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EDUCATIONAL FACTORS IN THE FORMATION OF INNOVATIVE HUMAN CAPITAL IN UKRAINE

Abstract. *The article analyzes the role of education as a key factor in the formation of innovative human capital. It is shown that the largest proportion of learners are covered by general secondary and higher education, and it is precisely within these levels that the main processes of human capital formation take place. The state of Ukrainian secondary and higher education is assessed in comparison with established global standards. For this purpose, a comparative analysis of the effectiveness of secondary education (based on PISA results) and higher education (according to global rankings, in particular QS) in Ukraine is carried out in the context of global trends. Within the framework of PISA studies, it is revealed that Ukraine, taking into account the volume of financial resources cumulatively spent on general secondary education (from the beginning of schooling until reaching the age of 15), calculated at purchasing power parity, belongs to the group of countries that spend no more than USD 75,000 on the education of one 15-year-old student. In this group of 32 countries, Ukraine ranks 4th, which is a relatively good result. However, during 2018–2022, an overall downward trend in results was observed for each subject tested within the framework of PISA. This indicates the need to reconsider measures aimed at improving the quality of general secondary education, taking into account resource constraints under the conditions of martial law. The main challenges caused by the war are also highlighted, in particular, educational losses and a shortage of teaching staff. A set of measures to improve the situation in the field of general secondary education is proposed, including the development of the New Ukrainian School, STEM education, deepening the implementation of digital technologies, and the adaptation of inclusive approaches. It is noted that the situation with the formation of innovative human capital in the domestic higher education sector, as the final level in this process, is worse. The best Ukrainian universities occupy positions in the second half of the lists of all well-known global rankings, and the share of GDP spent by Ukraine on R&D research, to which the higher education sector is directly related, is the lowest among all neighbouring countries. This indicates the presence of a systemic problem that needs to be urgently addressed, given the existential challenges facing Ukraine. Based on the experience of other countries, a number of measures that may improve the situation are proposed.*

Keywords: *innovative human capital, educational efficiency, PISA, general secondary education, higher education, education funding, innovative development.*

JEL classification: I25, O15, J24.

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In the contemporary landscape of the global economy, human capital has solidified its position as the primary endogenous factor of economic growth. Whereas the industrial era was characterized by the accumulation of physical capital and access to natural resources as key economic catalysts, the modern knowledge-based economy identifies intellectual capacity, creativity, and the ability to generate innovation as the dominant sources of added value. The theoretical foundations of human capital, established by Nobel laureates G. Becker and T. Schultz, are currently evolving into the concept of "innovative human capital" – a synthesis of knowledge and competencies that facilitate not only adaptation to rapid technological shifts but also the proactive leadership of such advancements.

According to data from the World Bank and leading analytical institutions, human capital constitutes approximately 60 % to 70 % of national wealth in developed nations. In Ukraine, however, this figure persists at a significantly lower level of roughly 30 % [1]. This discrepancy reflects a profound mismatch between the latent potential of the Ukrainian nation and the actual level of capitalization of the human factor. Consequently, the sub-optimal rates of national economic development stem not only from investment deficits and external hostile pressures but also from systemic inefficiencies in the mechanisms of human capital formation, within which the education system serves as a fundamental pillar.

The impact of educational transformations on the genesis and evolution of innovative human capital has become a focal point of global scholarly discourse. This intensification is evidenced by the exponential growth in publication activity within this domain, particularly in journals indexed in prestigious bibliometric databases such as Web of Science and Scopus (Fig. 1).

Fundamental contributions to the understanding of the nexus between educational quality and economic prosperity have been made by E. Hanushek and L. Woessmann [3]. Their empirical findings suggest that it is not the du-

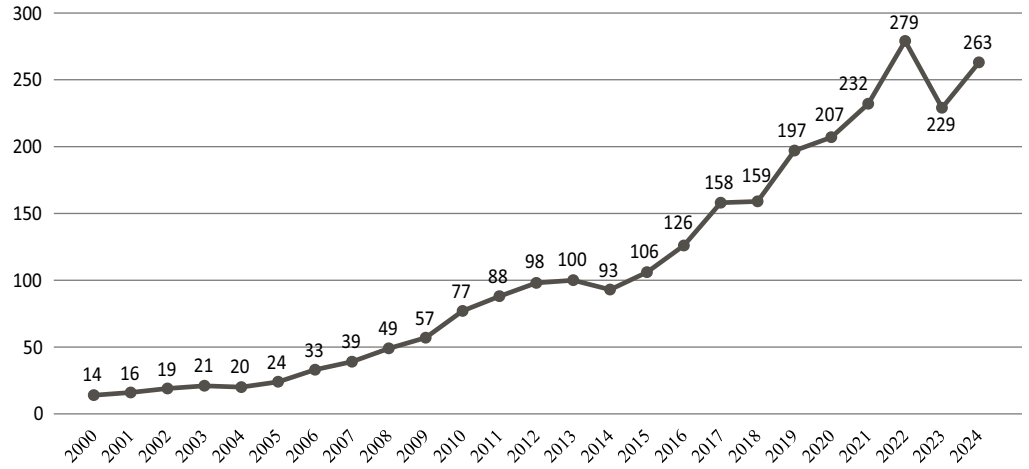

Fig. 1. **Dynamics of scholarly research concerning the impact of education on human capital development***, number*

Compiled by the authors based on source: [2].

ration of formal schooling, but rather the efficiency of educational technologies in cultivating authentic cognitive proficiencies that exerts a decisive influence on GDP as a metric of national development. Consequently, they argue that educational policy must prioritize learning outcomes (output) over the mere accumulation of institutional resources (input).

Nobel laureates J. Heckman and S. Mosso [4] emphasize the mitigation of educational disparities and their subsequent effect on human capital. They posit that investments directed toward early childhood development and high-quality secondary education yield the highest Return on Investment (ROI), proving significantly more effective than interventions at later stages. This underscores the imperative of ensuring equitable access to education for all school-age children. Complementing this view, R. Eynon, C. Lewin, F. Macgilchrist, M. Oliver, L. Pangrazio, J. Potter, N. Selwyn and B. Williamson [5] highlight the necessity of bridging the "digital divide", which, in volatile economies, can exacerbate social stratification and compromise the aggregate quality of human capital.

The conceptual framework of "National Innovation Systems", advanced by B.-A. Lundvall and R. Nelson [6], accentuates the role of higher education as the definitive stage in the formation of innovative human capital. They contend that a nation's innovative capacity is inextricably linked to the synergistic cooperation between academia, research centers, and industry. In this paradigm, higher education functions not merely as a supplier of skilled labor but as an instrumental agent in Research and Development (R&D). This perspective is further extended by S. Slaughter [7] through the theory of "academic capitalism", which justifies the evolving role of academic staff in the commercialization of knowledge and the proliferation of university-based technological startups.

Scholars also emphasize that while the continuous reproduction of human capital is vital for societal success, certain periods of social instability may hinder this process. This has led to the investigation of "educational resilience" in the context of crises and armed conflicts. E. Martey, M. Etwire and D. Atinga [8] examine the mechanisms required to prevent the collapse of educational systems under such conditions and the role of international cooperation in human capital recovery. Similarly, L. Londar and M. Pietsch [9] analyze the Ukrainian experience of fostering resilience during wartime, delineating the components of an organizational resilience model. Within this framework, research into "brain drain" and "brain circulation" underscores the critical importance of developing robust strategies for the repatriation of highly skilled migrants.

Addressing the specificities of the Ukrainian context, E. Libanova [10] identifies profound demographic and economic threats to human capital, asserting that the ongoing war has elevated the reproduction of human capital to a matter of national security. Other researchers [11] suggest that the impact of these challenges can be mitigated through accelerated digital transformation, the cultivation of Science, Technology, Engineering and Mathematics (STEM) competencies, and the overarching adaptation of the educational system to the requirements of Industry 4.0. Despite the extensive volume of existing literature, the synergistic nexus between

general secondary education reforms and the modernization of higher education remains insufficiently explored, particularly regarding the formation of innovative human capital under the stringent constraints of martial law. This article aims to clarify these issues.

Figure 2 illustrates the age-specific distribution of the student population in Ukraine for 2023, as compiled by UNICEF based on data provided by the SSI "Institute of Educational Analytics". The visualization indicates that school education, which covers the predominant share of the country's learners, typically commences at age 5–6 and concludes by age 18. While a marginal proportion of students enter higher education institutions (HEIs) at age 16, the majority of the cohort completes this stage by age 23. Furthermore, the data highlights a distinct segment of non-traditional students pursuing higher education beyond the age of 30, reflecting the ongoing trend of adult education and lifelong learning.

Table 1 shows a comprehensive statistical profile of student enrollment

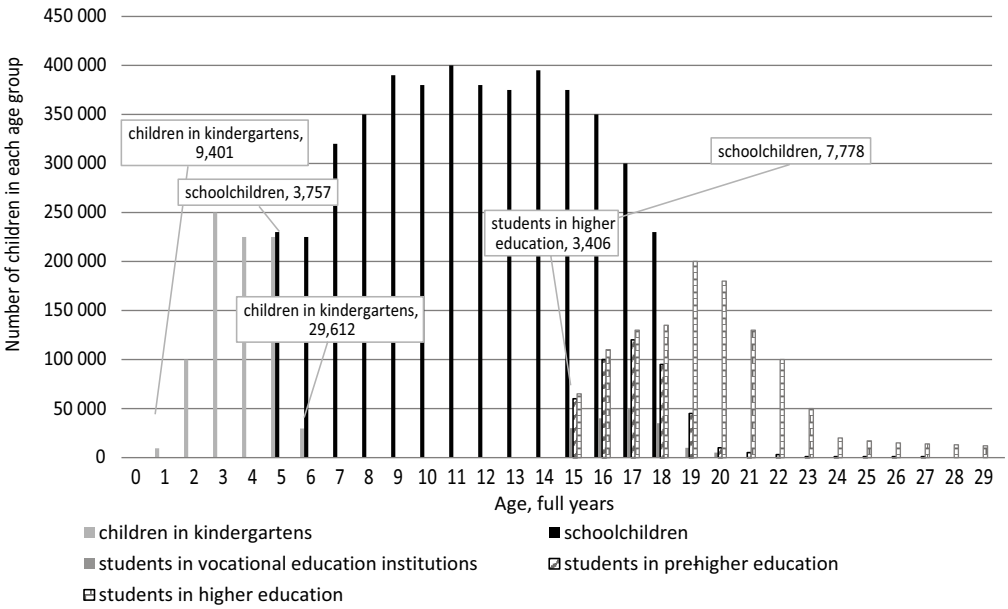

Fig. 2. **Distribution of the student population in Ukraine by educational level and age (2023)**

Compiled by the authors based on source: [12].

Table 1

Structural composition of students and teaching staff by educational level in Ukraine (2024/2025 a. y.)

Educational level	Number of students (thousands)	Number of teachers (thousands)	Percentage of students (%)	Percentage of teachers (%)
Preschool education	743.402	100.731	12.1	14.6
General secondary education	3,744.470	372.543	60.9	54.2
Vocational education	214.395	28.558	3.5	4.1
Pre-higher education	331.488	25.834	5.4	3.7
Higher education	1,112.965	161.385	18.1	23.4
Total	6,146.72	689.051	100.00	100.00

Compiled by the authors based on source: [13].

and pedagogical personnel across various educational tiers for the 2024/2025 academic year.

The empirical data reveals that general secondary education remains the most substantial pillar of the national educational infrastructure. Specifically, this sector encompasses 3.74 million students and 372,500 teachers, accounting for 60.9 % of the total student body and 54.2 % of the teaching workforce, respectively. Higher education represents the second-largest component, catering to 1.11 million students and employing 161,400 faculty members, which translates to 18.1 % and 23.4 % of the overall educational structure. Consequently, it is evident that general secondary and higher education are the primary domains for the formation of human capital in Ukraine.

To assess the efficacy of these sectors, we employ internationally comparable benchmarks. Figure 3 delineates the correlation between cumulative educational expenditure (calculated in

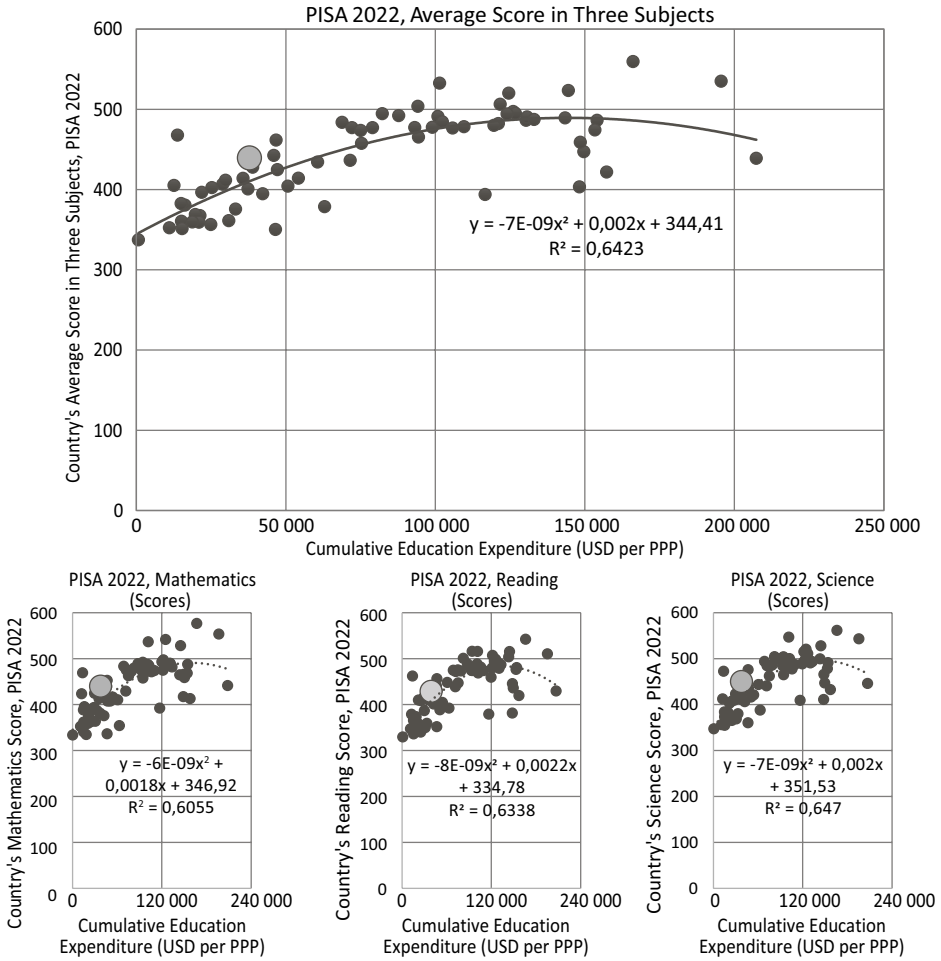

Fig. 3. **Graph of dependence between mean PISA 2022 scores (Mathematics, Reading, Science) and cumulative 9-year educational expenditure per student (USD PPP)**

Compiled by the authors based on source: [14].

USD at purchasing power parity (PPP) from the inception of schooling to age 15) and the mean performance scores achieved by 15-year-old students in the PISA 2022 assessment. Ukraine's relative standing is highlighted by an enlarged data point.

The analysis demonstrates that, based on cumulative financial inputs, Ukraine's general secondary education system belongs to a cohort of nations characterized by expenditures not exceeding 75,000 USD per student. Within this 32-country peer group, Ukraine ranks 4th, a result that indicates a high degree of resource efficiency. Notably, Ukraine outperformed several nations with significantly higher funding levels (e.g., Qatar), where students demonstrated lower academic proficiency.

However, longitudinal data from the Ukrainian Center for Educational Quality Assessment [15] indicates a discernible downward trajectory in student performance across all PISA domains between 2018 and 2022. This decline necessitates a critical re-evaluation of strategies for quality assurance, particularly given the acute resource limitations and the operational complexities imposed by martial law. Scholars emphasize the imperative of sustaining the "New Ukrainian School" (NUS) reform by tightening academic standards, bolstering STEM education, integrating advanced inclusive learning technologies, and implementing systemic measures to mitigate educational losses [16]. Furthermore, elevating the social prestige and professional quality of teaching staff remains a vital prerequisite for the sustainable reproduction of innovative human capital.

When evaluated through the lens of globally recognized benchmarks, the performance of Ukraine's higher education sector appears more constrained. Table 2 delineates the longitudinal ranking trajectories of leading Ukrainian universities within the QS World University Rankings for the period 2020–2025.

As evidenced by Table 2, even the Taras Shevchenko National University of Kyiv, the nation's flagship institution, consistently places in the second half of the global top 1000. Notably, only V. N. Karazin Kharkiv National University managed a brief ascent into the top 500 tier during the 2020–2021 period.

Table 2

Dynamics of leading Ukrainian universities' positions in the QS World University Rankings (2020–2025)

Universities	2020	2021	2022	2023	2024	2025
Taras Shevchenko National University of Kyiv	541-550	601-650	601-650	651-700	681-690	701-710
V. N. Karazin Kharkiv National University	491	477	511-520	541-550	691-700	741-750
Igor Sikorsky Kyiv Polytechnic Institute	701-750	701-750	701-750	701-750	731-740	801-850
National Technical University "Kharkiv Polytechnic Institute"	701-750	651-700	651-700	651-700	901-950	1001-1200
Lviv Polytechnic National University	751-800	801-1000	801-1000	801-1000	951-1000	1001-1200
Sumy State University	701-750	701-750	701-750	801-1000	951-1000	1001-1200

Compiled by the authors based on source: [17].

Researchers of Ukrainian higher education point to other problems as well, beyond these modest rankings, particularly concerning quality assurance. Institutional outputs – encompassing research achievements, academic freedom, and citation indices – demonstrate a weak correlation with current funding levels and resource allocations [18]. Furthermore, the absence of a systematic framework for tracking graduate employment remains a critical gap. At present, scientific leadership remains underdeveloped; unlike peer institutions in the EU and the US, Ukrainian university-based science has yet to become a primary driver of technological advancement, a situation exacerbated by chronic deficits in both material and financial resources [19].

This critical context is further illustrated in Figure 4, which benchmarks R&D intensity in Ukraine against neighboring countries and global leaders as of 2023. Given that the higher education sector is inherently intertwined with the generation of R&D, these figures are telling.

Leading knowledge-based economies, such as Israel and South Korea, allocate at least 5.0 % of their GDP to R&D. Among Ukraine's neighbors, the Czech Republic maintains the highest investment level (1.8 % of GDP), while Belarus reports a significantly lower share (0.58 %). Ukraine, however, exhibits the lowest expenditure in this cohort, at a mere 0.33 % of GDP. This underscores a profound systemic impediment to the cultivation of innovative human capital at its terminal stage. The development of breakthrough technologies necessitates a robust pipeline of highly qualified, innovative specialists produced by the higher education system. Addressing this deficit is an urgent priority that requires the integrated efforts of leading universities and innovative industries, taking into account the difficult existential challenges facing Ukraine.

Furthermore, according to many data, human capital currently forms 60–70 % of national wealth in developed countries. In Ukraine, this factor contributes only 30 % of national wealth [22]. This disparity highlights a significant underutilization of the nation's human potential.

Fig. 5 explores the correlation between the Human Development Index

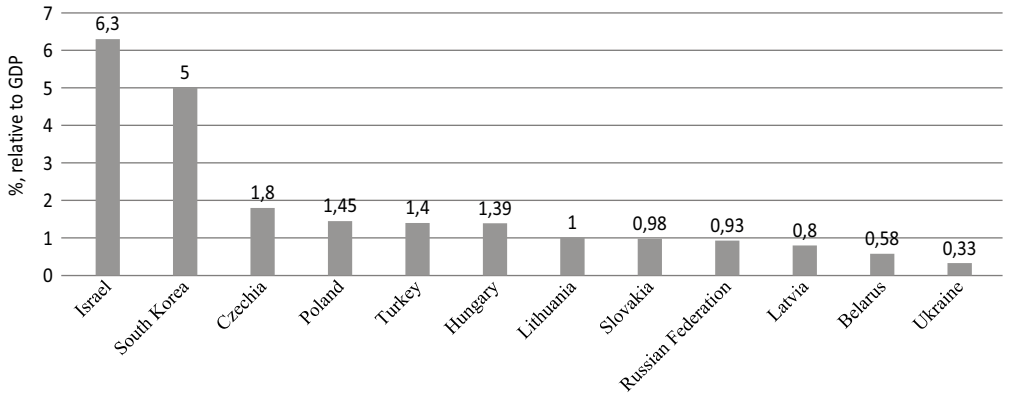

Fig. 4. **R&D expenditure as a percentage of GDP in 2024: Ukraine, neighboring states and global leaders**

Compiled by the authors based on sources: [20; 21].

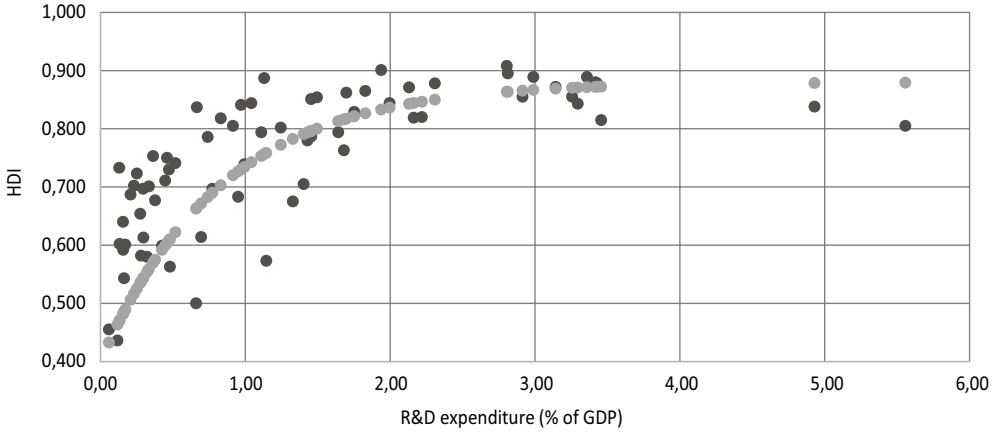

Fig. 5. **Dependence between the Human Development Index (HDI) and R&D expenditure (% of GDP) in 2023 (OECD countries)**

Compiled by the authors based on sources: [23; 24].

(HDI) – a primary metric of socio-economic prosperity and R&D intensity for 2023.

The relationship between these variables can be characterized as a saturation curve. The data indicates that HDI gains are most accelerated when R&D expenditures transition from negligible levels toward the 2 % threshold. This suggests that prioritizing the development of innovative human capital and the integration of advanced technologies can catalyze rapid improvements in socio-economic indicators and enhance the overall sustainability of national development.

The results of this study confirm that Ukraine's sustainable socio-economic development, especially during the critical phase of post-war reconstruction, requires a strategic focus on strengthening the role and influence of innovative human capital. This is necessary both to strengthen national defence capabilities and to address the urgent need for economic recovery based on a developed technological base.

Within the globalized knowledge economy, human intellect and creativity have emerged as the primary sources of added value. For Ukraine, bridging the gap in the capitalization of the human factor, which currently stands at 30 % of national wealth compared to 60–70 % in developed nations, is a decisive task for ensuring national survival and long-term prosperity.

The education sector serves as the fundamental catalyst for the formation of innovative human capital, with general secondary and higher education constituting its most influential pillars. These sectors encompass the vast majority of learners and pedagogical personnel in Ukraine.

The efficiency of Ukraine's general secondary education, despite acute resource constraints, remains relatively high in a comparative international context. The PISA-2022 results indicate that the Ukrainian educational system is capable of delivering competitive cognitive outcomes even with limited funding (ranking fourth among nations with expenditures below 75,000 USD per student). Nevertheless, the current trajectory toward declining academic performance and significant war-induced

learning losses requires an immediate strengthening of the NUS reform, enhancement of STEM teaching technologies, digital transformation of education, etc.

Conversely, Ukrainian higher education represents a more significant bottleneck in the process of innovative human capital formation. The modest standing of Ukrainian universities in global rankings (such as the QS second-thousand tier) and the critically low R&D intensity (0.33 % of GDP – the lowest among neighboring countries) underscore a profound disconnect between academia and innovative industries. Addressing this systemic weakness requires proactive state intervention to stimulate investment in Research and Development, with a medium-term goal of increasing R&D expenditure to at least 1.5–2 % of GDP. This demand is further amplified by the immediate necessity of advancing defence-related technologies. Furthermore, effective policies must be implemented to facilitate the repatriation of highly skilled migrants and to leverage the advanced technological competencies of veterans. Failure to address these issues risks relegating Ukraine to the role of a raw-material appendage within the global economy.

The reconstruction of Ukraine must transcend the mere restoration of destroyed infrastructure. It must be guided by the "Build Back Better" principle, utilizing innovative human capital as the primary strategic resource. The objective is to cultivate an innovation ecosystem where high-quality secondary education provides the cognitive foundation, while modernized higher education and science act as the engines for industrial renewal and the development of the dual-use technology sector.

Ultimately, only through the synergy of systemic reforms across all educational levels and the targeted support of innovation can Ukraine realize its latent potential, ensure sustainable post-war economic growth, and achieve seamless integration into the European Union.

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ОСВІТНІ ФАКТОРИ ФОРМУВАННЯ ІННОВАЦІЙНОГО ЛЮДСЬКОГО КАПІТАЛУ В УКРАЇНІ

Анотація. *У статті проаналізовано роль освіти як ключового фактора формування інноваційного людського капіталу. Показано, що найвагоміші частки здобувачів освіти охоплюються загальною середньою та вищою освітою й саме тут відбуваються основні процеси формування людського капіталу. Оцінено стан української середньої та вищої освіти порівняно з усталеними світовими стандартами. Для цього проведено порівняльний аналіз ефективності середньої (на основі результатів PISA) і вищої освіти (згідно зі світовими рейтингами, зокрема QS) України в контексті глобальних тенденцій. У рамках досліджень PISA виявлено, що Україна, з огляду на обсяги фінансових ресурсів, витрачених на загальну середню освіту кумулятивно (від початку навчання та до досягнення 15-річного віку) за паритетом купівельної спроможності, належить до групи країн, які витрачають на підготовку одного 15-річного учня не більше 75 тис. дол. США. У цій групі із 32 країн Україна посідає 4-те місце, що є відносно непоганим результатом. Проте впродовж 2018–2022 рр. спостерігається й загальна тенденція падіння результатів за кожним предметом, що тестується в рамках PISA. Це вказує на необхідність переосмислення заходів із підвищення якості загальної середньої освіти з урахуванням обмеженості ресурсів в умовах воєнного стану. Також підкреслено основні виклики, спричинені війною, зокрема освітні втрати та дефіцит педагогічних кадрів. Запропоновано комплекс заходів щодо поліпшення ситуації у сфері загальної середньої освіти, включаючи розвиток НУШ, STEM-освіти, поглиблення імплементації цифрових технологій, адаптацію інклюзивних підходів. Зазначено, що ситуація зі ство-*

ренням інноваційного людського капіталу у сфері вітчизняної вищої освіти як кінцевої ланки в цьому процесі є гіршою. Найкращі українські університети посідають місця в другій половині списку всіх відомих світових рейтингів, а частка ВВП, що витрачається Україною на R&D-дослідження, до яких безпосередньо причетна сфера вищої освіти, є найменшою серед усіх країн-сусідів. Це свідчить про наявність системної проблеми, яку потрібно терміново розв'язувати, зважаючи на екзистенціальні виклики, що постали перед Україною. На основі досвіду інших країн запропоновано низку заходів, які можуть поліпшити ситуацію.

Ключові слова: *інноваційний людський капітал, ефективність освіти, PISA, загальна середня освіта, вища освіта, фінансове забезпечення освіти, інноваційний розвиток.*

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