

## ADAPTIVE MODELS OF HIGHER AND VOCATIONAL EDUCATION: SYNERGY OF BUSINESS AND STATE IN ENSURING SUSTAINABLE DEVELOPMENT

*Ahadzhanov-Honsales Karen*

*Senior Lecturer, Sumy National Agricultural University, Ukraine*

*ORCID ID: 0000-0002-1409-4648*

**Introduction.** Global changes brought about by the Fourth Industrial Revolution and the consequences of the COVID-19 pandemic in 2020 are influencing the reform of educational systems worldwide. The unexpected and forced transition to distance learning has accelerated the implementation of new technologies in education, including virtual and augmented realities [1]. Virtual and augmented realities are being used more actively in all spheres of human activity and life. Accordingly, education/training uses them to meet the demands of life. However, as revealed in a number of studies, human activity in a synthetic environment can lead to cybersickness. This negative consequence is particularly important for young people due to their greater susceptibility to external factors [2] in a changing learning environment.

Activity in virtual reality (VR) can be accompanied by the appearance of cybersickness. The most studied side effects are related to motion sickness and eye strain. The resilience of cognitive functions in VR has been studied less. According to known data, the ability for mental rotation is linked to susceptibility to cybersickness, specifically in relation to age and gender differences. Although the study of mental rotation can be traced back to the 1960s, including the connection between spatial and mathematical abilities during development, there is insufficient research explaining whether this is related to professional training and whether it can be identified at the educational stage with a pre-selected profession. However, this could be a useful tool for providing adequate AR/VR tools and regulating the educational process to avoid or reduce cybersickness in students, including adaptive learning tools.

**Objective.** Analysis of the general and distinctive properties of the intelligence structure of students studying information technology, mathematics, as well as social sciences and humanities, with a priority on the ability for mental rotation and assessment of a person's mental state.

Mental rotation is a cognitive operation during which a mental image is formed and rotated in different orientations in space. Such a process typically requires cognitive manipulation and spatial transformation of a two-dimensional (2D) or three-dimensional (3D) object and is associated with general intelligence. The ability for mental rotation is assessed using special tests or as components of the intelligence structure. In the latter case, reaction time and accuracy are measures of test efficiency. The research method was provided as a development of the method used in our previous study of the psychophysiological provision of cognitive performance, and subsequent application to students as operator-researchers.

**Study 1.** 441 pupils (8th... 11th grade) from the fields of information technology (IT), mathematics (Math), humanities and social sciences (Soc), as well as 315 students (1... 6 years of study) from the same fields, completed the online R. Amthauer intelligence structure test. Analysis of results was conducted only for those individuals who completed all tests with a given level of speed and reliability.

The structural components of intelligence are calculated:

LS (Logical Selection) tests language sense, ability to form judgments.

GE (Detection of Common Features) tests abstract abilities.

AN (Detection of Similarities) tests combinatorial abilities, dynamic thinking.

RA (Computational, Mathematical) tests the ability to solve computational tasks of a practical nature.

ZR (Pattern Detection) tests logical and mathematical thinking.

FS (Figure Selection) tests spatial thinking in terms of geometric combinations on a plane when forming a whole shape from its fragments (2D mental rotation).

WU (Cube Tasks) tests spatial thinking (3D mental rotation).

Me (Memory, Attention) tests the volume and concentration of attention, as well as working memory.

The number of correct results for all components of the intelligence test was calculated.

**Study 2.** A further study was conducted to examine dynamic changes in the mental state and cognitive performance of postgraduates (technical fields) and young scientists (social sciences and humanities) over a month under the influence of internal (physiological indices) and external factors (solar and geomagnetic field indices).

A cognitive (logical-combinatorial) test was used. Test material: a sequence of numbers (from 0 to 9), which did not repeat and were arranged in random order; the task was to rearrange the numbers in ascending

order in several steps, at each of which only 2 adjacent numbers could be swapped. Time to complete each task was free (the next task appeared immediately after entering the answer). Time (TI) and accuracy of task completion were measured. The duration of a test session was 180 minutes; 4 sessions (the first was a training session for adaptation to the cognitive test and measurement of physiological indicators) were conducted once a week; only data from the third session were analyzed.

As indices of the physiological "cost" of activity and human state, we recorded heart rate (HR) and blood pressure (systolic BPs, diastolic BPd). HR, BPs, and BPd indices were recorded once at the beginning of every 20 minutes before (index "1") and during the test.

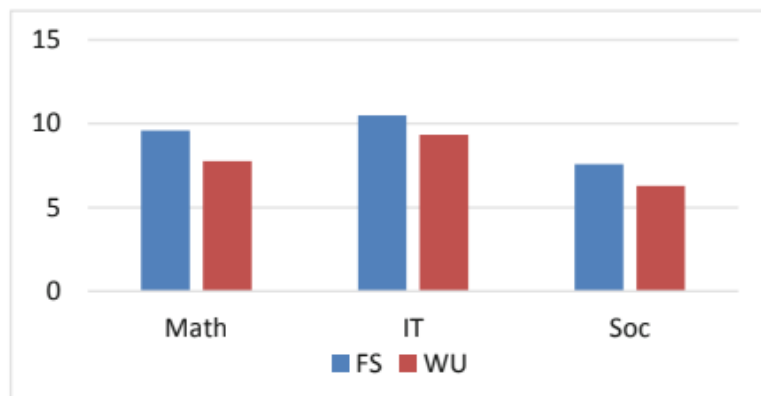
To test the influence of external physical factors on the performance of the cognitive task, solar activity was studied, as in study [3,4]. In our previous pilot study, an exact relationship was found between the efficiency of operator activity and solar wind (SW) parameters. To study this phenomenon in people with different professional mental organizations, we recorded indices of the proton component of the solar wind - speed SWsp (km/s) and density SWden (proton/cm<sup>3</sup>) according to data from the NASA website, as well as geomagnetic field parameters - the planetary Ks index, the "equivalent amplitude" index A.

Participants: 19 young researchers from social sciences and humanities fields, 24 postgraduates from technical fields.

According to the results of our previous research, it was established that the level of mental rotation (both 2D and 3D), as a component of general intelligence, develops up to the 9th grade and changes insignificantly in the 10th and 11th grades. Therefore, pupil and student data were analyzed without distinction between grades and years of study, respectively. Separate analysis was conducted only in relation to professional training, as well as school and university.

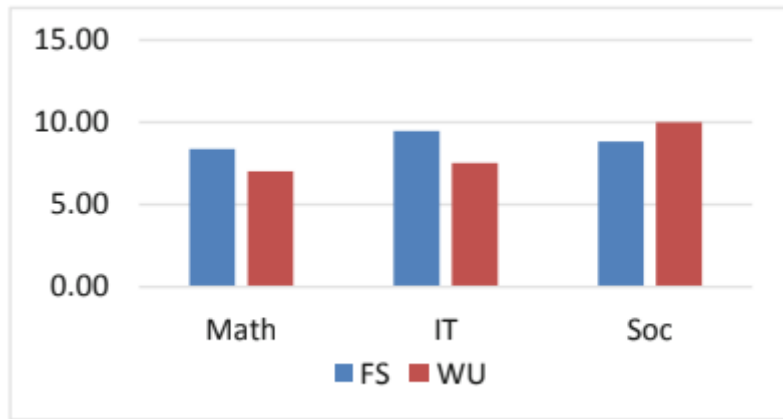
In Study 1, significant differences in the ability for mental rotation were found among pupils of the respective Math, IT, and Soc groups (Fig. 1).

As expected, the results of the 2D (FS) mental rotation test showed a higher level compared to 3D (WU). A quite interesting result is the higher level of mental rotation ability among IT students, even compared to mathematicians. The reason for this situation can be explained by the fact that children prefer to be IT specialists rather than mathematicians in Ukraine. All these types of professional training were based on the prior selection of schoolchildren for professional specialization.



**Figure 1.** Level of mental rotation development among SNAU students  
Source: Author's research

Similar proportions were found among university students, but the difference was not as significant and reliable when comparing students from mathematics and IT fields (Fig. 2).



**Figure 2.** Level of mental rotation development among students  
Source: Author's research

As expected, students of social sciences and humanities demonstrated the level of mental rotation development. This can be explained by the higher level of motivation to study at national humanities universities, whose students participated more actively in completing the tests.

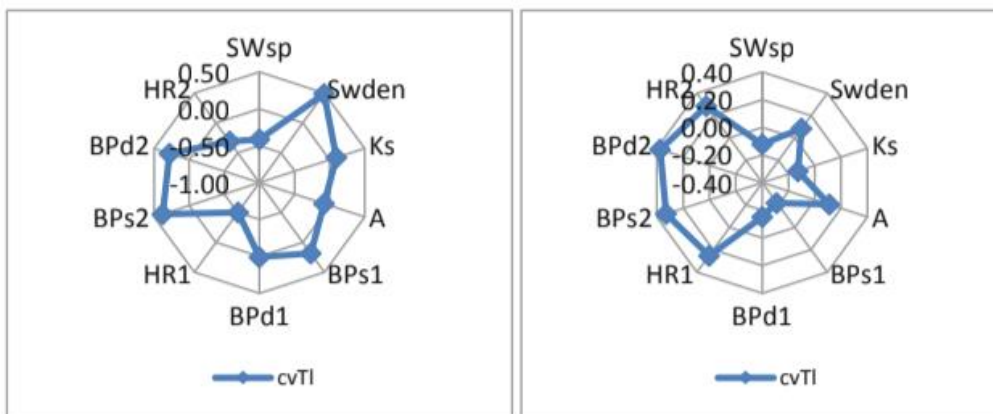
In any case, these facts may be a signal for choosing a future profession for Generation Z, at least in our country.

Further Study 2 was conducted to examine changes in the mental state and cognitive performance of students (both humanities and technical fields) over a month (registration of physiological indicators was carried out in parallel with the tests).

A comparative analysis of the variation in cognitive stability based on the speed of test completion among young researchers (both specialties relate to mental work) demonstrated clear differences in the relationship of cognitive test performance to external (solar wind parameters, i.e., solar radiation) and internal (state of the cardiovascular system) factors (Fig. 3). The correlation between the indices of these indicators and the variation (interpersonal) in test completion time had different levels and vectors of priority.

First, it is necessary to emphasize that a higher correlation with external factors (solar radiation, SW density,  $r = 0.5$ ) was found among postgraduates in the humanities fields, although all of them were selected for military service according to professional health level protocols.

Second, these results confirm the high relationship between cognitive performance and its physiological provision, which is especially important for adaptive learning [1,3].



**Figure 3.** Correlation diagrams of test speed variation in "humanities" (left) and "techies" (right)  
Source: Author's research

The article examines differences in the ability for mental rotation among schoolchildren and students in professional training (mathematics, information technology, and social sciences & humanities), as well as the different nature of the relationship of cognitive stability under the influence of internal and external factors in young specialists who have completed training in mathematical and humanities disciplines.

The results can be applied to optimize the use of AR/VR tools in the educational process depending on the individual/typological abilities of students for mental rotation. The aim of optimization is to reduce the risk of cybersickness when using virtual reality.

To develop measures for the development and improvement of the information and communication technology system in Ukraine in the post-war period, it is necessary to determine the advantages, disadvantages, and challenges of the organization of information and communication technologies at the current stage using quantitative and qualitative indicators.

Let us characterize the advantages in detail:

1. Accessibility and inclusivity - in times of war, it is often the only way to ensure the continuity of the educational process for higher education applicants; provides geographical independence - education can be obtained from any region, country, or part of the world; is flexible – allows adults (third age universities) to study.

2. Modernization and digitalization of education – accelerates the digital transformation of higher education institutions (HEIs); promotes the development of digital skills among teachers and students; ensures the introduction of innovative learning technologies into the educational process.

3. Increasing the resilience of the education system - the ability of the education system to function in emergency situations, which is critically important for Ukraine; creates backup mechanisms to ensure access to education.

4. Economic efficiency - reduces transportation and accommodation costs for students; optimizes the use of educational institutions' infrastructure.

Main challenges of information and communication technologies:

1. "Digital divide" - insufficient access to stable Internet and modern technical equipment (computers, tablets) in rural and frontline regions, loss of equipment due to destruction, displacement of HEIs from combat zones; power supply problems (blackouts) due to shelling are a significant obstacle to continuous learning.

2. Teacher training – it is necessary to improve qualifications for the development of digital competencies to work effectively with students studying remotely; the psychological aspect, "burnout" of teachers due to increased workload when working with students in the information and communication technology system.

3. Psychological and social aspects – problems with socialization and communication related to the lack of face-to-face interaction, which promotes the development of soft skills, formation of teamwork skills, and student adaptation; separately, problems of motivation and self-discipline can be identified, including difficulties in organizing effective learning for students who lack developed psychological qualities (independence, motivation, self-regulation of behavior, etc.).

4. Security and academic integrity - difficulty in monitoring academic integrity during online assessment of learning outcomes; ensuring data security and protection against cyberattacks.

Statistical data provided on the official website of the Unified State Electronic Database on Education (USEDE) on the results of admission campaigns for 2021-2025 in Ukraine indicate a 1.5-fold increase in the number of HEIs offering distance education.

Analysis of data on the number of applications from applicants to Ukrainian HEIs submitted for distance learning in 2021-2025 [5] allows us to conclude that there is a steady increase in the number of applications for distance learning while maintaining the general trend of a decrease in the total number of applications. Table 1 lacks data on admission to master's programs in 2025, as the admission campaign is still ongoing (Table 1).

**Table 1.** Number of applications from applicants to Ukrainian HEIs at the bachelor's and master's levels of higher education in 2021-2025.

Source: Developed by the author based on [1-5]

Year	Bachelor		Total	Master		Total
	Form of Education			Form of Education		
	Full-time	Distance		Full-time	Distance	
2021	1063885	705	1064590	125497	309	125806
2022	625038	1765	626803	222721	524	223245
2023	754107	2699	756806	208259	414	208673
2024	642728	2608	645336	201576	863	202439
2025	756558	5588	762146	-	-	-

Table 2 presents the results of a SWOT analysis of quantitative and qualitative indicators, the results of a survey of SNAU students regarding the quality of educational courses and the educational process, summarizing and systematizing the advantages, disadvantages, challenges, and threats of information and communication technologies (Table 2).

**Table 2.** SWOT analysis of information and communication technologies

Strengths	Weaknesses
Flexibility and accessibility: ICT allows learning anytime, anywhere with internet access. This is especially important for people who cannot attend traditional educational institutions due to geographical limitations, health conditions, or busy schedules.	Lack of social interaction: Unlike traditional learning, ICT can limit live communication with teachers and peers, which is an important element of socialization and communication skills development.
Individualization of learning: E-platforms often offer personalized study plans, allowing students to learn at their own pace. They can also choose courses matching their interests and professional goals.	Need for self-discipline: Success in e-learning largely depends on the student's motivation and self-discipline. Without proper control and self-organization, there is a risk of not completing the course.
Economic efficiency: In many cases, ICT is cheaper than traditional education. It saves on transportation, accommodation, printed materials, as well as on maintaining classrooms and infrastructure.	Technical problems: Access to quality ICT depends on the availability of a stable internet connection and appropriate equipment. Technical failures can interrupt the learning process.
Wide choice of courses: Students can access courses from leading universities and experts worldwide without leaving their country.	Quality of teaching and materials: Not all online courses are equally high-quality. There is a risk of encountering outdated or superficial materials, as well as unqualified teachers.
Use of modern technologies: ICT actively uses interactive elements, multimedia materials, virtual and augmented reality, making learning more engaging and effective.	Authentication issues: Controlling who exactly is taking the course and taking exams can be difficult, raising questions about the authenticity of the certificates obtained.

<b>Opportunities</b>	<b>Threats</b>
Expanding access to education: ICT can become a key tool for overcoming inequality in access to quality knowledge, especially in developing countries.	Cyber threats: Online platforms can be targets of hacker attacks, threatening the security of personal data of students and teachers.
Lifelong learning and professional development: E-courses are an ideal platform for those who want to constantly update their knowledge and skills according to labor market demands.	Problems with diploma recognition: Not all employers and universities recognize certificates and diplomas obtained through ICT on par with traditional ones.
Globalization of education: Thanks to e-technologies, it becomes possible to create global educational communities where students and teachers from different countries can exchange experiences.	Lagging behind technological progress: The educational technology market is constantly changing, and educational platforms can quickly become outdated if not updated.
Integration with artificial intelligence: The use of AI can significantly improve ICT by providing personalized recommendations, automating assessment, and adapting material to each student's needs.	Digital divide: Unequal access to technology and the internet can deepen social inequality, as people with limited opportunities will be excluded from the educational process.
Development of hybrid models: Combining traditional and e-learning (blended learning) allows obtaining the advantages of both approaches.	Information overload: The large number of courses and materials can lead to "information overload" and complicate the choice of quality content.

Source: Author's research

The results obtained in the SWOT analysis show that ICT has enormous potential, but to fully realize it, it is necessary to consider and work on existing weaknesses and threats.

The analysis of quantitative and qualitative data using SWOT analysis technologies made it possible to determine the main strengths and weaknesses of the ICT system, challenges, and threats. The strengths of ICT are flexibility and accessibility, the possibility of individualizing learning, economic efficiency, use of modern technologies, and a wide choice of courses. Weaknesses - ICT can limit live communication with teachers and peers, which is an important element of socialization and communication skills development; the need for self-discipline; technical problems; quality of teaching and materials (it is recommended to clearly define key course quality indicators: e.g., course completion rate, average grade, activity level, time interacting with content, student satisfaction with practice); it is advisable to introduce KPIs for courses that should be known to teachers and students to guide them and plan improvements. For successful management of the ICT system, solving authentication problems is important.

Opportunities – expanding access to education, lifelong learning and professional development, globalization of education, integration with artificial intelligence, development of hybrid models. Threats to the implementation and development of ICT include cyber threats, lagging behind technological progress, digital divide, information overload.

To overcome threats and further develop ICT, it is necessary to use a systemic approach to management, which can be ensured by developing appropriate programs at the state and regional levels. The mechanism for implementing ICT in Ukraine at the regional and state levels should be comprehensive and coordinated. It requires not only technical support but also a change in approaches to learning, improving the qualifications of teachers, and creating an appropriate regulatory framework.

**Modeling a set of support measures for information and communication technologies in HEIs.**

The main activity of a higher education institution (HEI) is providing consumer-oriented educational services.

Consumers of an HEI's activities are considered:

- External (employers, the state, society as a whole);
- Internal (students, teachers, HEI management).

Constant monitoring is an effective means of ensuring high quality education.

Various types of requirements for teaching staff exist in educational institutions. They are usually used to determine the possibility of a specific teacher holding a certain position during the competitive procedure for filling vacant positions.

Studying the experience of HEIs, which was developed and applied in individual teacher evaluation models, is of considerable interest.

These include excessive formalization of methods based on the assumption that the overall assessment of a teacher's activity is determined only by the quantitative characteristics of its components; the lack of a clear understanding of the directions for interpreting the obtained assessment results and the possibilities of their practical application; the difficulty of developing assessment methods, etc.

Thirtyakova N.V. notes that the criteria for evaluating the quality of a teacher's activity are not defined. Therefore, educational institutions have different types of requirements for teaching staff, which are usually applied to determine the possibility of a specific teacher holding a certain position through competitive selection for vacant positions [2].

Vasylieva Y. believes that science and practice urgently need general methods for evaluating the quality of a teacher's activity, which would outline the general task, the logic of evaluation stages, and the necessary conditions for its implementation.

Zakharevych V.G. determines that the development and implementation of a teacher evaluation system in each university should ultimately contribute to improving the quality of educational services and improving the methods of education quality management.

It should be noted that none of these approaches is perfect. Most methods have typical shortcomings that do not allow transforming the process of evaluating a teacher's activity into a tool for developing their professionalism.

The aim of the research is to develop approaches to managing the quality of the educational process using the assessment of teacher activity as a component of quality assessment in higher education.

The development of information support for decision support systems for managing the quality of the educational process can be carried out using the methodology of systemic ergonomic analysis, developed in the functional-structural theory of ergotechnical systems.

The concept of building formal models of a human-machine system covers numerous special component and morphological structures.

Information about system components (component structures) and connections between objects (morphological structures) is presented as a set of knowledge bases and databases. An interconnected complex of these structures forms a generalized information model of the human-machine system.

The proposed model is suitable for all types of systems: production, information, operational, as well as information processing and management systems.

The general approach to determining the information needs of decision-makers (DMs) for managing the quality of the educational process is presented in Approach to determining the information needs of decision-makers for managing the quality of the educational process.

Analysis of the list of information about student survey processes necessary for making decisions on managing the quality of the educational process leads to the conclusion that this information can be specified using two classes of structures: component and morphological [44].

Component structures are introduced to isolate essential elements necessary for describing survey processes.

Theoretical Framework: The Evolution of Educational Paradigms.

The post-war economy demands a shift from the "Linear Model" (education  $\rightarrow$  work) to a "Cyclical Adaptive Model" (work  $\rightarrow$  education  $\rightarrow$  innovation). In this context, we must analyze:

- The Concept of "Educational Agility": The ability of higher education institutions (HEIs) and vocational schools to pivot their specialization based on real-time labor market data.
- Sustainability through Human Capital: Education is viewed as the primary tool for achieving Sustainable Development Goal 4 (Quality Education) and Goal 8 (Decent Work and Economic Growth).
- The Triple Helix Plus: Expanding the traditional model to include a fourth element — Civil Society — to ensure that the synergy of state and business also meets the social needs of post-war communities.

The Synergy Mechanism: State Regulation and Business Incentives

For synergy to work, the relationship must be mutually beneficial.

### State Instruments for Educational Transformation

The state should transition from a "Controller" to an "Architect of Ecosystems":

1. Voucher Systems for Reskilling: Direct funding to individuals, allowing them to choose between university modules or corporate training programs.
2. Tax Incentives for Corporate Universities: Encouraging large businesses to open their training facilities to the public.
3. National Qualifications Framework (NQF) Update: Fast-tracking the recognition of non-formal education and digital micro-credentials.

### Business as a Co-Investor in Talent

Business involvement is no longer about philanthropy; it is about Risk Management. In a post-war environment, the lack of skilled labor is the #1 risk for reconstruction projects.

- Joint R&D Labs: Universities provide researchers; business provides the hardware and market-ready tasks.
- Embedded Curriculum: 30% of the curriculum is directly designed and taught by industry practitioners.

### Digitalization: From Online Classes to AI-Driven Personalization

Digitalization in the monograph should be treated not as a "tool for remote learning," but as a structural transformation.

- Big Data in Educational Planning: Using labor market analytics (e.g., LinkedIn data, job portals) to automatically adjust the number of state-funded spots in specific disciplines.
- Blockchain for Credentialing: Ensuring that certificates and degrees earned during the war/reconstruction are immutable and globally verifiable, aiding the mobility of the workforce.
- Digital Twins in Vocational Training: Using digital twins of factory equipment for remote training, reducing the need for expensive physical prototypes during the early stages of reconstruction.

### Case Studies and Global Benchmarks.

To reach the required character count, this section should include a deep dive into specific models:

1. The German Dual System: How it maintains low youth unemployment and high industrial quality.
2. The Singaporean "SkillsFuture" Initiative: A model for lifelong learning and state-led reskilling.
3. Post-Conflict Success Stories: Examples from South Korea or the Balkans regarding rapid educational shifts after periods of instability.

### Socio-Economic Impact and Sustainability

The final part of the article should quantify the potential results:

- Economic Impact: Reduction in the "skills gap" leading to a 2-3% increase in GDP growth during reconstruction.
- Social Impact: Reintegration of veterans through specialized adaptive programs.
- Environmental Impact: Training a new generation of "Green Engineers" to ensure the reconstruction is eco-friendly.

### AI-Driven Personalization and Big Data Analytics in Adaptive Educational Systems

The integration of Artificial Intelligence (AI) and Big Data into the educational landscape represents the pinnacle of digital transformation in the context of post-war reconstruction. For a nation rebuilding its economy, the "one-size-fits-all" approach to vocational and higher education is a luxury it cannot afford. Efficiency, speed, and precision in skill acquisition are paramount.

### Predictive Analytics for Labor Market Alignment

Adaptive models rely on the ability to predict which skills will be in demand six months or two years from now. By utilizing Big Data, the synergy between the state and business manifests in **Labor Market Information Systems (LMIS)**.

**Data Sources:** Scraping job portals, analyzing government reconstruction contracts, and monitoring global industry trends.

**Application:** AI algorithms can identify emerging "skill clusters." For instance, if data shows a surge in "Green Construction" tenders, the adaptive system automatically triggers the creation of modular certifications in sustainable architecture within local vocational colleges.

### **Intelligent Tutoring Systems (ITS) and Hyper-Personalization.**

In a post-war scenario, students (including veterans and displaced persons) enter the system with vastly different baseline knowledge and psychological states. AI-driven personalization addresses this through:

1. **Dynamic Learning Paths:** Unlike a static syllabus, an AI-driven platform adjusts the difficulty and pace based on the learner's real-time performance.
2. **Cognitive Load Management:** AI monitors engagement levels, suggesting breaks or alternative media (e.g., switching from text to a 3D simulation) to optimize retention.
3. **Automated Assessment:** Utilizing Natural Language Processing (NLP) to provide instant, detailed feedback on complex engineering or management assignments, allowing human instructors to focus on mentorship rather than grading.

### **Ethical Governance and Data Privacy.**

The synergy of state and business in handling student data raises critical ethical questions. To ensure sustainable development, the digital transformation must adhere to:

- **Algorithmic Transparency:** Ensuring that AI recommendations for career paths are not biased by gender, age, or socio-economic background.
- **Data Sovereignty:** Protecting the personal information of learners through decentralized identity protocols (Self-Sovereign Identity).

### **Professional Reintegration of Veterans via Adaptive EdTech: A Socio-Economic Imperative.**

The reintegration of veterans into the civilian workforce is not merely a social obligation but a strategic necessity for post-war economic stability. Veterans possess high-value "power skills"—leadership, crisis management, discipline, and strategic thinking—that are often "lost in translation" when applying for civilian roles. **Adaptive EdTech** serves as the bridge for this translation and rapid upskilling.

**Skill Mapping: From Combat to Corporate.**

The first barrier to reintegration is the lack of a standardized framework to convert military experience into academic credits or professional certifications.

- **AI-Powered Competency Mapping:** Adaptive platforms can use NLP (Natural Language Processing) to analyze military service records and extract transferable skills. For example, commanding a unit translates to Project Management and Operations Leadership; maintaining complex equipment translates to Systems Engineering.
- **Gap Analysis:** Once the mapping is complete, the EdTech system performs a real-time gap analysis against current market demands, suggesting only the specific modules needed to bridge the difference (e.g., a veteran with leadership experience might only need a 3-month module on "Agile Management" or "Digital Finance").

**Trauma-Informed Adaptive Learning.**

Post-war reintegration must account for the psychological state of the learner. Traditional, rigid educational environments can be counterproductive for those suffering from PTSD or sensory sensitivities.

- **Micro-learning & Flexibility:** Adaptive EdTech allows for "digestible" learning units that can be completed at the learner's own pace, reducing the stress associated with strict deadlines and crowded lecture halls.

- **Gamification as a Re-engagement Tool:** Using game-based mechanics in vocational training (VR/AR) can help keep veterans engaged, leveraging the "mission-oriented" mindset they developed during service.

**The Synergy of "State-Business-Veteran"**

The success of this model depends on a tripartite agreement:

1. **The State:** Finances the "Adaptive Learning Vouchers" and provides the legal basis for military-to-civilian skill conversion.
2. **Business:** Acts as the "Destination." Corporations provide the "ideal candidate profile" to the EdTech platforms, ensuring that the training is 100% relevant to open vacancies.
3. **Adaptive EdTech Platforms:** Act as the "Orchestrator," providing the personalized learning journey and real-time progress tracking to both the state (for accountability) and the employer (for recruitment).

### **Institutional aspects of forming a mechanism for the development of information and communication technologies**

For the successful implementation of information and communication technologies in Ukrainian higher education institutions (HEIs) in the post-war period, a multi-stage mechanism covering the state and regional levels is necessary. This mechanism must take into account both the challenges associated with the war (destruction of infrastructure, migration, financial constraints) and the opportunities for modernization and integration into the European educational space.

At the state level, the following measures are necessary:

1. **Development and funding of recovery programs.** The Ministry of Education and Science (MES) of Ukraine, together with the Cabinet of Ministers, should develop a state target program "Digital Higher Education for Post-War Recovery". This program should provide:

- Centralized funding for the restoration and creation of digital infrastructure for HEIs affected by hostilities.

- Preferential loans for institutions to purchase modern equipment and licensed software.
- Access to international grants and funds to support education digitalization projects.

2. **Creation of a single national platform.** Introduction of a centralized Learning Management System (LMS) that will be integrated with the Unified State Electronic Database on Education (USEDE). This will ensure:

- Unified standards and interaction between universities.
- The ability for displaced students and those abroad to continue their studies at Ukrainian HEIs.
- Providing access to e-textbooks and other educational materials on a single platform.

3. **Improvement of the regulatory framework.** It is necessary to review and adapt the legislative acts regulating higher education so that they fully meet the needs of distance and blended learning. This concerns issues of:

- Accreditation of educational programs implemented in electronic format, taking into account the experience gained during the war.

- Features of organizing exams and certification in a distance format.
- Confirmation of diplomas obtained in electronic form on par with traditional ones.

At the regional level, it is necessary to:

1. **Create regional educational hubs.** Based on leading HEIs in each region, digital educational hubs can be created to:

- Provide access to high-speed internet and computer labs for students who do not have adequate technical equipment.

- Conduct seminars and training for teachers on digital pedagogy.
- Coordinate cooperation between local universities and colleges for experience exchange.

2. **Involve local authorities and businesses.** Local authorities should actively cooperate with universities and regional businesses for:

- Sponsoring digitalization projects and providing grants for student startups in the EdTech field.
- Creating innovation laboratories and training centers equipped with private investments.
- Developing regional professional development programs for teachers and students in areas that are priorities for the region's economic recovery.

3. **Adaptation of educational programs.** HEIs should review their educational programs, integrating modern digital technologies and tools. This includes:

- Flexible study schedules that allow students to combine education with work, volunteering, or other activities.

- Creation of online courses for the most important specialties for post-war recovery (e.g., construction, engineering, IT, psychology).

- Use of a blended learning model that combines face-to-face classes with online formats.

Such a mechanism will allow for the effective implementation of ICT, which, in turn, will contribute to the rapid recovery and modernization of Ukraine's higher education system in the post-war period.

International support for information and communication technologies in Ukraine is becoming increasingly important, especially when traditional education faces challenges. This assistance is multifaceted and includes financial, technical, and expert support. It aims to strengthen educational infrastructure, improve teacher qualifications, and ensure access to quality learning resources for students.

International programs supporting the development of ICT in Ukraine often include grants from the European Union, such as the EU4Skills initiative, as well as projects funded by the World Bank.

Grants and investments from international organizations like the World Bank, the European Union, and various foundations help finance the development and implementation of educational platforms, the purchase of necessary equipment, and providing internet access to educational institutions. These funds allow for expanding the possibilities of distance learning and making it more accessible.

International partners provide technologies and software for creating effective e-learning systems. For example, companies like Microsoft and Google offer educational institutions free access to their platforms (Teams, Google Classroom), which facilitates the organization of the educational process, conducting online lessons, and communication between teachers and students.

Expert support is a direction that includes providing consultations, conducting training, and exchanging experiences. Foreign specialists share best practices, help develop curricula and teaching methods in the digital environment. This contributes to improving the digital literacy of teachers and implementing innovative approaches to learning.

Examples of successful initiatives include the "Diia.Digital Education" project, a national online platform offering free courses on digital skills for all citizens, created with the support of international partners.

Projects for equipping educational institutions: Foreign foundations help schools and universities obtain computers, tablets, and other equipment, which is critically important for organizing distance learning when traditional attendance is limited.

International support for ICT in Ukraine is not just assistance but an investment in the future, ensuring the continuity of the educational process and contributing to the modernization of the education system. This cooperation helps Ukraine not only overcome current challenges but also build a solid foundation for the development of innovative education.

In September 2022, Ukraine signed an Agreement on participation in the EU Program "Digital Europe" (2021-2027). The Program's calls aim to develop advanced digital skills, implement digital technologies in enterprises, build digital infrastructure, and increase the availability of digital services for citizens and state institutions of the European Union countries and countries associated with the Program. Higher education institutions have the opportunity to improve the quality of education and research through access to digital resources and international cooperation.

Another area of cooperation is the creation of Ukrainian EDIHs – digital hubs that provide practical assistance, such as the LEAP-hub. The hub is based on the experience and capabilities of the Lviv IT Cluster, which unites over 300 companies and implements dozens of initiatives in the field of education digitalization.

SNAU constantly develops international cooperation with foreign partners in various areas; most projects are aimed at improving the quality of the educational process and e-learning as its integral component. Projects of Erasmus +, the Czech Development Agency, the German Academic Exchange Service DAAD, Nestle Ukraine, the Swiss Cooperation Office in Ukraine, etc.

An example of international cooperation on the researched issue is SNAU's participation in the TOPAS project ("From Theory-Oriented to Practical Learning in Agriculture" (585603-EPP-1-2017-1-DE-EPPKA2-CBHE-JP) from 2017 to 2020, a European project co-financed by the EU program "Erasmus +". Work in the project's working group contributed to improving the technical support of the distance learning system; a computer lab was equipped with 10 HP personal computers, a multimedia board, graphic tablets, 2 laptops, and a server was purchased to support the operation of the Distance Learning Center for a total of over 100,000 euros.

Therefore, at the state level, the mechanism for implementing ICT should be aimed at strategic planning, regulatory regulation, financing, and coordination.

At the regional level, the mechanism for implementing ICT should focus on local adaptation of the state strategy, coordination of actions, and support for educational institutions.

For the successful implementation of information and communication technologies in Ukrainian higher education institutions (HEIs) in the post-war period, a multi-stage mechanism covering the state and regional levels is necessary. This mechanism must take into account both the challenges associated with the war (destruction of infrastructure, migration, financial constraints) and the opportunities for modernization and integration into the European educational space.

### **Conclusions.**

Differences in the ability for mental rotation among pupils and students in professional training (mathematics, information technology, social sciences & humanities) were studied, as well as differences in the nature of the relationship of cognitive stability under the influence of internal and external factors in young specialists who completed training in mathematical and humanities disciplines.

The main activity of a higher education institution (HEI) is the provision of educational services, which should be consumer-oriented. Consumers of a higher education institution's activities include both external (employers, the state, and society as a whole) and internal (students, teachers, HEI management) ones. An effective means of ensuring high quality education is its constant monitoring. Educational monitoring is a means of overseeing the transmission of social experience to the new generation, the correspondence of the actual results of the pedagogical system's activity to its ultimate goal. We believe that determining the degree of satisfaction of internal consumers is one of the main tasks of quality management. Such an assessment is necessary for adjusting actions in the educational processes of HEIs and making changes to organization management, educational programs and learning technologies, as well as accreditation of specialties. The quality of education or the output of a specialist required by employers primarily depends on the quality of the teacher's work.

Accordingly, the issues of controlling and evaluating the quality of a teacher's work are among the complex and important tasks in education quality management. It should be noted that the criteria for assessing the quality of a teacher's work in an HEI are not normatively defined. Consequently, educational institutions have various lists of requirements for scientific and pedagogical staff. As a rule, they are used when determining the possibility of a specific teacher holding a particular position during the competitive selection procedure for filling vacant positions. Today, there is great interest in studying the experience of HEIs that have developed and use certain models for evaluating teacher performance.

Based on available (in non-formalized or formalized form) information about the actual state of the system, managers at various levels make decisions on managing the quality of the educational process in HEIs. Particularly acute are the issues of providing input data and a formalized description of the system's functioning processes. The problem can be solved by developing information support for decision support systems (DSS) for managing the quality of the educational process in HEIs (for managers, department heads, employees of educational and methodological departments, and other persons responsible for accounting for the "human factor") using data mining technologies.

The issue of the quality of e-learning is considered at the international level; leading organizations such as the European Association for Quality Assurance in Higher Education (ENQA) and Quality Matters (QM) define basic criteria for evaluating online courses. These include: a clear structure of educational materials, consistency of learning outcomes with assessment methods, course interactivity, ease of access, and support for academic integrity.

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True sustainable development is impossible without a workforce trained in the principles of ESG (Environmental, Social, and Governance). The proposed adaptive models prioritize "Green Skills" and social responsibility, ensuring that the physical rebuilding of the country is matched by the ethical and intellectual advancement of its citizens.

The professional reintegration of veterans is a cornerstone of socio-economic stability. By utilizing adaptive EdTech to translate military leadership into civilian management, the state reduces welfare dependency and taps into a reservoir of highly disciplined, strategic talent. The calculated reintegration efficiency ratio demonstrates that investment in adaptive education is significantly lower than the long-term socio-economic costs of unemployment.

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