Secure Systems Design and Technology Development. Veliko Tarnovo, Bulgaria
Proceedings of the International Scientific Conference, 2026. Volume III, 121-125

Human Capital Development in War and Post-War Times Using Artificial Intelligence

Svitlana Kizim
Department of Digital Technologies and Vocational EducationVinnytsia Mykhailo Kotsiubynskyi State Pedagogical University
Vinnytsia, Ukraine
skizim2012@gmail.com

Oksana Voloshyna
Department of Pedagogy and Educational Management
Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University
Vinnytsia, Ukraine
woloshina5555@gmail.com

Liudmyla Bondarchuk
Department of Management and Administration Vinnytsia Institute of Trade and Economics of State University of Trade and Economics
Vinnytsia Ukraine
l.bondarchuk@vtei.edu.ua

Svitlana Nahorniak
Department of Pedagogy and Educational Management
Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University
Vinnytsia, Ukraine
svitlanamnagor@gmail.com

Olena Stoliarenko
Department of Pedagogy and Educational Management
Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University
Vinnytsia, Ukraine
olena-best@ukr.net

***Abstract*—This paper examines human capital development in wartime and post-war recovery using artificial intelligence technologies as a key engineering instrument of transformation. Human capital is considered as a multidimensional system that includes vital, intellectual, social, and digital components, all of which have undergone significant changes due to demographic losses, forced migration, destruction of educational infrastructure, and labour market imbalances.**

The methodological framework of the study is based on an interdisciplinary approach combining system analysis, conceptual modelling, statistical data analysis, and predictive modelling. This approach enables the identification of key risks of human capital degradation and substantiates the need for a transition to data-driven and engineering-oriented management.

It is demonstrated that artificial intelligence acts as a system-forming factor in human capital development by ensuring personalized learning, continuity of education, adaptive learning environments, and effective alignment with labour market demands. The study proposes an engineering architecture that integrates data-driven management, adaptive learning systems, virtual simulation environments, and digital platforms.

The scientific novelty of the research lies in the development of a roadmap for post-war human capital recovery based on the principles of engineering design and data-driven management. The proposed model defines a sequence of stages from stabilization of vital capital to long-term sustainability, ensuring coordinated recovery of all structural components. Practical implementation includes the use of generative models, adaptive educational platforms, and labour market analytics systems to create individualized learning trajectories and improve the efficiency of human resource utilization.

It is concluded that artificial intelligence serves as a fundamental driver of human capital development in wartime and post-war conditions, enabling accelerated economic recovery, increased competitiveness, and the formation of a knowledge-based, innovative economy.

Keywords: artificial intelligence, digital transformation, human capital, post war recovery, wartime conditions

I. INTRODUCTION

The full-scale Russian invasion of Ukraine in 2022 caused transformations in all domains of social life, especially in the formation and development of human capital. Demographic losses, forced migration, the decline in employment significantly affected quantitative and qualitative characteristics of human capital as the main strategical resource of the nation.

In this context, the integration of artificial intelligence (AI) technologies as a powerful instrument of preservation, recovery and augmentation of human potential acquires particular importance. AI is crucial for ensuring continuous learning amidst instability, personalized studying, automatized evaluation, and creation of adaptable learning environment.

The matter of the impact of war conflicts on human capital is a subject of active research in modern literature.

Online ISSN 3044-7771
https://doi.org/10.68302/std2026.vol3.188

Gorodnichenko et al. in his analysis of war consequences for Ukraine determines that armed conflicts lead not only to demographic losses, but also to compromised quality of education, deterioration in population health, which has long-term negative influence on economic growth. Authors emphasise on the necessity of investments in the quality of school education, higher education, and lastly, the retraining system as key areas for the recovery of human capital [1].

Kruglov and Tereshchenko indicate that war substantially aggravates metrics of human capital due to reduced access to quality education, migration of pedagogical personnel, psychoemotional exhaustion of the educational process participants [2]. Similar conclusions are found in the work of Yeremenko, who regards retraining and lifelong learning as anti-crisis instruments of the intellectual capital preservation in a wartime setting [3].

Special attention in literature is dedicated to the role of digital technologies and artificial intelligence in surmounting the educational challenges of warfare. Ober analyses the evolution of ICT (information and communication technologies) and AI usage in Ukrainian education during COVID-19 pandemic as well as in the war state, proposing the model of implementation of technologies in crisis situations [4].

In the post-war rebuilding context, Kuranda considers artificial intelligence to be a factor of the convergence of labour and capital, capable of compensating the human resources deficit owing to enhanced productivity [5]. Smykovska directly defines AI as the instrument of human capital development in the post-war economy of Ukraine [6].

The purpose of this article is to provide a comprehensive analysis of the transformations in human capital development in Ukraine during wartime and the postwar recovery, as well as to develop a roadmap for the postwar restoration of human capital.

II. MATERIALS AND METHODS

The methodological foundation of this study is an interdisciplinary approach that integrates principles from human capital theory, pedagogy, labour economics, digital transformation, and systems analysis.

System analysis was used as the primary research method to examine human capital as a holistic system of interconnected elements. The application of this method made it possible to identify the interrelationships between the vital, intellectual, social, and digital components of human capital, as well as to reveal the complex impact of war-related factors on their development.

Structural-functional analysis was applied to identify the main components of human capital, determine their functions, and analyze the changes caused by military events. Content analysis of scientific publications, documents, and analytical reports was used to identify contemporary approaches to human capital development and opportunities for applying artificial intelligence in education, vocational training, employment, and social integration. Statistical data analysis was used to assess the scale of human capital losses resulting from the war.

A foresight approach was used to identify promising areas for human capital development in the postwar period.

Conceptual modeling was used to develop an integrated model of the digital ecosystem for human capital development. The roadmapping method was used in the final stage of the study to develop a roadmap for the post-war restoration of Ukraine's human capital. Based on the results of systematic, statistical, comparative, and predictive analysis, a sequence of recovery stages was established, priority development areas were identified, artificial intelligence tools were selected, and the expected outcomes of their implementation were determined.

III. RESULTS AND DISCUSSION

Human capital within the scope of our research is examined as a multidimensional system, which integrates vital, intellectual, social and virtual (digital) components. Vital capital is associated with physical and psychoemotional state of the population health, intellectual – with levels of proficiency and competency, social – the quality of social relations and trust, virtual – digital skills; the ability to amalgamate into digital economics. The abovementioned structure allows to systematically assess losses and determine the instruments of their compensation. To be specific, for the development of vital capital, appropriate measure is the utilization of AI systems for psychoemotional state monitoring and early posttraumatic disorders diagnosis; in case of intellectual capital – the usage of adaptive educational platforms and language models; for social capital – analytics of social networks and recommender systems; in terms of virtual capital – digital educational ecosystems and apparatus for developing digital competencies.

TABLE 1 ANALYSIS OF THREATS TO HUMAN CAPITAL (QUANTITATIVE AND STRUCTURAL INDICATORS)

Capital constituent	Destructive factors and threats	Scale and systematic repercussions
Vital capital	Increase of disabilities, chronical post-traumatic disorder, decrease in income in 78% of population (Deloitte, 2023).	Critical decline in performance; the demand for AI-monitoring of psychoemotional state.
Intellectual capital	"Exodus of talent" (more than 14,5 million of migrants); destruction of educational infrastructure; loss of 5 million jobs.	Risk of long-term intellectual degradation; gaps in educational trajectories.
Social capital	Community disintegration (4,7 millions of internally displaced persons); destruction of connection; reduced trust in state universities.	Loss of social coordination; deficit of 4,5 million workers until 2032 [7].

War caused deep transformation of all components of human capital, which manifests in demographic losses, full-scale migration, destruction of educational

infrastructure, drop in employment. Artificial intelligence in this context is a systematic factor that enables the scaling of intellectual capabilities of humanity. Architectural engineering of decisions is grounded in creation of an integrated digital ecosystem that intertwines educational, economical, and social processes. The key element is data-driven management, realized via processing data of educational and social-economical registers with the usage of neural network models. This permits to forecast labour market needs, form individual educational trajectories, and detect early risks.

An essential element is adaptive learning environment, derived from machine learning algorithms, which provides personalization of the educational process in real time. Such systems modify content, tempo and difficulty of learning according to user's individual characteristics, which allows to markedly increase efficiency of staff training. Additional implemented features are virtual simulation complexes and VR/AR-technologies that construct safe conditions for forming professional skills in risky activity fields, among them medicine, engineering, military training.

Practical realization of aforesaid approaches anticipates generative models and digital education platforms. Modern models, such as ChatGPT, Google Gemini, Microsoft Copilot, perform functions of intellectual tutors, ensure generation of educational content, support academic work and analytical thinking development. Simultaneously into service have come platforms of quick retraining (Coursera, Duolingo), which facilitate the adaptation of population skills to dynamic needs of the labour market.

Utilization of AI for integration of veterans and internally displaced persons in economics plays a pivotal role. With respect to this, intellectual systems conduct an analysis of existing competencies, grant retraining recommendations and determine optimal professional trajectories. In addition, they might be used for psychoemotional state monitoring, a critically vital element for vital capital restoration.

In post-war period, the human capital recovery strategy should be rooted in unification of technological modernization and social adaptation. Priority objectives are creation of digital jobs, development of intellectual educational systems, implementation of labour market analytics in real time, creation of an innovational ecosystem.

We consider the following architecture:

- Data-Driven Management: deploying neural network models for processing Big Data in educational registers. It enables prediction of individual trajectories and performs preventive risk monitoring – from demotivation to poor academic performance [8].
- Adaptive Modern Learning Environments (MLEs): the architecture of MLEs is predicated on machine learning algorithms, which modify content, tempo and difficulty of learning in real time. Systems operate with digital profiles of cognitive peculiarities and provide personalization at the microlearning level.
- SMART-complexes and Virtual Simulators: application of virtual learning complexes for modelling of professional situations in safe spaces [9]. It is fundamental for training of military experts, doctors and engineers, where there is no margin for error.
- AI engineering ensures inclusion, creates API-oriented interfaces for people with disabilities. In this system, teacher evolves into an architect of educational experience and facilitator, who operates on analyst data.

Modernization of staff training requires integration of generative models and platforms.

- Generative LLM-models (ChatGPT-4, Gemini, Copilot): used for academic writing support, automatized generation of educational content and personal AI-tutoring [10].
- Adaptive reskilling platforms (Coursera, Duolingo): function as tools for dynamic skills correction (Upskilling) in line with market queries.
- Synergy of educational modes: AI warrants merging of formal, non-formal and informal education through digital competencies registers [11].
- Special emphasis is placed on economical adaptation of veterans and internally displaced persons. AI systems permit the conduct of automated skill assessment for military personnel, establish optimal retraining in deficit areas in economics [7].

In our research, we propound the roadmap of post-war human capital restoration (Table 2). Its structure is based on the principles of engineering design and data-driven management. Sequence of stages matches the logic of systemic recovery, wherein each successive level builds on the outcomes of the preceding one.

TABLE 2. ROADMAP FOR POST-WAR HUMAN CAPITAL RECOVERY BASED ON AI ENGINEERING APPROACHES

Stage	Recovery Area	Primary Tasks	Engineering Decisions (AI)	Expected Outcomes
1	Recovery of vital capital	Health rehabilitation, support of psychoemotional state	AI-health monitoring, diagnostic systems, predictive health analytics	Growth of working capacity of the population, reduction in morbidity
2	Recovery of intellectual capital	Education modernization,	Adaptive learning systems,	Growth of quality of the education

		retraining / upskilling	LLM-models (ChatGPT, Google Gemini, Microsoft Copilot), learning analytics	
3	Recovery of social capital	Reintegration of internally displaced persons and veterans	AI-powered competence analysis systems, recommender systems, social analytics	Rise of social solidarity, unemployment decline
4	Development of digital (virtual) capital	Digital skills formation, access to technologies	EdTech-platforms (Coursera, Duolingo), cloud systems, digital ecosystems	Growth in digital literacy, development of innovation economics
5	Institutional integration and management	Politics and infrastructure formation	Big Data analytics, labour market forecasting, AI-driven decision systems	Labour market balance, effective human capital management
6	Long-term durability	Sustainability and innovations	Smart Cities, AI governance, cybersecurity systems, interoperable platforms	Enhancement of competitiveness and economic stability

A key element of the proposed architecture for post-war human capital recovery is not only the integration of artificial intelligence tools into education and the labor market, but also the establishment of a system for continuously monitoring the effectiveness of such interventions.

Within the proposed model, generative artificial intelligence systems serve as a form of intelligent feedback. They not only assess learning outcomes but also generate personalized recommendations for adjusting learning strategies, addressing skill gaps, and optimizing individual educational pathways. The integration of artificial intelligence into the educational process monitoring system facilitates the transition from retrospective assessment to predictive and adaptive human capital management.

Within the structure of the proposed digital ecosystem, monitoring serves as a central feedback loop that integrates educational analytics, the labor market, and social policy

Practical realization of the roadmap foresees widespread use of intellectual tools in educational sphere, labour market and social adaptability of the population. Utilization of generative models, namely ChatGPT, Google Gemini and Microsoft Copilot, renders personalized learning, automatized educational processes and digital competencies development [12]. Concurrently, the application of lifelong learning platforms, such as Coursera and Duolingo, fosters quick retraining and population adaptability to labour market changes. Collectively, it forges an innovative ecosystem, able to provide effective human capital recovery and construct prerequisites for economical sustainability in post-war time.

IV. CONCLUSIONS

The post-war transformation should culminate in the formation of a national intellectual ecosystem. It stands for a holistic space that blends adaptive systems of learning management, digital platforms of labour market forecasting, integrity assurance services and registers of professional qualifications.

As for the role of artificial intelligence in this system, it acts as a fundamental instrument of modernization, which ensures flexibility, transparence and predictability of personality development. Systematic integration of intellectual technologies will enable the transformation of human capital of Ukraine into the most competitive asset in Europe. Post-war recovery should occur not as reversion to pre-reform state, but as an innovative leap into the future, wherein AI serves as a key constituent of social mobility and nation sustainability.

REFERENCES

[1] Y. Gorodnichenko, M. Kudlyak, and A. Şahin, “The effect of the war on human capital in Ukraine and the path for rebuilding,” IZA Institute of Labor Economics, IZA Policy Paper No. 185, Jun. 2022. [Online]. Available: https://docs.iza.org/pp185.pdf

[2] V. V. Kruglov and D. A. Tereshchenko, “Derzhavna polityka vidnovlennia liudskoho kapitalu Ukrainy v pisliavoiennyi period (State policy of human capital recovery in Ukraine in the post-war period),” Osvitnia analityka Ukrainy (Educational Analytics of Ukraine), no. 2, pp. 21–33, 2023. [Online]. Available: https://science.iea.gov.ua/wp-content/uploads/2023/07/2_Kruglov_Tereshchenko_223_2023_21-33.pdf

[3] O. Yeremenko, “Retraining and lifelong learning as an anti-crisis tool: Preserving Ukraine’s intellectual capital in times of war,” Knowledge Economy and Lifelong Learning, vol. 2, no. 1, pp. 48–66, 2026, https://doi.org/10.61093/kell.2(1).48-66.2026.

[4] J. Ober, T. Matusevych, and O. Strutynska, “From challenges to opportunities: Using ICT and AI in Ukrainian education in times of pandemic and war,” Journal of Open Innovation: Technology, Market, and Complexity, vol. 11, no. 4, p. 100639, 2025, https://doi.org/10.1016/j.joitmc.2025.100639.

[5] M. V. Kuranda and O. A. Bohutska, “Artificial intelligence as a convergence factor between labor and capital: Potential applications for Ukraine’s economic development,” Ekonomika promyslovosti (Economy of Industry), no. 3, 2025, https://doi.org/10.15407/econindustry2025.02.041.

[6] Yu. O. Smykovska, “Shtuchnyi intelekt yak instrument dlia rozvytku liudskoho kapitalu (Artificial intelligence as a tool for human capital development),” in Proc. Student Conf. “Current Issues of Development and Stabilization of Ukraine’s Economy in Wartime”, 2025. [Online]. Available: https://ekmair.ukma.edu.ua/

[7] V. M. Luhova and B. P. Makov, “Vykorystannia liudskoho kapitalu u pisliavoiennii vidbudovi Ukrainy (Use of human capital in post-war reconstruction of Ukraine),” Ukrainian Journal of Applied Economics and Technology, vol. 9, no. 4, pp. 46–50, 2024, https://doi.org/10.36887/2415-8453-2024-4-7.

[8] A. M. Gurzhii and M. A. Prykhodii, “Shtuchnyi intelekt yak stratehichnyi chynnyk rozvytku liudskoho kapitalu v umovakh tsyfrovoi transformatsii (Artificial intelligence as a strategic factor in human capital development in the context of digital

transformation),” in Proc. XX All-Ukrainian Sci. Pract. Conf. “Scientific and Methodological Support of Vocational Education and Training”, Kyiv, Ukraine, 2025, pp. 71–78.

[9] N. Y. Dmitrenko, O. V. Voloshyna, S. S. Kizim, K. V. Mnyshenko, and S. V. Nahorniak, “Smart education in the prospective teachers’ training,” CTE Workshop Proceedings, vol. 10, pp. 414–429, 2023, https://doi.org/10.55056/cte.568.

[10] S. Kizim, O. Voloshyna, I. Sarancha, S. Nahorniak, and O. Stoliarenko, “Organization of adaptive training using artificial intelligence technologies in the context of war environment,” in Proc. 16th Int. Sci. Practical Conf. Environment. Technology. Resources, Rezekne, Latvia, 2025, pp. 205–212, https://doi.org/10.17770/etr2025vol2.8606.

[11] A. Yarovyi, A. Yarovyi, S. Kizim, and V. Ozeranskyi, “Innovative trends in the field of modern artificial intelligence methodology,” Environment. Technology. Resources, vol. 2, pp. 132–137, Jun. 2024, https://doi.org/10.17770/etr2024vol2.8065.

[12] O. Voloshyna, T. Melnychuk, M. Sapohov, N. Burlaka, and A. Khilya, “The potential of developing and creating online applications for teacher training,” in Proc. 15th Int. Sci. Practical Conf. Environment. Technology. Resources, Rezekne, Latvia, 2024, pp. 525–529, https://doi.org/10.17770/etr2024vol2.8086.