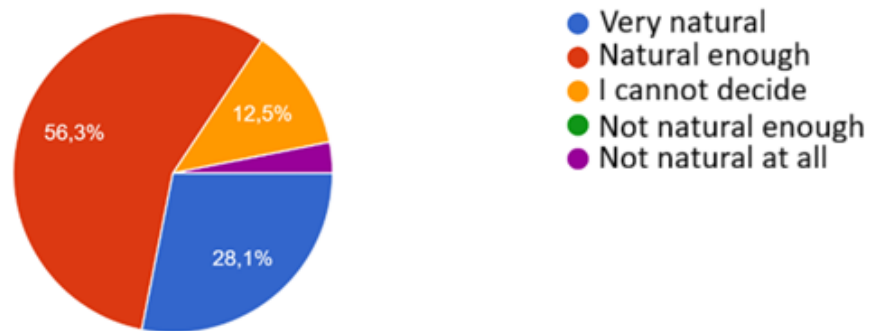


Figure no. 6: *The level of naturalness of the AI component*
(Source: Authors' own contribution)

According to the data presented in Figure no. 7 and Figure no. 8, the responses collected through the questionnaire clearly indicate that the participants expressed a high level of satisfaction with their experience using the application. The majority of respondents reported that the application met their expectations, functioned effectively and contributed positively to their overall learning experience. In addition to expressing personal satisfaction, many participants also

stated that they would confidently recommend the application to others, suggesting that they perceive it as both valuable and reliable. This willingness to endorse the tool further reflected their positive perception of its quality and performance. Taken together, these findings provided strong support for the practicality, relevance and overall usefulness of the proposed learning tool, reinforcing its potential as an effective resource in the educational context.

How satisfied are you, overall, with the application?
32 responses

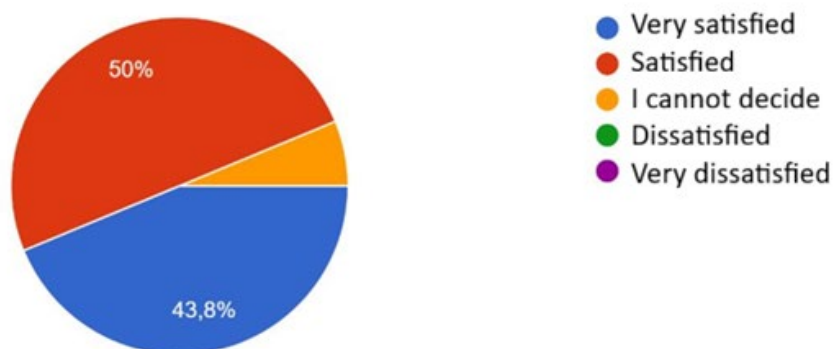


Figure no. 7: *The level of satisfaction regarding the use of the application*
(Source: Authors' own contribution)

Would you recommend the app to other people interested in AI-assisted learning?
32 responses

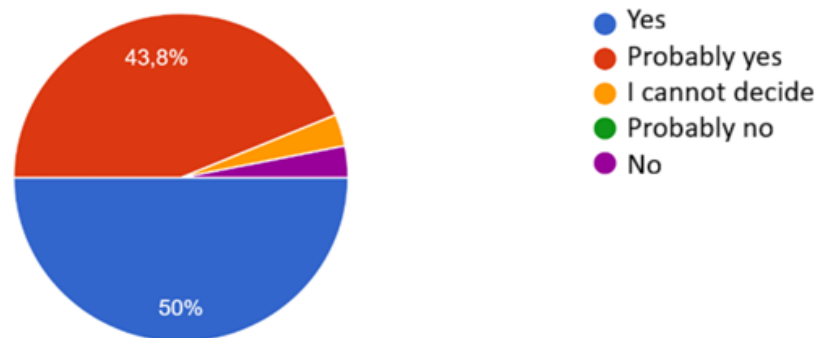


Figure no. 8: *Confirmation of recommending the application to other people interested in the same way of learning*
(Source: Authors' own contribution)

5. Conclusions

This paper examined the role of critical thinking in optimizing operational agility in the context of emerging and disruptive dual-use technologies, from the perspective of civil and military technical education. The analysis showed that technological transformation cannot be addressed solely through infrastructure investments, but requires cognitive and educational change. Operational agility results from the interaction between technology, organizational structures and cognitive skills. The findings indicated that, in the absence of critical thinking, technologies such as artificial intelligence, autonomous systems and Big Data may generate dependence and systemic vulnerabilities. Critical thinking acts as a cognitive control mechanism, enabling contextual evaluation of information and integration of human responsibility into decision-making, particularly in high-security domains. The study also highlighted the role of AI-based learning assistant application designed to stimulate individual work and support the development of autonomous analytical skills. The research identified convergence

between civilian and military technical education, supporting cooperation and transfer of good practices. What is more, future work will include integrating critical thinking into curricula through case studies and AI-assisted simulations, strengthening teacher training and enhancing civil-military cooperation. The study proposes a framework linking education, critical thinking and operational agility.

Acknowledgements

The authors would like to thank the individuals who contributed to the testing of the application and provided the necessary feedback. Their support significantly improved the quality of this article.

Author Contributions

Conceptualization & design of the study, A.P.S.; methodology, M.V.N.; formal analysis, M.V.N.; application design, M.V.N.; data collection & interpretation, A.B.; validation of results, D.C.D; writing-review D.C.D. All authors have read and approved the final version of the manuscript.

REFERENCES

- Alberts, D.S., & Hayes, R.E. (2006). *Understanding command and control*. CCRP Publication Series.
- Bennett, N., & Lemoine, G.J. (2014). What VUCA really means for you. *Harvard Business Review*, 92(1-2), 27. Available at: <https://ssrn.com/abstract=2389563>.
- Brundage, M., et al. (2018). *The malicious use of artificial intelligence: Forecasting, prevention and mitigation*. arXiv preprint. DOI:10.48550/arXiv.1802.07228.
- D'Alessio, I., Aitella, U., Giannini, A.M., & Burrai, J. (2024). What about military decision-making? A bibliometric review of published articles. *Behavioral Sciences*, 14(7), 514. Available at: <https://doi.org/10.3390/bs14070514>.
- Enstad, K., & Hagen, A.M. (2026). No common understanding? A scoping review of professional military education in the twenty-first century. *Scandinavian Journal of Educational Research*, 70(1), 80-100. Available at: <https://doi.org/10.1080/00313831.2025.2459408>.
- Facione, P.A. (2011). *Critical thinking: What it is and why it counts*. Insight Assessment. Available at: https://www.researchgate.net/publication/251303244_Critical_Thinking_What_It_Is_and_Why_It_Counts.
- Floridi, L., et al. (2018). AI4People – An ethical framework for a good AI society: Opportunities, risks, principles and recommendations. *Minds and Machines*, 28(4), 689-707. Available at: <https://doi.org/10.1007/s11023-018-9482-5>.
- Li, H., & Tian, F. (2026). Advancing decision-making through AI-human collaboration: A systematic review and conceptual framework. *Group Decision and Negotiation*, 35(2), 26. Available at: <https://doi.org/10.1007/s10726-026-09980-1>.
- McAfee, A., & Brynjolfsson, E. (2017). *Machine, platform, crowd: Harnessing our digital future*. New York: W.W. Norton & Company.
- Mena-Guacas, A.F., López-Catalán, L., Bernal-Bravo, C., & Ballesteros-Regaña, C. (2025). Educational transformation through emerging technologies: Critical review of scientific impact on learning. *Education Sciences*, 15(3), 368. Available at: <https://doi.org/10.3390/educsci15030368>.
- NATO. (2024). *Cognitive warfare*. Retrieved February 19, 2026, from <https://www.act.nato.int/article/cogwar-concept/>.
- NATO. (2025). *Emerging and disruptive technologies*. Retrieved February 19, 2026, from <https://www.nato.int/en/what-we-do/deterrence-and-defence/emerging-and-disruptive-technologies>.
- OECD. (2021). *Education at a glance 2021*. Paris: OECD Publishing. Available at: <https://doi.org/10.1787/b35a14e5-en>.
- Seol, I.-H. (2024). Future warfare and the construction of data-centric intelligent integrated systems: An analysis of the U.S. Joint All-Domain Command and Control (JADC2) case. *Korea Research Institute for Strategy*, 31, 7-34. DOI:10.46226/jss.2024.11.31.3.7
- Troitiño, D. (2025). Artificial intelligence in Estonia: Strategy, implementation and future perspectives. In *Proceedings of the III Congresso Ibero-Americano de Direito e Tecnologias Digitais* (Braga, Portugal). Available at: https://www.researchgate.net/publication/397873193_Artificial_Intelligence_in_Estonia_Strategy_Implementation_and_Future_Perspectives.