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The Potential of Science Education for Development of Responsible Citizenship in Ukraine

[Potencjał edukacji naukowej dla rozwoju odpowiedzialnego obywatelstwa w Ukrainie]

Streszczenie: Nasze badania koncentrują się na tym, w jaki sposób procesy społeczno-kulturowe wspierają odpowiedzialne obywatelstwo w Ukrainie poprzez nabywanie umiejętności naukowych w oparciu o nadrzędne znaczenie narracji filozoficznej. Autorzy starają się przedstawić różne dylematy, począwszy od niejednoznacznych wyzwań, przed którymi stoi edukacja naukowa, konfrontując się z pojęciami dobrego obywatelstwa w różnych kontekstach społeczno-kulturowych. W związku z tym skupiamy się na etycznych aspektach obywatelstwa w ramach programu edukacji naukowej, który nie sprowadza się jedynie do przyswajania faktów naukowych. Pokazujemy, że jest to niezbędne narzędzie do rozwijania krytycznego racjonalizmu, osądu moralnego i zaangażowania obywatelskiego. Program nauczania koncentruje się na rozwoju umiejętności naukowych, motywując uczniów do angażowania się we własne autodydaktyczne poszukiwania naukowe. Utrzymujemy, że ciekawość poznawcza i krytyczna analiza z pewnością przełoży się na zdolność nadawania sensu trudnym etycznym i społecznym wyzwaniom ukraińskim, a także pozytywnie wpłynie na podejście do edukacji pedagogicznej. Ponadto analizujemy ukraiński program nauczania przedmiotów ścisłych w kontekście szerszych krajowych i globalnych wyzwań związanych z osiągnięciem umiejętności naukowych jako podstawowego filaru przyszłego uczenia się i nauczania. Mówiąc dokładniej, proponujemy politykę zakorzenioną w badaniach opartych na dowodach jako elemencie całej postępowej edukacji, aby umożliwić uczniom rozwijanie narzędzi, których potrzebują, by stać się lepiej poinformowanymi, aktywnymi obywatelami zdolnymi do wprowadzania pozytywnych zmian społecznych.

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Wyniki naszego badania odnoszą się do konieczności przeprowadzenia reformy edukacji w Ukrainie poprzez modernizację zarówno infrastruktury fizycznej, jak i pedagogicznej. Autorzy przedstawili argumenty za stworzeniem silnych podstaw budowania społecznej potrzeby poznania naukowego wśród dobrze poinformowanych obywateli, co doprowadzi do powstania pokolenia zdolnego do rozważenia i rozwiązania złożonych kwestii etycznych i społecznych. Podjęte badania pozwalają na weryfikację osiągniętych już wyników w kategoriach szerszego dyskursu filozoficznego i edukacyjnego, mając na uwadze to, w jaki sposób konflikty zbrojne mogą wpływać na tworzenie świadomej populacji zdolnej do kierowania wspólnych wysiłków na rzecz rozwoju zrównoważonego, sprawiedliwego postępu, który służy zarówno jednostce, jak i całemu społeczeństwu.

Summary: Our research focuses on how sociocultural processes can foster responsible citizenship in Ukraine through scientific literacy within an overarching philosophical narrative. In particular, the authors aim to outline various dilemmas, beginning with the ambiguities that science education faces when confronting notions of good citizenship within differing sociocultural contexts. Hence, we focus on the ethical and moral aspects of citizenship within a science education agenda that is not reducible to the learning of scientific facts. We show that it is an essential instrument for developing critical rationality, moral judgment and civic involvement. This agenda is centered around the development of scientific literacy, motivating students to engage in their own auto-didactic pursuit of scientific inquiry. The authors maintain that this sense of curiosity and critical engagement is bound to translate into an ability to make sense of difficult ethical and social Ukrainian terrain as well as positively influence approaches to pedagogical education. We further examine Ukrainian science education curriculum in the context of the broader national and global challenges of attaining scientific literacy as a foundational pillar of any future learning and teaching. More specifically, the authors propose a policy rooted in evidence-based inquiry as a centerpiece of all progressive education to allow students to develop the tools they need to become better informed, active citizens able to bring about positive societal shifts. The findings of our study relate to the call for educational reform in Ukraine through the modernization of both its physical and pedagogical infrastructure. The case is made for creating a strong foundation of scientifically-minded attitudes amongst the well-informed citizenry, which will lead to a generation able to consider and address complex ethical and social issues. The research interprets its results in terms of a broader philosophical and educational discourse with a view as to how military conflicts can affect the producing an informed population able to direct its concerted efforts towards the development of sustainable, equitable progress that serves both the individual and society at large.

Słowa kluczowe: filozofia edukacji, odpowiedzialne obywatelstwo, edukacja naukowa, wartości obywatelskie, transformacja społeczno-kulturowa, infrastruktura edukacyjna, modernizacja kształcenia nauczycieli.

Keywords: science education, philosophy of education, civic values, sociocultural transformation, educational infrastructure, pedagogical modernization.

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Introduction

The philosophy of science education encompasses more than mere scientific facts and process skills; it elucidates how individuals acquire a scientific perspective on the world and employ scientific inquiry. In its essence, science education is a fundamental process of producing rational individuals, capable of understanding and negotiating the challenging terrain within which they live. The philosophical foundation of science education therefore goes beyond simply covering scientific knowledge; it aims to foster an individual's capacity for engagement with the living world through the inquiry mode. The concept of enlightenment is the emergence of individuals from self-imposed nonage through the application of reason (Velleman J.D., 2005, p. 20). It encompasses Kantian concepts such as autonomy and the capacity to think freely in order to respond to the fundamental aspects of science education that aim to cultivate rationally informed worldviews.

This discourse is further informed by John Dewey's pragmatism, which corresponds to an education system that integrates learning with real-world applications. This encourages inquiry and experimentation in order to enhance critical-thinking and problem-solving skills. In particular, Dewey argued that education is not only about teaching, but rather has mainly to do with how people should be educated to become responsible democratic citizens (Dewey J., 2011, p. 18–20). Consequently, the incorporation of scientific literacy into the fabric of a society serves as a democratic foundation for a nation and its populace, as participating in democratic processes necessitates making informed decisions and aiding social/economic advancement.

This idea is echoed in the philosophical doctrine of communitarianism as defined by Alasdair MacIntyre who advocates for the role of a community in forming moral values and encouraging responsible citizenship attitudes. More specifically, MacIntyre perceives education as a vehicle for the inculcation of social responsibility and improving of societal well-being. These tasks are of critical importance to our national education system, where the problem stems from the fact that in Ukraine, due to the radical changes taking place at the socio-political level, a philosophical reflection on science education has to address issues that have an interlinked dual nature: forming a modernized base of knowledge acquisition coupled with facilitating scientifically informed pro-social attitudes (Stolz S., 2019, p. 12–15). Education must therefore encourage responsible citizenship and the norms that go with it. Hence, ethical behavior, social responsibility, and community engagement are virtues that provide the moral foundation for applying scientific knowledge to society.

Within the local paradigm, in Ukrainian culture, science education not only occupies a place in the system of knowledge but also acts as a tool for forming social identities in the ethical dimension. Consequently, in order to produce a scientifically literate society, the inclusion of science education into the fabric of our national collective psyche is necessary because it will contribute significantly to informed decision-making while driving the nation's overall economic and social development. Having said that, it follows that the philosophical realm of discourse regarding science education in Ukraine ought to incorporate two aspects, namely the educational and citizenship components (Hladchenko M. and others, 2020, p. 114).

Given this, we maintain that the philosophical underpinnings of science education are based in critical thinking and empirical reasoning, which provides the best and most appropriate platform for imparting such virtues within the broader, overarching philosophical paradigm of responsible citizenship. Through science education, individuals are empowered with the cognitive scaffold to question and understand critically social issues that affect their lives, while making well well-informed decisions in their more mundane day-to-day affairs. At the same time, the standards of responsible citizenship: conscious behavior, insistence on recognizing and observing legal rights and obligations serve as a moral framework in which scientific knowledge can be applied to the spiritual side of interpersonal development. Accordingly, the authors suggest a four-pillar analysis backed by comprehensive research of this issue based on: modernization of pedagogical education (Dovgyi S. and others, 2022; Hattie J., 2009; Nusmbaum M., 2010; Salhberg P., 2011; William D., 2011;), national educational policymaking (Boichenko V., 2021; Kahanec M. and others, 2023; Vieira R.M. and Tenriero-Viera C., 2014), development of science education infrastructure (Analysis of war damage, 2024; Kravchenko T., 2020; Kuzmenko A. and others, 2022; World Bank, 2020), creation of advisory and expert bodies, and development of the nationwide science education infrastructure (OECD, 2019; Sieriakova I. and Kokoza G., 2019; Zinchenko V. and others, 2022) among others.

Modernization of Pedagogical Education: Teachers Capable of Nurturing Responsible Citizenship Competencies

The important step in preparing teachers for the new level of pedagogical education will be the modernization of pedagogical education, corresponding to the requirements and expectations of a swiftly shifting landscape of global pedagogical approaches and requirements. In Ukraine, being able

to adapt to this shift is of paramount importance amidst war-induced social unrest and the urgent need for drastic educational reforms whereby teachers can no longer be seen merely as conveyors of knowledge but have to reorient themselves toward being able to inculcate critical thinking and the development of research competencies. This reflects the growing context of inquiry-based learning in science education, which teachers are conti-nuously expected to develop in tandem with the cultivation of science-based research habits in students. Progressive educators should not only know and impart their subject well, but they should also possess the ability to teach children research skills. It involves changing the pedagogy from didactic to more inquiry-based, problem-solving and independent research-oriented methods (Dovgiy S. and others, 2018, p. 278).

British education philosopher Dylan William states that effective teaching is not about delivering content; it is about creating the conditions under which students can understand and apply that content. This requires a shift from traditional teaching methods to those that actively engage students in the learning process (William D., 2011). This perception is shared by numerous approaches in philosophical pedagogics that favor alternative forms of instruction in line with the global trend towards a more personal, active, and investigative approach to education. Hence, research competencies are central to science education because they provide students with the means to constantly learn and thereby become the active members of society. Ukrainian teacher pedagogy modernization should be associated with the preparation of teachers who are able to efficiently implement research-based methodologies into their teaching. This means not just telling students what we think the scientific concepts are, but also creating a classroom where students investigate and critique on their own.

On an international level, there is an increasing agreement that research-based competencies are equally necessary for the education of academic staff. John Hattie notes that teachers who create a classroom culture of inquiry and exploration are likely to instill in students not just the knowledge of facts but are able to stimulate an attitude of curiosity and exploration making them engaged learners and citizens (Hattie J., 2009, p. 20). Consequently, education for democratic citizenship has also gained momentum on a global scale. Education systems must equip students with the knowledge, skills, and values needed to live and work in a globalized world, including the ability to understand and appreciate different perspectives, and to contribute to the common good. In light of this, in Ukraine, the work of teachers should be understood as a significant factor of social change within the overarching global competency framework, which should be in line with the aims of the nationwide responsible citizenship agenda.

Martha Nussbaum, an American philosopher and advocate of liberal education, agrees when she notes that education for citizenship requires not only the transmission of knowledge but also the cultivation of empathy and moral reasoning. These qualities are essential for democratic participation and the development of a just society. (Nussbaum M., 2010, p. 27). It is in these terms that such a perspective on personal and professional formation can elucidate the presuppositions regarding the civic--ethical, national and international dimensions of progressive education. Hence, to be deemed a success, any efforts of modernization of the pedagogical education in Ukraine must meet both of these objectives, which cannot be adequately ensured unless we adopt a principally new approach to teacher training. As noted by Pasi Sahlberg: „Continuous professional development is the cornerstone of effective teaching. Teachers must be provided with the resources and support needed to continually refine their practice and adapt to new educational demands" (Sahlberg P., 2011, p. 23–24).

Accordingly, from a broader conceptual perspective it follows that the modernization of pedagogical approaches in Ukraine is a key component of the overall reform of the national system of education. As a result, the role of teachers in science education and social interaction is changing. By implementing proven, effective teaching practices that emphasize critical modes of inquiry and civic engagement, Ukraine can produce a citizenry that is both scientifically literate and socially responsible, shaping the future of the nation one classroom session at a time.

Implementation of National Policies Geared Toward Supporting Science Education in the Face of National and Global Challenges

In the 21st century science education has become a necessary condition for solving national and worldwide problems. In particular, it is essential that a society possess the ability to respond scientifically to the mounting socioeconomic challenges. Hence, the launching of the sweeping scientific education policy is essential in Ukraine, given the current systemic social and political transitions that require building our society's resilience under conditions of sustainable socio-economic growth. In the conditions of Ukraine's integration into the global community, science education acts as a strategic base for establishing knowledge economy and preparing citizens to solve global problems. This predicament highlights the relevance of national policy approaches to science education for improved economic competitiveness and social cohesion.

Most Ukrainian educators and policymakers have unequivocally welcomed recent reforms in science education that aim to bring it into line with European standards. Experts agree that policies must be evidence-based guaranteeing development and accountability since a sweeping reform requires robust policy targeting tools and resources for its successful implementation. As Ukraine is becoming more and more integrated into the global scientific community, it cannot stand aside these wider problems since societies unable to produce scientifically literate citizens fit for global problem-solving would struggle to tackle such challenges as climate change, public health and energy security. As is noted by a number of researchers focusing on this issue: „The Ministry of Education and Science of Ukraine must focus on policy development and establishing frameworks for quality management and control to ensure accountability to the public interest. It will be important not only to measure performance and incentivize investment, innovation, and experimentation, but also to provide the necessary resources to support quality enhancement" (Kahanec M. and others, 2023).

Accordingly, higher quality science education (STEM education, in particular) for all students should be more affordable. Our educational establishment should strive for education equity, making sure that every citizen has equal opportunities to contribute to the scientific enterprise taking advantage of the potential benefits from the advances it makes (Boichenko V., 2021, p. 90). This requires that the government should raise the bar on science education accessibility allowing the general populace to do more science by doing away with policies, which bar citizens from pursuing scientifically literate fields and vocations. This, in turn requires a collective, concerted effort on the part of teachers, policymakers and the international community to enable science education in Ukraine to take a firm hold and develop.

Consequently, the most efficient way to ensure that the initiatives aimed at developing progressive science education policies thrive while reflecting national and global needs is through the creation of a coherent nexus of social involvement. At the same time, the idea of citizenship is a rather ambivalent notion. In particular, at the domestic level, certain qualities of 'good' citizenship are attached by the philosophies of political liberalism, communitarianism and certain classical national models. Indeed, modern European citizenship is a derivative form of statehood (largely regulatory at the EU level) being neither national in substance, nor having any strong ideological obligations citizens have towards their respective states (Lehning P., 2001, p. 245).

Furthermore, citizenship identity has to do with membership as a wholesale category: working and living among people who are part of a shared history, language, values and culture. Hence, taking into account this enriched understanding of the concept of citizenship we can start to flesh out the idea of citizenship as a constellation of civic virtues – the values, attitudes and behaviors that one is supposed to manifest in order to be perceived as a good citizen. In fact, a defining feature of citizenship is the capacity to question authority, hold leaders accountable and where possible challenge those in control if their actions constitute a threat to democracy (Vieira R.M. and Tenreiro-Vieira C., 2014, p. 670).

Central to the very concept of citizenship is the capacity and willingness to use power to disrupt authority and make a difference in holding those in power accountable for their actions. We agreed upon a number of specific and very concrete goals in the UNESCO agenda, which correspond to the definition of citizenship. Most especially, if as a nation we decide that the way forward is to strive towards a scientifically literate and engaged society, then we will be able to confront whatever challenges lie ahead by harnessing what science and technology have to offer in order to ensure that our future is more prosperous and sustainable. Accordingly, greater collaboration and combined action of a committed educational community will be essential in enabling science education and innovation to play the roles that humanity needs them to play for it to respond constructively to our mounting global challenges and contribute positively at the global level (Science education for responsible citizenship, 2015).

Another essential philosophical aspect of good citizenship is social responsibility. The underlying social responsibility upon which, examined more closely, is simply an honest recognition that the actions of an individual create ripples into the world and little rivers among society. It is therefore little surprise that citizens supporting social responsibility appear on the end of the spectrum promoting inclusivity and SDG values. Ultimately, a well-educated populace represents a better population to implement meritocracy into civic life, able to evaluate information critically and busy constructing and enhancing democratic institutions and modes of interaction. This, then determines that this inexorable but challenging mission rests with our educators and schools to teach our young how to become responsible citizens who reciprocate by building up a more peaceful, aware and equitable society.

Development of the Infrastructure of Science Education in Ukraine

It is essential that we understand science education infrastructure as an important part of every educational system because this provides intellectual and physical resources needed in teaching and learning. This kind of development also needs to be analyzed using philosophy of education approaches. The advancement of science education infrastructure in Ukraine is ultimately needed in order to create a population who are capable of asking difficult and challenging questions for present and future domestic needs at national level and global one as history has shown a failure from another side, creating a brain drain elsewhere. This infrastructure is not limited to the physical spaces and equipment required to carry out knowledge production, but also implies that an entire host of interlocking networks and systems are functioning properly to ensure collaboration, innovation and open access to information.

Recent research conducted by the UNESCO on science education paints a distressing picture: „The conditions for conducting scientific and experimental work in Ukraine have significantly deteriorated since the Russian invasion of February 2022. As a result of the bombing of Ukrainian cities over the past two years, many scientists in the public sector have been forced to change both their city of residence and their place of work. By January 2024, 12% of Ukrainian scientists and university teachers had been forced to emigrate or relocate internally. About 30% of all Ukrainian scientists have been forced to work remotely. Another 1,518 scientists have volunteered for combat duty. The cost of restoring Ukraine's public research infrastructure has been estimated at US$ 1,2637 billion" (Analysis of war damage, 2024). The research adds that: „In parallel, the number of contracts concluded with domestic and foreign business partners has fallen sharply, further diminishing the income of scientific institutions. Opportunities for joint research and technical projects have been curbed by the migration of scientists. These factors have led to a drop in scientific productivity at both national and international levels" (Ibid).

That said, the significance of a well-functioning infrastructure in science education is self-evident, a proof of which we see when we look upon it from an international purview. Hence, a survey conducted by the OECD in 2019 proved that there is a relationship between the quality of academic performance and how much laboratories are equipped with beneficial modern tools for scientific investigation (OECD, 2019). Therefore, countries willing to invest in modern (the one associated with cutting-edge science discoveries) scientific education infrastructure tend to yield scientifically literate

graduates and students who can solve problems. These findings underscore the point that investments from Ukraine in its science education infrastructure should be made a focus as part of broader educational reform efforts. To end the problems of science education infrastructure in our nation, a fast-acting country wide coordinated strategic and multi-pronged thinking with targeted investment in rationalization and modernization of laboratories and supply of modern scientific equipment accompanied by an effective adoption over large number of schools/teachers to 21st century science teaching methodology based on inquiry led active learning curriculum.

Digital infrastructure is another task that needs development now more than ever due the global trends of digitalized and remote based, AI assisted teaching learning. Along the same lines, specialists from the World Bank maintain that investment in digital infrastructure such as access to high-speed internet and online learning platforms is indispensable in offering quality science education to more universal cross-sections, mostly those from the rural edges (World Bank, 2020). This needs an up gradation which can be done through a nationwide revival of older modes of infrastructural as well as the introduction of some digital technologies in our curricula at all level to make the reach and effectiveness of the science education approach.

It is necessary to design an integrated and coherent roadmap with specific goals and benchmarks for each distinct stage from a nationwide (science) education infrastructure development; such requires thinking in the long run. Regarding this Tetyana Kravchenko argues that prospering of any infrastructure development initiative relies on competent and visionary governance. In particular, in order to cover both short-term and long-term objectives, policymakers will need to work closely with educators, industry partners, and international organizations to bring about a comprehensive strategy of civic education development (Kravchenko T., 2020, p. 15).

In this context, we could turn to an example from Finland where a country quite reputed for their standard of education have ensured that they invest heavily in creating world-class science education facilities. Accordingly, the explanation behind high performance in schools, such as those ranked at the top of PISA (Program for International Student Assessment) books in science education is the students access to unfailing and well-planned infrastructures that enable them use 21st century technology resources and learning materials designed to promote creativity and group work (Kuzmenko A. and others, 2022, p. 179–180). This means that our educational leaders across this country can gain valuable insights

from these international models that can inform their own efforts to develop infrastructure. If these successful schemes would be introduced to the local context with a goal of developing an infrastructure for quality science education in Ukraine, and building up as socially responsible social actor capable to battle against sociocultural, economic and ecological challenges of modern world then it has no right for failure.

Certainly, the establishment of a science education infrastructure in Ukraine is a vital function and an essential element of broader national reforms aimed at long-term large-scale reform through the upgrading of its educational system. To accomplish the above and for Ukraine to establish itself as a center of excellence in science mathematics, our study projects that there exist major hurdles that must be overcome (inadequate facilities, material resources plus systemic issues) The creation of a nationwide approach to improve science education requires efficient strategic investments, leadership effectiveness alongside international cooperation for Ukraine, coupled with an upgraded infrastructure aimed at preparing students readying them not just serve national needs but also the global community (Ibidem, p. 177). Such an effort will necessarily demand a joint and long-standing engagement of the policy-making authorities, educators and the society as a whole, while bringing durable dividends to the educational realm in Ukraine.

Creation of Advisory, Expert Bodies and Institutions in the Field of Science Education

Advisory and expert bodies are key drivers in science education policy formulation, curriculum design that led subsequently to the quality of educational programs. The institutions, whether independent or government--affiliated, offer the necessary talents and oversight to assist in this ongoing process of improvement of science education in Ukraine. The existence and progression of these bodies are crucially needed to make sure that educational practices match national priorities and develop in accordance with global trends.

The success of science education reform depends to a great extent on the quality of advice and special expertise that specialized bodies provide. They serve as a conduit between research and practice, so that educational policies draw on the most up-to-date scientific and pedagogical advances. According to a number of researchers what significantly slows down this progress is that: „Even today, despite the best efforts of the Ukrainian government and legislators, there is a clear divide between the educational

work of universities, where professors and lecturers teach and train specialists, and scientific institutes focused on the realization of research" (Zinchenko V. and others, 2022, p. 230). This highlights the crucial role advisory groups play in transforming research into practical guidelines to enhance science education instruction.

Hence, we are witnessing a trend whereby the advisory and expert bodies in the field of science education are presently undergoing a transformation in Ukraine. Moreover, during the past decade, a number of such institutions have been established with the purpose of advising and assisting with a nationwide educational reform. It should be noted that these bodies are generally both independent and government-affiliated institutions with their own frameworks based on various forms of affiliation and partnership. At the same time, additional development is still required for these bodies to be able to cope with the problems of science education in Ukraine.

The impact of the national science education advisory institutions when making policy suggestions reveals the critical need for a substantial advisory system to help steer strong national educational strategies. According to an analysis conducted by OECD, advisory and expert bodies are fundamental components of a transparent society, which is crucial for effective governance in the field of education. Another added benefit of the activity these organizations conduct is that they provide a forum for sharing ideas on how to address challenges, devising fresh approaches, and tracking progress. Accordingly, the European Commission has a number of experts who help shape science education policies in member states. These networks connect researchers, implementers and policy makers to share, discuss and direct and improve their practices in order to develop successful education policies (OECD, 2019).

While the issue of scientifically informed policies is a multipronged one, all agree that to be efficacious institutions require capacity building, which is not just about training specialists, but also, it's creating a space for innovative ideas to move from research into the policy This highlights the importance of establishing agencies as a supportive environment for effective advisory bodies. This entails cultivating closer ties with universities, research and international governmental organizations. By encouraging these connections, advisory bodies can help make sure their recommendations are based on science and a broad pool of proven experience from around the world (Sieriakova I. and Kokoza G., 2019, p. 39). This means making clear decisions and giving advice based on firm industry knowledge and good evidence. Additionally, transparency means keeping the public informed about the work and recommendations of these bodies regularly to help build public faith and support for science education reforms. Consequently, the

authors are convinced that the establishment of advisory and expert bodies for science education is an important area of broader educational reform for Ukraine. These institutions are critical to creating policies, forming the development of modern, efficient, student-oriented curricula while inculcating and validating successful science education practices. Hence, if capacity building, collaboration and accountability could be achieved, the broader system of intragovernmental counseling would be capable of greater effectiveness and transparency. In particular, the improvement of these advisory institutions will enable science education system in Ukraine to respond efficiently to national and global challenges. As a result, the findings and recommendations of these agencies will be critical for future innovation and overall enhancement of Ukraine's educational landscape on the global scene.

Conclusions

The findings of this study highlight the importance of science education in promoting scientific literacy, responsible citizenship philosophy and critical thinking in the Ukrainian society. In order to be successful, the project of the nationwide science education in Ukraine should be holistic, including policy-making initiatives, infrastructure improvement and modernized teacher (re)training programs. Incorporating these competencies into the curriculum would create a generation capable of supporting economic growth and democratic consolidation in Ukraine. This emphasis is grounded in the philosophy of responsible citizenship that emerges from a family of interrelated doctrines, namely rationalism, pragmatism, and communitarianism, all of which conceptually underpin and drive the proposed reform of science education in Ukraine.

In this context modernization of pedagogical education is vitally important since it provides teachers with tools that can help develop the research and social competencies of students. Our teachers serve as the primary agents of change within the educational system and must therefore be skilled in inquiry-based learning strategies to cultivate research awareness in their classrooms. This method is consistent with the shift toward 21st century learning: student-centered, activity, problem-based and critical thinking, active and interactive learning, all of which have gained global recognition and support. In light of this, suggestions for Ukrainian educators extend to the use of pedagogical approaches that not only transmit knowledge but develop socially-minded students engaged in knowledge-building and ethical application of their scientifically-informed worldview.

At the same time, there is a need for a philosophical reflection as how we can arrive at carefully developed, adaptive national policies to support science education. To make certain that science education is sustainable and contextually meaningful, policies will need to align with global standards and evidence-based research. To this end we suggest that the strategic development of these policies should reinforce cultivation of critical thinking and scientific literacy, empowering and enabling citizens to confront complex urgent issues linked to climate change, technological breakthroughs or public health challenges.

Another aspect in need of drastic stimulation with the Ukrainian educational landscape is science education infrastructure. As indicated by our philosophical analysis, a number of critical challenges presently stall the development of this area: old-fashioned instrumentation, insufficient laboratory areas and lack of national and institutional investment in the scientific infrastructure. Filling these gaps requires a comprehensive program that involves making targeted investment in infrastructure, modernizing pedagogical methods and implementing technology to increase access to quality education, especially in rural or underprivileged communities. Interactive science education classes along with digital-literacy infrastructure in science education would provide vital widespread access to the concepts of applied inquiry, which are indispensable for scientifically educated citizenry.

Achieving this, both from a conceptual and a practical standpoint, will necessitate the establishment of advisory and expert bodies that will provide the right guidance to ensure further progress in science education. Whether they are established as independent institutions or a part of the government, such offices should have central planning roles in national policy-making and guide curriculum development to make programs relevant and to maintain quality. Many of these bodies are only as good as the degree to which they operate independently, impartially and in line with evidence--based guidance. Facilitating cooperation between advisory mechanisms, institutions of higher education and international organizations will provide Ukraine with an unprecedented opportunity for access to the world's leading experience and best practices which can stimulate innovation and bring quality to its science education system.

Rationalistic, pragmatic, and communitarian principles that have long characterized philosophical perspectives on science education with a view toward facilitating civic ethical development and socio-political engagement. The broader framework of such education system should go beyond transmitting scientific knowledge by fostering values, attitudes, and actions associated with responsible citizenship. Developing this system would

strengthen not only the capacity of our national education system to meet the students´ needs in a rapidly changing world, but would also create the interdisciplinary opportunities for learning that are central to the broader goals like economic development, social cohesion and global engagement that can only be achieved through implementing a nationwide science education curriculum that develops rational, resilient and innovative citizens who can grapple with and hopefully solve the pressing problems of our century.

BIBLIOGRAPHY

Analysis of war damage to the Ukrainian science sector and its consequences, 2024, UNESCO, https://unesdoc.unesco.org/ark:/48223/pf0000388803 (25.04.2024).

Boichenko Vytaliy, 2021, *Current trends in STEM education development in Ukraine*, Innovative Solutions, Modern Science, 2(46), pp. 87–97, https://doi.org/10.26886/2414-634X.2(46), (7.2021).

Dovgyi Stalislav, Topuzov Oleh, Halchenko Maksym., Matusevych Tetyana, Revin Frol, 2022, *Science-driven education as a precondition for the formation of the competitive Ukrainian economy*, Financial and Credit Activity: Problems of Theory and Practice, 1(42), pp 474–483, https://doi.org/10.55643/fcaptp.1.42.2022.3683.

Hladchenko Myroslava, Dobbins Michael, Jungblut Jens, 2020, *Exploring Change and Stability in Ukrainian Higher Education and Research: A Historical Analysis through Multiple Critical Junctures*, Higher Education Policy, 33, pp. 111–133, https://doi.org/10.1057/s41307-018-0105-9.

Dewey John, 2011, *Democracy and education*, Simon & Brown.

Hattie John, 2009, *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*, Routledge, https://doi.org/10.4324/9780203887332.

Kahanec Martin, Leu-Severynenko Snizhana, Novosad Anna, Stadnyi Yegor, 2023, *Rebuilding education for stronger and smarter Ukraine*, https://cepr.org/voxeu/columns/rebuilding-education-smarter-and-stronger-ukraine (24.01.2024).

Kravchenko Tetyana, 2020, *Civic education as essential pre-requisite for human existence in law-governed society: the British case study*, Young Scientist, 11(87), pp. 379-383. https://doi.org/10.32839/2304-5809/2020-11-87-82.

Kuzmenko Anastasiia, Matviienko Liudmyla, Kanova Lyudmyla, Burenko Maryna, Bukliv Roksolyana, 2022, *Development of Ukrainian education and science in the context of global challenges and military aggression: results, problems, prospects*, Amazonia Investiga, 11(58), pp. 177–185, https://doi.org/10.34069/AI/2022.58.10.19.

Lehning Perry, 2001, *European citizenship: towards a European identity?* Law and philosophy, 20(3), pp. 239–282. https://doi.org/10.1023/A:1010681009751.

Nussbaum Martha, 2010, *Not for profit: Why democracy needs the humanities*, Princeton University Press.

OECD, 2018, *The power of education policy: Insights from OECD countries*, OECD Publishing, https://doi.org/10.1787/9789264281127-en (19.01.2024).

OECD, 2019, *Science education for the future: Insights from PISA*, OECD Publishing, https://doi.org/10.1787/9789264313828-en (12.02.2024).

Sahlberg Pasi, 2011, *Finnish lessons: What can the world learn from educational change in Finland?* Teachers College Press.

Science education for responsible citizenship. Report to the European Commission of the expert group on science education, 2015, https://op.europa.eu/en/publication-detail/-/publication/a1d14fa0-8dbe-11e5-b8b7-01aa75ed71a1 (16.03.2024).

Sieriakova Iryna, Kokoza Ganna, 2019, *Civic education in Ukraine: a qualitative study of students' experiences of civic engagement (on the example of Kyiv National Linguistic University)*, Advanced Education, 6(13), pp. 36–43, https://doi.org/10.20535/2410-8286.157613.

Stolz Steven, 2019, *Alasdair MacIntyre, Rationality and Education*. Springer Cham.

Velleman J. David, 2005, *A Brief Introduction to Kantian Ethics*, in: *Self to Self: Selected Essays*, Cambridge University Press, pp. 16–44.

Vieira Rui Marques, Celina Tenreiro-Vieira, 2014, *Fostering Scientific Literacy and Critical Thinking in Elementary Science Education*, International Journal of Science and Mathematics Education, 14(4), pp. 659–680, https://doi.org/10.1007/s10763-014-9605-2.

Wiliam, Dylan, 2011, *Embedded formative assessment*, Solution Tree Press.

World Bank, 2020, *The digital imperative: Education and technology in the 21st century*, World Bank Publishing.

Zinchenko Viktoriia, Kaidanovska, Olena, Boyko Angela Potikha Oksana, Chaika, Svitlana, 2022, *Education and science of Ukraine in the realities of large-scale military aggression and global challenges of the 21st century*, Revista Eduweb, 16(2), pp. 223–233, https://doi.org/10.46502/issn.1856-7576/2022.16.02.16.