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The state of scientific education in ukraine and the readiness to implement its practices in secondary schools and extracurricular institutions: 2023–2024. Educational Monitoring Results

Стан наукової освіти в Україні та готовність до впровадження її практик у загальноосвітніх школах та позашкільних закладах: 2023–2024. Результати освітнього моніторингу

Scientific education is crucial in today's world, where science and technology are fundamental to the advancement of society. A significant contribution to enhancing the integration of scientific education into the general and extracurricular education systems in Ukraine is made by the Institute of Gifted Child, which is a part of the National Academy of Educational Sciences. The Institute promotes the development of specialised science-oriented education, which was defined in the new law *On Education* as one of the four types (along with artistic, athletic and military) of specialised education [1], which may be gained in the framework of formal, non-formal, and informal education, and aim at acquiring competences in the respective field of professional activity during education in a continuous integrated educational process at several or all levels of education and requires early identification and development of individual aptitudes.

Despite the pedagogical field's inherent conservatism, Ukraine has been making unprecedented efforts to modernize and reform its educational system in recent years in response to new social, environmental, and military challenges. Ukraine's integration into the European community is accelerating the transformations in education driven by the development of new standards, educational models, curriculum design approaches, and pedagogical practice innovations. One of the catalysts for change is the growing emphasis in school education on preparing students for life in an uncertain global environment and the rapidly changing job market. STEM education in Ukraine has expanded rapidly in recent years. Official documents define this concept as a system of natural sciences and mathematical education aimed at developing a personality through the formation of competences, a natural science perspective on the world, worldview, and life values [11].

The monitoring of the state of scientific education implementation in the country was done as part of the research project titled "Methodological Basis for Implementation of Specialized Science-Oriented Education Models in General Secondary and Extracurricular Education Institutions" (State registration number 0123U100272). The monitoring included an examination of existing educational models and standards, an investigation of the needs and challenges encountered by students and teachers, and an assessment of the potential for incorporating innovative approaches into the educational process. The active development of scientific education is viewed as a strategic priority for the formation of young people capable of critical thinking and the creation of cutting-edge technologies, which is critical for national

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security and economic progress, particularly in light of the military threats and hybrid challenges that Ukraine has faced as a result of war.

Thus, ensuring high-quality scientific education is crucial for empowering the younger generation to effectively address the complex challenges of the future, promote the country's scientific development, and strengthen its defence capabilities. In this context, monitoring and improving educational strategies in the field of scientific education are becoming key tasks for many educational institutions in Ukraine.

1. METHODOLOGY OF EDUCATIONAL MONITORING

The primary goal of the educational monitoring is to assess the state of implementation of scientific education principles, models, forms, and methods in Ukraine, as well as to identify opportunities for the development of educational innovations in general secondary and extracurricular institutions while taking into account current challenges and societal needs.

Educational monitoring objectives:

1. Analysing regulatory framework. Review legislative and regulatory acts governing scientific education in Ukraine, including instruments on specialised science-oriented education.

2. Analysing research data. Review the achievements of domestic scholars in formulating the theory and methodology of scientific education.

3. Analysing instructional materials. Review the curricula, programs and methodologies used in Ukrainian educational institutions, focusing on the application of scientific education practices.

4. Analysing the achievements of major research and educational institutions influencing, practising, and implementing scientific education. Explore the role of such institutions in overcoming the difficulties and challenges faced by scientific education in Ukraine, particularly in the context of a full-scale invasion and hybrid war.

5. Analysing the state and preparedness of teachers to implement scientific education practices. Conduct surveys among educational stakeholders and interviews with experts in scientific education to evaluate the quality of implementation of scientific education, availability of instructional resources and effectiveness of applied methodologies.

6. Developing recommendations. Formulate practical recommendations for improving scientific education in Ukraine, including proposals related to innovative educational models and teaching techniques that will help prepare young people for solving modern research and technological tasks.

Methods of educational monitoring. Various methods have been applied to monitor the state of scientific education, namely:

1. Questionnaire surveys. Three online surveys of educators were conducted to evaluate their views on the relevance of scientific education for modern educational institutions, the state of implementation of research/inquiry-based learning, the effectiveness of teaching techniques, opportunities and motivation to adopt innovations, etc. The first two surveys included lecturers, teachers, researchers and students who participated in the roundtable, "Prospective Educational Models of Specialised Science-Oriented Education" (September 20, 2024, Kyiv), and the research and practice conference, "Innovative Practices of Scientific Education" (December 6-12, 2024, Kyiv). The third online survey was conducted among the teachers of secondary schools in Ukraine.

2. Analysing official educational documents. An examination of laws, decrees, orders, standards, curricula, model programs, instructional aids, resource books, and other documents was conducted to assess the incorporation of scientific education content, forms, and methods in official documents governing education.

3. Analysing scholarly publications, reports and research in the field of scientific education. The development of scientific education issues in the research and educational

discourse was analysed.

4. Interviews. Structured interviews were conducted with leading experts in scientific education to gain a deeper insight into the challenges and prospects in the field. A focus group was held with teachers and administrators of general and extracurricular institutions within the framework of the research and practice conference, "Innovative Practices of Scientific Education" (December 6-12, 2024, Kyiv).

5. Monitoring in real-life settings. Educational institutions were visited to monitor the educational process, on-site use of technology, instructional techniques, and interaction between participants in the educational process. This also included observations of research experiments, hands-on activities, project defence, etc.

6. Analysing test and assessment results. The results of the PISA testing, participation in research competitions and olympiads to assess the level of knowledge and competences of pupils and students were studied.

7. Case study. Specific examples of successful practices and challenging situations in scientific education were thoroughly examined to identify effective strategies and approaches. The experience of the UNESCO Centre, the Junior Academy of Sciences of Ukraine, was studied, including the operation of the science museums.

Through the combination of these methods, a comprehensive picture of the state of scientific education in general secondary and extracurricular institutions was obtained, strengths and weaknesses were identified, and recommendations for the improvement thereof were developed.

2. THE NATIONAL THEORETICAL, REGULATORY, EDUCATIONAL AND METHODOLOGICAL FRAMEWORK OF SCIENTIFIC EDUCATION AND PISA FINDINGS: ANALYSIS RESULTS

2.1. Conceptual framework for scientific education

The term "scientific education" was coined in the last decade by scholars from the Institute of Gifted Child (part of the National Academy of Educational Sciences of Ukraine) and the Research Department of the National Centre "Junior Academy of Sciences of Ukraine." This term arose as a result of reevaluating current international educational approaches, adapting best academic practices from other countries, and fusing them with national traditions of research and inventive education, as well as the education of intellectually gifted students. The following Ukrainian scholars contributed to the development of scientific education as a new paradigm: S. Dovgyi, N. Polikhun, I. Slipukhina, I. Voloshchuk, V. Meleshko, S. Babiichuk, Y. Hotsuliak, M. Halchenko, M. Milenina, O. Stryzhak, I. Savchenko, I. Chernetskyi and others. The Institute of Gifted Child of the National Academy of Educational Sciences of Ukraine has created a Glossary on Scientific Education [2], which offers definitions of concepts in this research and terminology field. The Glossary covers more than 250 terms reflecting various aspects of scientific education: its definitions, history, forms and methods, principles and standards, global and national trends, achievements and prospects.

The study of various aspects of scientific education has led to their generalisation and unification around a common core: the application of scientific methods and research (exploratory, inventive, design, and innovative) activities in the educational process.

Thus, scientific education is defined as follows: 1) an educational paradigm whose implementation is necessary to develop in students the ability to apply the scientific method of cognition in learning and daily life, as well as their intellectual capacities and cultivate in students a set of mental properties essential for their future careers and living in a dynamic and unpredictable society, which also provides for the engagement of students in resolving manageably complex educational and real-world research tasks and to form a foundational understanding of research activities [2]; 2) a set of modern educational approaches which are based on the body of scientific knowledge and introduce research elements into the

educational process and promote such practices; which are implemented through disciplinary or interdisciplinary (also trans-, inter-, multi-, etc.) lines of education of different types, forms and levels of education; and which are aimed at developing skills for solving both personal and global problems. Scientific education has a multi-level goal: at the basic level, it is the development of scientific literacy and global citizenship, and at the advanced level, it is the cultivation of scientific thinking, research creativity, and competence [3].

In general, the word “scientific” is used in relation to education to emphasise a special approach or the particularity of the educational content. Here are some aspects that may explain why using the term “scientific” with education may be justified in certain contexts: focus on the educational content related to scientific subjects; emphasis on a particular methodological approach, such as the use of experimental and quantitative methods typical for scientific disciplines, highlighting the importance of evidence-based data, objectivity and systematic analysis; this term is indicative of the educational programs preparing students for academic or research careers, for example, at universities or research centres; emphasis on learning objectives related to the development of critical thinking, analytical and R&D skills. It is essential to understand that while education generally seeks to develop knowledge and skills, it does not always employ scientific methods or focus on scientific knowledge in the narrow sense of the term. Thus, the qualifier “scientific” helps emphasise specific aspects of the educational process or content.

Therefore, the term “scientific education” reflects the essence of the combined educational areas and contributes to a holistic picture of the development of scientific knowledge and skills in different contexts. This supports the idea of an integrated approach to education, where science is the basis for addressing real-world problems and developing society.

Scientific education can be viewed through its many aspects, directions and dimensions. In our opinion, these may include:

Natural, environmental, and mathematical education as separate subject areas that both develop a basic understanding of scientific principles and laws of the Universe and are relevant and in demand for practical implementation in overcoming modern challenges.

Interdisciplinary STEM/STEAM education that integrates science, technology, engineering, art and mathematics to address complex issues, going beyond traditional disciplines and stimulating innovative thinking.

Research and inventive education at all levels of education, starting with preschool, aimed at self-directed learning, practical application of knowledge, and development of critical and innovative thinking.

Specialised science-oriented education (refers to secondary education), which is provided by scientific lyceums and boarding lyceums and is aimed at engaging and preparing students for research and engineering activities [4], where the focus is on deep immersion in specific scientific fields.

Extracurricular education with a focus on research and experimentation, particularly in the system of the Junior Academy of Sciences of Ukraine, which places emphasis on research and invention projects of talented youth.

Education for sustainable development that integrates the principles of environmental awareness, sustainability and responsibility into all aspects of teaching and learning, emphasising the importance of scientific knowledge for addressing global issues.

Educational programs at the highest levels of training – master’s, postgraduate and doctoral programs, including the “nature of science" and “methods of scientific research” courses that expand understanding of scientific methods, history and philosophy of science.

It is also important to note that in the modern world, the latest technologies play a key role in scientific education and are its integral part. Innovative technologies, such as artificial intelligence and big data, open up new opportunities for learning and research and contribute

to finding sustainable solutions for global challenges.

The following scholars, among others, have studied various aspects of scientific education in Ukraine: N. Dzhura, L. Prysiazhniuk (environmental and natural education of preschool children), N. Anatska (characteristics of environmental education), O. Fonariuk (non-formal mathematical education), O. Onopriienko (mathematical competence), S. Semenets (developmental mathematical education), O.Kuzmenko, O. Strizhak, I. Slipukhina, N. Polikhun, I. Chernetskyi, N. Honcharova (the essence and content of STEM education), N. Morze, O. Strutynska, M. Umryk, T. Kramarenko, O. Pylypenko (educational robotics as a component of STEM education), K. Postova, H. Onopchenko, O. Haliuka, S. Antoniak, A. Ovchatova (implementation of STEM education in Ukraine), S. Babiichuk, H. Kuzmenko, H. Sakunova, I. Moroz (foreign experience of STEM education), O. Oleksiuk (STEM education in primary school), O. Hrebiuk, I. Shafran, N. Polikhun, O. Riezina (research-based learning), O. Skolota, V. Chubar, A. Ivanchuk, A. Solohub (inventive learning), N. Polikhun, I. Slipukhina, I. Chernetskyi, I. Voloshchuk (specialised science-oriented education), M. Halchenko, D. Svyrydenko (philosophy of science and scientific education), S. Dovgyi, V. Bykov, I. Savchenko, L. Kovbasenko (science education in the system of the Junior Academy of Sciences of Ukraine), O. Vysotska, I. Koreneva, N. Pustovit, O. Khmelevska, O. Pometun (education for sustainable development), V. Medvid, Yu. Danko, I. Koblianska, R. Brukhanskyi, I. Voloshchuk, V. Madzigon, O. Dziubliuk, Ya. Chaikovskyi (methodology of scientific research) and others.

2.2. Regulatory and legal framework of scientific education

According to our observations, the regulatory framework for science education is currently under development. Historically, the processes of education reform that led to the development of a new educational paradigm in Ukraine received a boost in 2016 as a result of the establishment of the New Ukrainian School Concept (hereinafter referred to as NUS) [5], which paved the way for child-centred pedagogy, critical thinking development, and responsible citizenship. For the first time in the education system's history, the principle of partnership – where students participate in the educational process alongside teachers and parents – is used as its foundation. This approach reflects the democratisation of the educational process, where all participants are considered active and equal partners. The partnership principle emphasises the importance of engaging students in decision-making about their learning and school life. This promotes responsibility, autonomy and motivation among students as they feel that their voice matters. Students take a more active role in learning, school life and other aspects of their education. This principle also reflects the idea of constructivism, which claims that knowledge is best absorbed when students are actively engaged in learning and when they experiment, explore and question. Students are no longer just consumers of educational services; they become active participants who acquire educational experience together with their teachers. This approach also promotes better understanding between students, teachers, and parents as they work together as co-participants in the educational process, which helps improve learning and supports mutual respect in the educational environment. This approach is also characteristic of science education, which is based on the curiosity and identity of the child.

In 2018, the government approved the new "State Standard of Primary Education" [6], and in 2020, the "State Standard of Basic Secondary Education" [7], which set the requirements for mandatory learning outcomes and competences of students, the total academic load in the basic curriculum, and the state certification form. These documents are crucial to implementing the NUS Concept and advancing scientific education because they promote project-based learning, research-based learning, group projects, and other strategies that encourage students' engagement in the cognitive process.

A new law, "On Education", was approved in 2017 [1], which defines new types of

education for Ukraine – non-formal and informal. Non-formal and informal education are important components of the scientific education system, as they help expand and deepen scientific knowledge and skills beyond traditional academic structures. Non-formal education includes organised learning activities that take place outside of formal educational institutions. It has a particular structure but is less rigid and more flexible than formal education. It can contribute to scientific education through science clubs and circles, museums and science centres, science fairs and festivals, etc. Informal education takes place spontaneously and often has no pre-organised structure. It can be self-education or learning through everyday experience. This type of education is also highly relevant to scientific education, as it involves independent research using literature, online resources, videos and other materials to expand one's knowledge and understanding of science; everyday experiences and observations that can lead to scientific insights and conclusions and enhance understanding of scientific principles; Internet forums and online communities that can contribute to deeper engagement with scientific issues and knowledge sharing. Both non-formal and informal education enable individuals to discover and cultivate their research interests in a less structured but often more motivating context. These types of education foster lifelong learning and can lay the groundwork for developing critical thinking and pursuing research and innovation. Thus, they play a key role in the continuous building of a flexible and adaptive research community.

An equally important step in the law "On Education" [1] was the introduction of "specialised education", particularly one of its areas – "science-oriented education", which is obtained at two levels: 1) basic science-oriented education is obtained at specialised institutions alongside with basic secondary education and involves gaining initial competences for research, experimental, engineering, inventive and innovative activities; 2) field-specific science-oriented education is obtained at specialised institutions alongside with complete general secondary education and aims at continuing education at further levels of education. In 2019, the Regulation on Scientific Lyceums was adopted [8], which defines the basic principles of scientific lyceums operation regardless of their form of ownership and subordination. These initiatives marked the establishment of a whole system of specialised educational institutions – scientific lyceums and boarding lyceums - that provide in-depth training for intellectually gifted students in the sciences and should create conditions for engaging students in research and engineering activities. This creates an environment where gifted students can unlock their full potential. These institutions transform into places where students meet like-minded people and mentors who support their interest in science and help them develop their research projects. Article 26 of the Law of Ukraine, "On Research and Scientific and Technical Activities", regulates students' engagement in research and engineering activities" [4]. The next step in this direction was the creation of the Standard of Specialised Science-Oriented Education [9], which regulates the research activities of students from grades 5 to 11 (12) in the natural sciences, social sciences, humanities, and technical and technological profiles. The development and implementation of this Standard are important milestones in the formalisation of scientific education, as they set clear criteria and benchmarks for research activities in formal education settings. This ensures quality training that is consistent with the modern requirements of scientific work and makes graduates competitive at the national and international levels. Alongside these processes in general secondary education, important changes took place in extracurricular education of research and experimental type. In 2017, the activities of the National Centre "Junior Academy of Sciences of Ukraine" (JAS) received international recognition and the organisation was granted the status of a UNESCO Category II Centre for Science Education; next year, in 2018, it also became a part of the Copernicus Academy – an international network of 37 countries aimed at promoting the European Union's Earth Observation Programme [10]. These statuses

emphasise the high level of research and education activities of the JAS system and recognise its contribution to the development of scientific education at the international level. This helps to improve the image of Ukraine in the field of education and science. Cooperation with these reputable organisations provides access to international expertise and best educational practices, including sharing knowledge, teaching methods, curricula and resources. The Copernicus Academy status provides Ukrainian students and researchers with access to data from 29 European satellites and enables them to participate in international events in the field of remote sensing of the Earth. This promotes the quality of scientific education, expands opportunities for students and teachers, and strengthens international cooperation in science and education.

In 2020, the government adopted the Concept for the Development of STEM Education until 2027 [11] and the Action Plan for the Implementation of the Concept for the Development of Natural and Mathematical Education (STEM-Education) until 2027 [12], which united the efforts of all government organisations involved in STEM-education in Ukraine and that can contribute to its development. The adoption of the Concept and the Action Plan are significant steps forward for Ukraine's educational system. The focus on natural sciences and mathematics (STEM) reflects the government's strategic vision of preparing young people for the challenges of the modern technological and innovative world. Implementing this concept can significantly transform Ukraine's education system, making it more adapted to the needs of the contemporary labour market, capable of generating innovations, and ensuring the country's sustainable development in the long run. We can also mention here the Law of Ukraine "On Innovative Activity", which defines the legal, economic and organisational framework for the state regulation of innovative activity in Ukraine, sets out the forms of state incentives for innovations and is aimed at supporting the development of the Ukrainian economy through innovation.

2.3. Educational and methodological framework of scientific education

The Ministry of Education and Science of Ukraine enforces state policy in education and science, developing and implementing national education standards, including for STEM subjects. It also actively works on modernising curricula, introducing the most up-to-date techniques and teaching methods, and upskilling teachers.

The New Ukrainian School (NUS) Concept is a large-scale reform of the general secondary education in Ukraine, implemented by the Ministry of Education and Science in cooperation with the NGO Smart Osvita, aimed at creating a modern, innovative and inclusive educational system that is in line with the needs of society and the challenges of the time. The main aspects of this reform can be summarised as follows [13]: 1) The NUS aims to develop key competences such as critical thinking, problem-solving, creativity, teamwork and communication; 2) It also focuses on developing civic and social competences, environmental awareness and a healthy lifestyle; 3) Implementing interactive instructional methods, project work, and integrated learning; 4) Applying information and communication technologies in the educational process; 5) Revising and updating curricula, textbooks and materials in line with modern standards and introducing new subjects and courses that meet the needs of modern society; 6) Creating conditions for the education of children with special educational needs in secondary schools; 7) Continuous professional development of teachers through training sessions, workshops, online courses, and the adoption of new approaches to teaching; 8) Transitioning from the traditional to formative assessment, which is aimed at supporting students' development, using different assessment methods to obtain a comprehensive picture of student performance. The implementation of the NUS was launched in 2018 in the first grades and is planned to unfold and gradually cover all levels of general secondary education.

As part of the NUS, research-based instructional methods, including the Inquiry-Based Learning (IBL) approach, are being implemented. The main idea of IBL is that students

independently search for answers to questions, solve problems and conduct research, which encourages their activity and development of critical thinking. Teachers are provided with methodological guidelines for implementing research-based learning. These guidelines include instructions and examples on organising the educational process based on research and student inquiries. The new curricula for the NUS include IBL components that promote the integration of research approaches into various subjects. For example, in natural sciences, students learn phenomena and processes through experiments and projects. Training sessions and workshops are organised for educators on how to use IBL effectively in their classes. This includes using open-ended questions, research projects and other activities designed to encourage students to pursue independent research.

STEM education is an integral part of the NUS concept and plays a vital role in its implementation. The integration of STEM into the NUS aims to develop the key student competences required for successful adaptation to modern society and the labour market. This approach accentuates the importance of interdisciplinary learning, allowing students to apply knowledge from different subjects to solve practical tasks and real-world problems. An important component of STEM education within the NUS Concept is the application of cutting-edge technologies and digital tools that help make learning more interactive and engaging. These include computer modelling, programming, robotics, and other technological innovations. Students learn to use these tools to complete tasks and create their own projects and research. Teacher training is also key to integrating STEM education into the NUS. Teachers participate in special training courses and workshops, learning the latest teaching methods to integrate STEM components into the educational process effectively. This helps them better prepare students for the world's challenges today and encourage their engagement in research.

In general, STEM education under the NUS aims to create an educational environment conducive to research, experimentation and creativity, developing the student skills necessary for successful life in a modern technological society. This approach also promotes innovative thinking and entrepreneurial skills – essential for students' personal and professional development.

The state reforms of the Ministry of Education and Science of Ukraine are implemented jointly with certain state research and education organisations, which are tasked with developing scientific education and creating teaching and learning materials. The development of science-oriented education is influenced by several key organisations and institutions committed to supporting and developing scientific education among young people. The leading organisations and institutions are as follows:

- The National Academy of Educational Sciences of Ukraine (NAES), which includes fifteen research institutions, conducts research in education and pedagogy and develops methodological guidelines and curricula, particularly for specialised scientific education. This line of activity is overseen by the Institute of Gifted Child and the Institute of Pedagogy. As part of its cooperation programmes with the Ministry of Education and Science, the NAES conducts research and education activities on topical issues. The institution's research and methodological findings are published in the digital library at lib.iitta.gov.ua.
- The Institute of Education Content Modernisation (IECM) is a key organisation promoting the adaptation of innovations and modern technologies in the educational process in Ukraine. The IECM develops methodological guidelines, conducts research, and supports teachers and academic institutions in integrating STEM education. The organisation actively promotes digital competences among educators and students.
- The Junior Academy of Sciences of Ukraine (JAS) is a national organisation of extracurricular education that plays a key role in promoting scientific education among young people in Ukraine. It has a network of local branches in all regions of Ukraine. The Academy's

activities aim to identify, support and develop gifted students, engage them in research and promote their further professional careers in science. The JAS is creating a network of children's science museums to popularise science and build the scientific literacy of youth. The Junior Academy of Sciences of Ukraine features a virtual STEM centre providing remote and in-person professional methodological and technological support in organising STEM education as well as scientific laboratories in various fields of knowledge. A prominent event held by the JAS under the auspices of the Ministry of Education and Science is the annual All-Ukrainian Student Research Projects Competition.

- In addition to the abovementioned, other initiatives and projects aimed at developing scientific education in Ukraine include support programmes for young scientists, research grants, and competitions for school and university students. All these initiatives seek to popularise scientific knowledge, develop research skills and engage young people in science and technology. There are several organisations dedicated to the implementation and development of STEM education:
- STEM is FEM – an initiative that aims to promote girls' engagement in science and technology through webinars and meetings with experts and mentors. The project's goal is to unite more than 500 girls interested in STEM, creating a holistic ecosystem that guides them from school to their first job in their chosen field.
- STEM Osvita Ukraine. This NGO strives to make STEM education accessible and exciting for Ukrainian school students, taking into account current challenges such as the need for teachers to have digital competencies and the uneven levels of education among children. The organisation develops projects and programmes supporting teachers and students, regardless of location or circumstances.
- Osvitoria. It is a non-profit NGO that supports implementing the STEAM approach in schools, emphasising the importance of real-world projects to motivate students and raise the image of schools by creating integrated courses and circles such as robotics and 3D modelling.

Many universities and research institutions in Ukraine offer specialised programmes for gifted young people, run scientific conferences and workshops, and provide opportunities for school students to participate in research and projects. International organisations such as UNICEF, UNESCO, and a variety of international foundations support scientific education in Ukraine through grant programmes, training sessions, projects, and initiatives. It is worth mentioning in this context the UNESCO Chair on Science Education at the M. Dragomanov Ukrainian State University (https://unesco.udu.edu.ua/), which was established in 2021 to create an integrated system of training, research, information and legislative support in the field of scientific education and talent development.

Overview of Ukraine's main results in PISA 2018–2022

Ukraine joined PISA for the first time in 2018. The results of the PISA programme showed that Ukrainian students have certain educational achievements, but there is also significant potential for improvement. In 2018, the average scores of Ukrainian students in different categories were as follows:

- Reading: 466 points.
- Mathematics: 453 points.
- Science: 469 points.

These results indicate that Ukrainian students perform below average compared to OECD countries, with average scores of around 487 for reading, 489 for mathematics and 489 for science. The PISA 2018 results showed that the level of performance in reading, mathematics and science among a significant proportion of Ukrainian 15-year-olds is insufficient, and there is a significant gap between the performance of students from different socioeconomic groups, educational institutions and locations [14].

In 2022, adolescents took the tests during the war, and the results were as follows:

- Reading: 428 points.
- Mathematics: 441 points.
- Science: 450 points.

These results are also below the OECD average. Specifically, only 58% of Ukrainian students attained the basic performance level in mathematics, while the average for OECD countries is 76%. In the current cycle, Ukraine was represented by only 18 regions; therefore, conclusions about time trends should be drawn with great caution. Given these circumstances, it appears that the performance of Ukrainian students in 2022 declined compared to the previous PISA cycle in 2018: the score in mathematics dropped by 12 points, science by 19 points, and reading by 38 points.

The recommendations that follow relate primarily to the problems identified from the PISA results, the main ones being: 1) low level of proficiency of Ukrainian 15-year-olds in mathematics, reading and science; 2) significant gender gaps in reading and mathematics; 3) significant learning losses in reading; 4) insufficient resource provision of educational institutions; 5) decline in the psychological well-being of students [15].

Key strategic solutions to improve these indicators should include enhancing proficiency in specified fields, setting clear goals for the development of the education system, reviewing curricula, tracking learning outcomes, raising the status of teachers and investing in their training, and providing support to low-performing students and schools.

Conclusions based on the analysis of the national theoretical, regulatory, educational and methodological framework of scientific education and PISA results.

The analysis of the legislative, scientific, educational and methodological frameworks in Ukrainian education shows that, since 2016, the country has taken unprecedented steps towards integration with European and Western countries. This is reflected in adopting democratic procedures aimed at bringing the post-Soviet education system to a new level of quality and consistency with modern global standards. Specifically, the adoption of the New Ukrainian School Concept, the introduction of STEM education, and the development of non-formal and informal education have become key elements of the reform, focusing on the cultivation of critical thinking, innovativeness, and the integration of interdisciplinary knowledge among students.

The introduction of new educational concepts and approaches enjoyed considerable support from international organisations such as UNESCO, contributing to high compliance with European standards. The conceptual and terminological framework has been studied and elaborated in recent years, and the first steps have been taken to develop the educational and methodological framework. The study programs have been updated with a focus on interactive and project-based learning, research practices, and application of modern technologies, which helps build student skills required to succeed in a globalised world. This includes the development of STEM competences, which is an important step in preparing students for the challenges of the 21st century.

The education reforms had a robust start but have not yet produced significant outcomes (as shown by PISA results) because systemic reforms have not yet reached the high school level. It is important to explore the causes of the existing problems and evaluate the effectiveness of the proposed measures. The PISA results have proven the urgency and appropriateness of the current education reforms in Ukraine, and they need to be continued and accelerated.

3. THE STATE OF SCIENTIFIC EDUCATION IN UKRAINE AND THE READINESS OF EDUCATORS TO IMPLEMENT ITS PRACTICES: ANALYSIS RESULTS

The findings of the survey conducted during the roundtable, "Prospective Educational Models of Specialised Science-Oriented Education" (20.09.2023, Kyiv).

As part of the event, a survey of participants was conducted, with 711 respondents representing the following levels of education: 34 % – general secondary education; 24,6 % – higher education; 11,7 % – extracurricular education; 11,1 % – vocational education; 10,4 % – primary education: 2,4 % – postgraduate education and others. The majority of respondents were experienced teachers whose experience in teaching or research and teaching was as follows: 23,4 % – more than 30 years; 28 % – more than 20 years; 26 % – more than ten years; 12,2 % – more than five years.

The survey of respondents' attitudes to research-based education, which is the basis of specialised science-oriented education, revealed the following results:

- 38,1 % of respondents have some experience (not extensive) in implementing research practices, 31,2 % have considerable experience; 16,7 % are familiar with research practices but do not have experience implementing them; and 12,5 % are experts in conducting research and teaching others.
- 62 % of respondents consider the introduction of research-based learning in general secondary education extremely important; 27,7 % see it as a necessary but complicated process; 8,4 % recognise the relevance of this task but do not consider it a priority. Some respondents mentioned the expediency of introducing research-based education only for specific student categories or high school students.
- 51,1 % of respondents believe that schools are widely but not sufficiently practising research approaches; 27,6 % are familiar with research-based learning at school; 13,6 % believe that this type of learning is fully implemented; and 3,9 % think it is completely absent. Several respondents said that teachers are not ready to implement research-based learning and that only a few enthusiastic teachers have achieved some success.

The findings of the survey conducted during the 3rd All-Ukrainian Research and Practice Conference, "Innovative Practices of Scientific Education" (6-12.12.23, Kyiv).

As part of the event, a survey of participants was conducted, which included 317 respondents representing the following levels of education: 48,8 % – general secondary education; 17,1 % – higher education; 7,3 % – extracurricular education; 14,6 % – vocational education; 7,3 % – primary education: 2,4 % – postgraduate education and others. The majority of respondents were experienced teachers whose experience in teaching or research and teaching was as follows: 41,5 % – over 30 years; 19,5 % – over 20 years; 22 % – over 10 years; 12,2 % – over five years.

The survey of respondents' views on the state of implementation of inquiry-based science education models in their educational institutions revealed that the majority of educators believe that these models are either completely absent, or are applied in isolated cases, or unsystematically (22 % each); only one-third of all respondents reported that the implementation of such models is either currently underway (14,6 %) or has already been completed and these models are already successfully applied (4,9 %). The remaining 14,6 % of respondents had no information on this.

When asked what is most important for the successful implementation of innovative scientific education practices in Ukrainian educational institutions, the teacher responses were as follows: methodological support for scientists (4,9 %), teacher motivation and upskilling (9,8 % each), and special equipment and teaching aids (17,1 %). The option "all of the above" was chosen by most respondents (58,5 %).

The findings of the survey conducted in January–April 2024 among teachers of general secondary education institutions.

The survey included 45 respondents, 91,1 % of which were female and 8,9 % were male. Most respondents were experienced teachers whose experience in teaching or research and teaching was as follows: 44,4 % – over 30 years; 24,4 % – over 20 years; 15,6 % – over ten years; 4,4 % – over five years. Natural sciences were represented by 31,2 % of the

respondents, humanities by 28,8 %, physical and mathematical sciences by 17,8 %, and other subject areas by 22,2 %.

The survey of respondents' views on the relevance of introducing research-based learning in secondary schools showed that most respondents consider it very relevant (44,4 %) and relevant (37,8 %); 15,6 % believe it is partially relevant, and 2,2 % think it is of little relevance. No respondents consider it irrelevant.

Most teachers (55,6 %) evaluate the state of research-based learning in their institutions as partially developed – there are some initiatives and programs of research-based learning, however, they are not commonly used or widely available. 24,4 % and 13,3 % of respondents believe research-based learning is well- and poorly developed in their institutions, respectively. A minimal number of respondents represents the extreme rates: very well developed and not developed at all – 2,2 % each.

Respondents evaluated their personal experience of using research-based learning methods in their teaching practice as regular 26,7 %, insignificant – 44,4 %, occasional – 15,6 %, and no experience – 13,3 %. Only 2,2 % of respondents mentioned they do not want to pursue such practices.

With regard to familiarity with the 5E instructional model of inquiry-based learning, 53,3 % of respondents are either unfamiliar (24,4 %) or slightly familiar (28,9 %); 35,6 % have a general idea but have never applied it, and only 11,1 % are well aware and have applied it in practice.

68,8 % of respondents said they were either unfamiliar (40 %) or only slightly familiar (28,8 %) with the Wynn Garlen model of inquiry-based learning, which is driven by inquiry cycles and Big Ideas. 31,1 % of respondents have a general idea of the model. None of the teachers had ever used the model in practice.

When asked about their preparedness to implement various innovative practices of research-based education in their classrooms, 51,1 % of respondents expressed their readiness with some reservations (I am ready to implement, but foresee certain obstacles, such as lack of resources or the need for additional training); 20 % reported being partially prepared yet with some doubts (I am ready to implement, but foresee some obstacles, such as lack of resources or need for additional training); 17,8 % said they were completely ready and had no obstacles; 11,1 % reported being poorly prepared (I feel unsure of my ability to implement research-based learning and anticipate numerous difficulties, such as time constraints, lack of support or resources).

When asked whether a lot of resources (teaching materials, research equipment, etc.) are needed to implement research-based learning effectively, the majority of teachers (66,6 %) believe that significant resources are needed, including "plenty" (24,4 %) and "reasonably much" (42,2 %). For 22,2 % of respondents, the necessary resources depend on the circumstances, and only 11,1 % do not consider resources to be a crucial factor, of which 6,7 % can get by with a minimum, and 4,4 % consider the methodology and approach to be more important than resources. When asked whether they feel supported by the school administrations and colleagues in implementing new pedagogical approaches, 75,6 % of respondents acknowledged full support, although 37,8 % reported occasional disagreements with the administration. 15,6 % of teachers have support, but it is not active. 8,8 % of teachers do not have such support.

Answering the question about how students perceive/are likely to perceive the use of research-based learning, 31,1 % of respondents said "very positive", and 42,2 % said "positive with some challenges"; 15,6 % believed that students would need to adapt to new approaches; 11,1 % anticipated student resistance to change.

Regarding the methods of research-based learning performance assessment, 35,6 % of respondents consider mutual assessment to be the most effective; 28,9 % – portfolios, 17,8 %

– oral presentations and discussions; 13,3 % – traditional tests and examinations; 4,4 % – observations and indirect assessment methods.

Regarding the need to receive additional training or resources for effective research-based learning, 82,2 % of teachers indicated that they needed more training or resources, of which 24,4 % stated that they require comprehensive training, 13,3 % partial training, and 4,4 % believed they are sufficiently trained.

Regarding the factors that influence the successful implementation of innovative scientific education practices in Ukrainian educational institutions, 42,2 % of respondents believe that the most influential is teacher motivation, including financial; 22,2 % place first the creation of an environment favourable to innovation at school, as well as the activity and creativity of the team; 15,6 % emphasise the importance of having high-quality educational equipment, including consumables and technologies; 11,1 % consider the availability of programmes for the development of teacher research competences to be the most important; 6,7 % place first the availability of high-quality teaching materials, and 2,2 % believe the all of the above is essential.

When asked how the war unleashed by russia affects the relevance of implementing scientific education in Ukraine, 33,3 % of respondents believe that the relevance is increasing: the war draws attention to the need for strong scientific education, especially in defence and security-related fields. The same proportion (33,3 %) thinks the relevance is changing: the war is adjusting the educational priorities, focusing on humanitarian and social aspects while emphasising the importance of scientific literacy. Some 17,8 % of respondents believe that the war is hampering implementation – although scientific education remains relevant, the war creates significant obstacles to its implementation due to the destruction of infrastructure, lack of resources and internal migration. There are 8,9 % of respondents who think that the war diverts attention and resources from education, including scientific ones, and places greater focus on immediate needs and survival issues. At the same time, 6,7 % of respondents do not see a significant impact of the war on the relevance of science education, as educational *needs remain stable.*

Findings of the focus-group survey among teachers and administrations of general and extracurricular education institutions conducted during the Research and Practice Conference, “Innovative Practices of Scientific Education” (6-12.12.23, Kyiv demonstrated that there are some powerful general secondary education institutions in the country that are acquiring the status of science lyceums and have the educational and methodological base for integrating research-based learning into curricula and some experience in implementing scientific education. An essential component of the educational process for these institutions is close cooperation with researchers from partner universities and the exploration of international experience. The main requirements for scientific lyceums include the conclusion of cooperation agreements with higher education institutions, the availability of field-specific methodology commissions and the involvement of experienced academic staff to supervise students’ research activities. High school reform is currently underway in Ukraine, which may affect the structure and functioning of science lyceums. One of the important goals is ensuring effective outcomes of students’ engagement in educational and research activities, as evidenced by the availability of patents, inventions and implemented research projects.

Conclusions from the analysis of the state and readiness of teachers to implement scientific education

The survey of teachers showed a positive attitude and diverse experiences of respondents with research-based approaches across Ukrainian educational institutions. Most respondents practice research-based instruction to some extent, however irregularly. Only a small proportion of respondents consider themselves experts in the field. Most respondents believe that implementing research-based learning in schools is essential, although they have

concerns over its complexity and the selective need for such learning. The surveys revealed that the percentage of teachers familiar with Inquiry Based Science Education (IBSE) models is low, as is the level of their application. There is a significant gap between the capabilities and the actual state of research-based learning in schools. Many teachers believe there is a lack of systemic integration of research-based instruction into the school curriculum. According to teachers, effective research-based learning requires significant resources, dedicated equipment, methodological support, teacher upskilling, and, most importantly, teacher motivation, including financial. The majority of teachers indicate that they have full support from the school administrators and students. Most respondents expressed preparedness to implement research-based practices with some reservations, such as a lack of resources or the need for additional training. The war in Ukraine is affecting the relevance and opportunities for implementing scientific education, with changes in priorities, destruction of infrastructure and internal migration. The best prepared to implement scientific education are teachers of institutions obtaining the status of "scientific lyceum" or "boarding lyceum", but they also need additional training.

The research highlights the importance of further support and advancement of research-based practices in Ukraine as an essential element of scientific education that can contribute to the development of student's critical thinking and practical skills.

4. RESULTS OF INTERVIEWS WITH EXPERTS IN SCIENTIFIC EDUCATION CONCERNING THE STATUS THEREOF IN UKRAINE

Expert 1: Dr. Halchenko Maksym, Director, Institute of Gifted Child of the National Academy of Educational Sciences of Ukraine

1. How would you describe the current general status of scientific education in Ukraine in a few sentences? What are the main achievements?

Scientific education is the term coined by the researchers of the Institute of Gifted Child of the NAES of Ukraine, which appeared as a result of the generalisation of gifted education pedagogy and inquiry-based science education to unite the idea that inquiry is at the heart of the talent development on the one hand, and reaches beyond natural sciences subjects to humanitarian and social sciences on the other. The realisation of scientific education in Ukraine is widely based on international experience and takes its natural progressive development. Conceptual Principles of Secondary School Reform "The New Ukrainian School", Standard of Specialized Science-Oriented Education, and the Concept of the Development of STEM Education till 2027 were successfully introduced on a government level.

2. What would you say about implementing research-, invention-, entrepreneurship-based and other innovative approaches and practices of scientific education in Ukrainian general secondary and extracurricular education institutions (relevance, status, trends)?

First, the initiatives mentioned above were driven by the need for Ukraine to catch up with current trends in international education. Both the Institute of Gifted Child of the National Academy of Educational Sciences of Ukraine and the Junior Academy of Sciences, and later created UNESCO Chair on Science Education, were the initiators and co-developers of the mentioned initiatives and plenty more: STEM Education Department at the Institute of Modernization of Education of the Ministry of Education and Science of Ukraine foundation; WG on implementation of STEM education in Ukraine; Action plan for implementation of STEM education in Ukraine or 2016-2020; MES Order of May 17, 2017 No. 708 "Creating and functioning of the All-Ukrainian Scientific and Methodological Virtual STEM Centre; Order of the Ministry of Education and Science of Ukraine of April 29, 2020 No. 574 "On Approval of the Model List of Teaching Means and Equipment for Classroom and STEM Laboratories"; Action plan for implementation; Concepts of development of science and mathematics education (STEM EDUCATION) by 2027. What is more, in collaboration with the stakeholders, the above institutions are active in implementing the named initiatives. Just to name a few:

1. The annotated catalogue "STEM EDUCATION: Problems and Prospects" was developed containing the list of regulatory support for the implementation and development of STEM education, a list of scientific and practical publications covering the results of theoretical and experimental studies in STEM education, catalogue of educational and methodical literature; recommended network resources to support students' research activities.

2. Numerous educational programs were developed.

3. The virtual STEM Centre of the Junior Academy of Sciences of Ukraine was created.

4. All-Ukrainian event for the Best STEM Publication was launched.

5. The competition, *The Best Gender-Sensitive STEM Lesson Online*, was launched.

6. A STEM school educational project for teachers was launched.

7. The STEM-week event is held annually within the framework of the All-Ukrainian Stem-Spring Festival to implement the Concept of STEM-Education, share the experience in the development of STEM-education directions in Ukraine and participation in April European STEM-events.

3. What are the main current challenges and problems in implementing scientific education in Ukraine? What are the possible ways to overcome them?

Ukraine's science and education sector faces common challenges as a result of russian aggression:

- Damage and destruction of the properties in Ukraine's science and education sector.
- Damage, destruction and looting of research equipment.
- Decreased number and migration of teachers, researchers and engineers.
- Reduced financing of the scientific and education institutions in Ukraine.
- Reduced number of scientific publications – one of the platforms for fostering cross-sectoral collaborations in Ukraine's economy and establishing connections with global scientific and education communities.
- Reduction of scientific and educational centres of the JAS of Ukraine, which serve as a platform for training future generations of researchers.

Apart from the challenges caused by the war, there is one major issue that needs to be solved – teacher education. This process takes time and could be achieved both by initial training and CPD.

4. What existing programmes and initiatives do you think are most effective in promoting and improving the quality of science education?

The Institute of Gifted Child of NAES of Ukraine took an active part in creating The Standard of Specialized Science-Oriented Education. The standard became a research field in STEM/ STEAM activities of the Institute of Gifted Child of NAES of Ukraine:

- 2022-2024 IGC researches and prepares recommendations for the use of STEM-education methods in specialized institutions with science-oriented education.
- Methodological recommendations for "Implementation of STEM education in the context of integration of formal and informal education» have been prepared.
- The methodological guide "STEAM-education from theory to practice" is being prepared.
- "STEAM Lessons in the ART Museum" was realized.

Institute of Gifted Child of NAES of Ukraine took an active part in creating the Concept of the Development of STEM Education till 2027 and an action plan based on the implementation of similar projects in Europe. IGC continues to focus on elaborating methodologies and conducting research on STEM/STEAM. "Scientific and methodological support for the development of creativity in the implementation of STEM/STEAM in specialised science-oriented educational institutions" will be studied by one of the departments of IGC by 2025.

5. What do you see as the main priorities and directions for the development of scientific education in Ukraine in the near future? What approaches and models are most relevant for implementation?

International cooperation, research, teacher education at all levels of education, policy-making, and the unification of efforts of academia and industry are priorities for the development of scientific education in Ukraine. IBSE, STEM/STEAM, project-based learning, problem-based learning, School-Wide Enrichment Model, etc. – the approaches with the inquiry as a focal point are core for the scientific education implementation.

6. Please share any advice on introducing scientific education in schools and extracurricular institutions.

I would rather concentrate on the bottom-up demand for positive changes in education.

Expert 2: Voloshchuk Ivan Stepanovich, Doctor of Education, Associate Professor, Head of the Department of Innovative Technologies in Gifted Education.

1. How would you describe the current general status of scientific education in Ukraine in a few sentences? What are the main achievements?

In the Ukrainian educational system, scientific education is emerging as a new paradigm. This refers to both general secondary education and the focus on implementing specialised secondary science-oriented education. The most significant achievement is the intention to open scientific lyceums and boarding schools shortly.

2. What would you say about the implementation of research-, invention-, entrepreneurship-based, and other innovative approaches and practices of scientific education in Ukrainian general secondary and extracurricular educational institutions (their relevance, status, trends)?

Any research practice used to put the scientific education paradigm into practice should be based on the scientific method of reality understanding. Inventive practices of scientific education should be based on the technical or social implementation of scientific knowledge in any form. As for entrepreneurial practices, any technical or social idea formed on the basis of the knowledge gained through the use of the scientific method of cognition of reality should find its implementation in practice. This is about relevance. There is practically nothing to say about the state of affairs. We still need to implement the above. We have no long-term practice. Consequently, no trends are visible.

3. What are the main current challenges and problems in implementing scientific education in Ukraine? What are the possible ways to overcome them?

There are two challenges: 1) creating conditions for the implementation of the scientific method of knowledge and; 2) opening proper specialised science-oriented secondary educational institutions.

4. What existing programmes and initiatives do you think are most effective in promoting and improving the quality of scientific education?

There are no state-financed programmes. Positive initiatives include opening scientific lyceums (boarding lyceums) based on the principles outlined in the Concept of Secondary Specialised Science-Oriented Education and the Regulation on Scientific Lyceums (Boarding Lyceums).

5. What do you see as the main priorities and directions for developing scientific education in Ukraine in the near future? What approaches and models are most relevant for implementation?

Widespread use of the scientific method of knowledge. Development of a rational network of secondary specialised science-oriented educational institutions.

6. Please share any advice on introducing scientific education in schools and extracurricular institutions.

To ensure that science education does not disappear before it is born, a balanced rather than voluntaristic approach to the development of curricula, training programmes, textbooks, teacher training, etc., is necessary.

Expert 3: Nataliia Polikhun – Cand. Sc. Education, Senior Researcher, Head of the Department for Giftedness Support at the Institute of Gifted Child of the National Academy of Educational Sciences of Ukraine.

1. How would you describe the current general status of scientific education in Ukraine in a few sentences? What are the main achievements?

The interest of the teaching community in the forms and methods of scientific education at school. A legislative framework is being formed with a focus on specialised science-oriented education, STEM education; a lot of research related to this area of education has been launched, the management bodies have intensified their activities, the STEM Education Department at the State-Owned Research Institution "Institute for Content Modernization" has been established and is actively working, businesses, research institutions, museums, etc. have taken initiatives.

2. What would you say about implementing research-, invention-, entrepreneurship-based and other innovative approaches and practices of scientific education in Ukrainian general secondary and extracurricular education institutions (relevance, status, trends)?

The introduction of innovative practices in scientific education is an urgent problem, but they require methodological justification, methodological support, dissemination of already tested materials with developed recommendations, etc.

3. What are the main current challenges and problems in the implementation of scientific education in Ukraine? What are the possible ways to overcome them?

One of the main problems is the theoretical and practical training of teaching staff in scientific education. Partnership, cooperation, and collaboration of educational institutions and research organisations in creating and implementing educational programmes, including for gifted children and youth, is important. Such interaction between institutions and experts should be supported by laws, etc.

4. What existing programmes and initiatives do you think are most effective in promoting and improving the quality of science education?

At the national level, these are, first of all, the initiatives of the STEM-education department, initiatives of educational research institutions, including the Institute of Gifted Child, the Institute of Pedagogy at the National Academy of Educational Sciences of Ukraine, etc., the creation of a UNESCO Chair on Science Education at the National Pedagogical Dragomanov University, the creation of the Science Museum of Science and branches thereof at the National Centre "Junior Academy of Sciences of Ukraine", initiatives of NGOs and institutions, in particular the STEM Education Coalition, etc.

5. What do you see as the main priorities and directions for developing scientific education in Ukraine shortly? What approaches and models are most relevant for implementation?

Creation of science centres in cooperation and collaboration with educational institutions, research organisations, enterprises and businesses. Expanding the network of science museums, spreading interactive scientific education programmes in any field and any content integrated with the school curriculum to other museums. At the legislative level, it is necessary to stimulate educational and scientific initiatives from universities, research institutions, museums, enterprises, businesses, etc., as well as hold mass events such as Science Festivals and demonstrate scientific achievements as interactive platforms for children and parents. It would be advisable to create educational communities to share and disseminate initiatives, new methods, teaching materials, testing scientific ideas, and update educational programmes and approaches to teacher training, professional development, etc.

6. Please share any advice on introducing scientific education in schools and extracurricular institutions.

To disseminate the Department for Giftedness Support's achievements in the field of promotion of scientific education, to join the scientific and practical activities initiated by the Institute of Gifted Child together with the NC "JASU".

Expert 4: Valerii Oleksandrovych Bykov, Acting Director of the Poltava Regional Council's municipal institution "Poltava Oblast Junior Academy of Sciences for Pupils and Youth", PhD candidate at H. S. Skovoroda Kharkiv National Pedagogical University.

1. How would you describe the current general status of scientific education in Ukraine in a few sentences? What are the main achievements?

Ukraine has a long and rich scientific tradition, and the glorious names of its outstanding scientists, inventors and pioneers are engraved in world history. Many research institutions, universities, institutes, and academies are successfully conducting research in Ukraine and are respected by the leading global scientists. In recent years, there has been a growing interest among young people in research, especially in military-related fields. At the same time, there is insufficient funding for science, and the outdated facilities and resources of many scientific institutions and educational establishments need to be reformed, modernised, and updated. The war and the occupation by russian invaders of part of Ukraine's territories have had a very negative impact on the development of scientific education. Many talented scientists are forced to work abroad, and many educational and scientific institutions have been destroyed. Among the achievements, it is worth noting particular successes in the IT sector and defence technologies (in particular, the development of marine drones and rocketry). Ukrainian scientists have made significant contributions to fields of science such as physics, mathematics, chemistry, biology, medicine, and engineering. Professor Yurii Hohotsi is currently considered one of the world's most cited modern Ukrainian scientists. Yurii Kotermak from Drohobych was one of the first world-renowned scientists awarded a Doctor of Arts and Medicine degree in Ukraine. Among the most famous scientists of the Poltava region, we would like to mention Hryhorii Skovoroda, Mykhailo Ostrohradskyi, Volodymyr Vernadskyi, Mykola Pylychykov, and Fedir Pirotskyi. Academician Borys Paton, a great friend of the Junior Academy of Sciences of Ukraine, was a scientist who was mainly concerned with promoting science among schoolchildren and young people.

2. What would you say about implementing research-, invention-, entrepreneurship-based and other innovative approaches and practices of scientific education in Ukrainian general secondary and extracurricular education institutions (relevance, status, trends)?

The relevance of introducing research-, invention-, entrepreneurship-based, and other innovative approaches and practices of scientific education in Ukrainian educational organisations, including extracurricular ones, is primarily due to the need to stimulate the formation and development of a systematic scientific and creative style of thinking, research competences, critical attitude, preparation of young people for the challenges of our time, and the need to increase competitiveness in a global context. Globally and specifically in Ukraine, the interest of high school students and their mentors in research has been growing recently. In our country, this is largely facilitated by the educational system of the Junior Academy of Sciences, which is tasked with promoting science among young people, supporting innovation and scientific progress, facilitating communication and sharing experience through intellectual competitions, tournaments, Olympiads, seminars, clubs, and other events. The primary mission of the Junior Academy of Sciences is to educate a new, patriotic generation of scientists and researchers, a new scientific elite of Ukraine, which will be able to effectively contribute to the development of national science, modern technologies and society as a whole. The latest trends include the opening of interactive science museums, mathematics museums, business incubators (Ukrainian Future), and experimental research laboratories

(ExLab) by the National Centre and regional branches of the Junior Academy of Sciences. Speaking specifically about the Poltava Regional Junior Academy of Sciences, we hold start-up days, forums ("Educating the National Elite"), festivals ("Scientific Intentions provide an opportunity to unite for a common goal"), training seminars ("Guidelines for Science Education"), workshops ("Educational Experience Platform: Scientific Journeys"), etc.

Among the priority tasks defined by the Poltava Regional Junior Academy of Sciences for the near future are as follows:

- establishment of a comprehensive scientific interactive educational space (research hub), *Poltava Oblast Academy of Sciences Experimentarium,* with modern research laboratories, science museums (mathematics, physics, biology, chemistry, art history), a make culture workshop, a research SMART greenhouse, and a photo and video studio;
- expansion of the network of branches of the Junior Academy of Sciences in Poltava Oblast;
- modernisation of the educational process in the Poltava Regional Junior Academy of Sciences and branches thereof;
- diversification of the institution's funding sources through fundraising.

3. What are the main current challenges and problems in the implementation of scientific education in Ukraine? What are the possible ways to overcome them?

It is evident that the biggest challenge in Ukraine is a terrible, destructive war. The war that takes the lives and health of the best Ukrainians, destroys economic, cultural and scientific infrastructure, and poses enormous threats to the territorial integrity and national security of Ukraine, and that exacerbates environmental, social, demographic, and other vital problems. The population decline raises the issue of merging higher education institutions to reduce their total number, improve educational services' quality, and optimise resource use. These are painful issues that are impossible to see positively, which makes people more tense in society and hinders the advancement of scientific education's ability to improve the situation.

As for the problems of implementing scientific education, I believe that a separate law is urgently needed that would more clearly regulate the structure and activities of the Junior Academy of Sciences of Ukraine, highlight the specifics of its functioning, indicate the peculiarities of approaches that differ from those of other extracurricular institutions, and provide specific theoretical justifications and practical recommendations. After all, it is clear that scientific education, and thus the activities of the Junior Academy of Sciences, are becoming critically important for the economy and the livelihoods of the population during wartime. Moreover, after the victory, the country will need to rebuild, restore, and organise security measures that prevent the recapture of the territories. Without science, without the development and implementation of new innovative technologies, progress is impossible, and without scientific achievements, recognition and respect for the country at the international level is unachievable.

4. What existing programmes and initiatives do you think are most effective in promoting and improving the quality of science education?

According to the Strategic Action Plan of the Ministry of Education and Science of Ukraine until 2027, it is logical to formulate the need to create a single Centre for Tournament, Competition and Olympiad Movement in Ukraine. Indeed, the centralised coordination and management of the JASU and Olympiad movement will systematically improve the quality of education, develop scientifically gifted youth and stimulate the competitiveness of Ukrainian education in the global context, contribute to the more effective development of the country's intellectual potential as a whole and train a new generation of experts in various fields.

Among the existing methods and approaches to the implementation of scientific education in Ukraine are attempts to apply Inquiry-Based Learning (learning based on

students' requests through research, i.e. through the process of constructing knowledge by students themselves, by formulating their questions on a particular topic and actively seeking answers to them) MriyDiy School Project (a programme of non-formal education in project management and development of flexible skills for the 21st century); Philosophy for Children programme based on Matthew Lipman's methodology; a training course on teaching the basics of economic thinking at school developed by the Bendukidze Centre; and the use of artificial intelligence as a generative tool. The most well-known and popular approach (and the one that underpins the Concept of the New Ukrainian School) is the integrated STEM (STEAM, STRAEM) approach. Currently, the STEM strategy is considered one of the key factors for achieving scientific and technological progress in Ukraine. Under this approach, Science, Technology, Engineering and Mathematics are not taught as separate subjects but are learned in a complex way through practice-oriented activities, taking into account the need to acquire competencies vital for a successful person in the 21st century. I am impressed by the broader interpretation of this approach – as STRAEM. In my opinion, the letter R in the acronym STRAEM stands for *research*. Accordingly, I consider the STRAEM approach to be one of the most effective in disseminating and improving the quality of scientific education. After all, research to solve specific problems and generate new knowledge is a crucial aspect of the Junior Academy of Sciences. I see the introduction of art in the integrated approach as the art of public speaking, the rhetoric of public discussions, the preparation of poster and presentation design with harmonious proportions, balanced colour scheme, etc.

5. What do you see as the main priorities and directions for the development of scientific education in Ukraine in the near future? What approaches and models are most relevant for implementation?

The ability to find solutions to certain problems, adapt quickly to different situations, predict and project the future, and present your projects effectively – these skills do not appear on their own. However, they are definitely developed when a child dives into the world of scientific research and finds himself or herself in the competitive environment of the JAS competitions, Olympiads, tournaments, festivals, and training courses. Therefore, I see the main priority for developing scientific education in Ukraine as improving and deepening the Junior Academy of Sciences activities, expanding the network thereof, and developing the collaboration of the JAS with higher education institutions, research and other educational institutions in Ukraine and abroad. Involvement of business companies in cooperation with the JAS departments is also a critical priority for the coming years. The Junior Academy of Sciences instils a love of scientific activity in the sensitive period of the children's bodies' development, motivates research and experimental activities, and expands the boundaries of the scientific worldview in a timely and effective manner. And when the scientific worldview expands, scientific systemic thinking appears, a vision of a holistic picture of the world with all its multiple connections, the ability to systematise and classify certain things (erudition), and assertiveness, i.e., the capacity to articulate one's viewpoint in a fair and considerate way while respecting the moral rights of fellow students; and meta-skills, which are abilities that facilitate the swift and logical assimilation of both new and pre-existing knowledge and skills, facilitate successful study, and have an impact on all aspects of our lives. And then we can talk about a new quality of education, about training a citizen of Ukraine to be an educated, responsible, proactive, entrepreneurial patriot with a civilised set of universal values.

Why the Junior Academy of Sciences? Because it operates under the auspices of UNESCO, has the status of a Copernicus Academy, and cooperates with NASA, CERN, Argonne National Laboratory, Francis Crick Institute, and others. The priorities of the Junior Academy of Sciences are to promote the values of scientific knowledge, skills and abilities of research, experimental, scientific, design, inventive and search activities among children and young people. In addition, during the war, the Junior Academy of Sciences activities help high school

students to socialise, interact, communicate, find support from peers, mentors, and scientists, receive psychological assistance, develop resilience, and determine their future professional activities.

6. Please share any advice on introducing scientific education in schools and extracurricular institutions.

It is necessary to use digital technologies in scientific education as widely as possible, join international projects, and ensure inclusiveness and gender equality. Adequate funding and a separate law on the functioning and activities of the Junior Academy of Sciences as a unifying platform for scientific education will be a new qualitative step in the formation and development of science in Ukraine.

Expert 5: Kurlova Zinaida Oleksandrivna, Deputy Director for Education and Methodology at the public extracurricular educational institution "Kyiv Junior Academy of Sciences for Student Youth". Honourable Mention in Education of Ukraine.

1. How would you describe the current general status of scientific education in Ukraine in a few sentences? What are the main achievements?

Today, science-oriented education in Ukraine is still relatively new and needs more organization. Science-oriented education is provided through the organisation of research-oriented training, the main component of which is the research activity of students. Unfortunately, distance education in recent years has had a negative impact on the development of scientific education. In addition, general secondary education institutions are not adequately provided with modern laboratory equipment for research and experiments. Opportunities for scientific research are provided by the educational institutions of the Junior Academy of Sciences of Ukraine through cooperation agreements with scientific and specialised institutions. As a result, JAS's members carry out their scientific research in laboratories accompanied by leading scientists.

2. What would you say about the implementation of research-, invention-, entrepreneurship-based and other innovative approaches and practices of scientific education in Ukrainian general secondary and extracurricular education institutions (relevance, status, trends)?

It is pertinent to introduce novel methods and techniques of scientific education in Ukrainian general secondary and extracurricular educational institutions; however, this can only be accomplished with the development of cross-cutting educational programs, sufficient modern facilities and resources, and current methodological support.

3. What are the main current challenges and problems in implementing scientific education in Ukraine? What are the possible ways to overcome them?

Introduction of scientific education standards is practically impossible (qualified personnel are unmotivated by low salaries, financing of extracurricular educational institutions is made on a residual basis, lack of social security, including official housing, health insurance, cross-cutting programs, textbooks, logistics, methodological support, and modern equipment), and, accordingly, equal access to scientific education.

4. What existing programmes and initiatives do you think are most effective in promoting and improving the quality of science education?

The most effective is the experience of implementing research and experimental approaches in science-oriented education at extracurricular educational institutions within the Junior Academy of Sciences of Ukraine.

5. What do you see as the main priorities and directions for developing scientific education in Ukraine in the near future? What approaches and models are most relevant for implementation?

The main priority and direction for the development of scientific education in Ukraine is improving the Junior Academy of Sciences educational system as a structure that has trained a galaxy of scientists known not only in Ukraine but also worldwide. It is necessary to

create several Youth Science Centres (YSCs) in all regions of Ukraine that are fitted with modern equipment and everything required for scientific research. Provide the YSCs with highly qualified personnel (for this purpose, introduce relevant specialities in higher education institutions).

6. Please share any advice on introducing scientific education in schools and extracurricular institutions.

Undoubtedly, scientific education should be introduced into schools and extracurricular institutions. However, this should be preceded by training and providing educational institutions with cutting-edge resources, technical facilities, highly skilled professionals, and social guarantees for professionals, including legal and regulatory ones.

Expert 6: Moiseienko Yelyzaveta Valeriivna – Cand. Sc. History, Head of the Ethnology section at the public extracurricular educational institution "Kyiv Junior Academy of Sciences for Student Youth".

1. How would you describe the current general status of scientific education in Ukraine in a few sentences? What are the main achievements?

In Ukraine, scientific education is currently in a complicated situation. The continued implementation of scientific education in Ukraine is complicated by issues with funding, poor management of educational institutions, low staff motivation, and ineffective application of scientific discoveries. Additionally, there are issues with irregular and chaotic interactions between scientific institutions and general secondary and extracurricular educational institutions.

2. What would you say about implementing research-, invention-, entrepreneurship-based and other innovative approaches and practices of scientific education in Ukrainian general secondary and extracurricular education institutions (relevance, status, trends)?

The implementation of research-, invention-, entrepreneurship-based and other innovative approaches and practices by general secondary and extracurricular educational institutions depends on the specifics of the educational institution, its staff and financial capabilities and the vision of its development strategy. The relevance of research, innovation and entrepreneurial practices is becoming increasingly popular and in demand by all participants in the educational process, as they promote the development of critical thinking, and creative skills, socialise and adapt students to life in society. For example, among extracurricular educational institutions, the Kyiv Branch of the Junior Academy of Sciences has long been successfully implementing research projects, competitions, and start-up initiatives. Encouraging students to participate in foreign research initiatives and strengthening collaboration with Ukrainian and worldwide research institutes are examples of how these techniques are being developed further. Overall, there is a gradual upward trend in this direction, but for innovative ideas in educational institutions to realize their full potential, more support and development are required. A straightforward, continuous application of the "general secondary education institution – private educational institution – higher educational institution" chain would be ideal and would significantly improve the situation.

3. What are the main current challenges and problems in implementing scientific education in Ukraine? What are the possible ways to overcome them?

The main challenges include financial constraints that preclude adequate funding of research; the introduction of martial law in Ukraine negatively affects the implementation of long-term strategies for the development of scientific education; low student motivation to engage in science; and lack of mechanisms to attract and retain students in scientific activities. Increased funding and investment, the introduction of incentive programs and programs for teachers, students, and section/circle leaders, the development of scientific infrastructure (laboratories not only for technical/natural sciences education but also for humanities

education), and collaboration with international institutions and organizations are the ways to address these challenges.

4. What existing programmes and initiatives do you think are most effective in promoting and improving the quality of scientific education?

Conferences and seminars are an excellent way to spread scientific education since they allow students to network and learn from one another. Scientific education can be promoted by holding lessons/classes at scientific and higher educational institutions. Effective initiatives for primary/secondary school students include the School of the Young Scientist at the Kyiv Junior Academy of Sciences, the Futurum Children's Academy at the National Centre "Junior Academy of Sciences", and various exciting lectures for older students. Another interesting project is Science Kids, which promotes science among children and teenagers.

5. What do you see as the main priorities and directions for the development of scientific education in Ukraine in the near future? What approaches and models are most relevant for implementation?

Stable funding for scientific research. Creating conditions for engaging students in scientific activities. To boost the status and make a positive image of science, it is necessary to attract well-known scientists, hold popular scientific events (for example, "Scientific Picnics" in Shevchenko Park), and promote students' scientific achievements among the general public. It is essential to incorporate research into the curriculum. Incentivise researchers and teachers who work with students. Providing teachers with the knowledge and skills to implement modern teaching methods and support students' scientific interests. Establishing cooperation with international institutions and organisations to exchange experiences and implement joint research projects.

6. Conclusions Drawn from the Analysis of the Expert Assessment of the Scientific Education's Status in Ukraine

Summarising experts' opinions on the status of scientific education in Ukraine, it can be argued that it is at its initial development stage. The situation is difficult due to the war and lack of material, technical, managerial, scientific, and pedagogical resources. Despite a solid and promising beginning, a number of obstacles and inconsistent applications have prevented scientific education from fully developing. The establishment of science lyceums and boarding schools, as well as the development of STEM education, are important milestones in this process. However, in wartime, projects pertaining to the defence sector and studies of its aftermath take centre stage, which also impacts scientific education agendas. These factors point to the need for further development and stabilisation of the educational system, especially in integrating scientific research and technological innovations that can contribute to the country's qualitative recovery.

Experts note that introducing research-, invention-, entrepreneurship-based, and other innovative approaches in Ukrainian general secondary and extracurricular educational institutions is promising, but it proceeds slowly. Despite certain efforts by government and non-governmental institutions, there are a number of obstacles to achieving sustainable results. The primary challenges are the lack of facilities and resources, unclear methodological justification, lack of up-to-date methodological support, development of cross-cutting educational programs, and methodical application of innovations in practice. This indicates that a comprehensive strategy involving infrastructure upgrades, curriculum development, establishing long-term connections between general secondary, extracurricular, and higher education institutions, and ongoing professional development for teachers is required to ensure high-quality scientific education.

Experts point out that the war has resulted in significant losses. Ukraine's scientific and educational sector has faced serious challenges as a result of russian aggression. In particular,

significant assets of the science and education sector, including research equipment, were destroyed and damaged or looted in the occupied territories. In addition, there is a massive migration of teachers, researchers, and engineers, leading to a decrease in scientific publications and overall funding for scientific and educational institutions. The decline in the number of research and education centres negatively impacts the training of future generations of researchers and on establishing links with the global research and education communities. A major problem is the insufficient number and quality of the teaching staff of domestic educational institutions, and the organisation and provision of quality training. The reason for this is the low motivation of qualified personnel due to insufficient remuneration, limited funding for extracurricular institutions, lack of social security and necessary educational support, hampering equal access to scientific education for all students.

Experts also draw attention to significant achievements in the development of scientific education in Ukraine, highlighting the work of the Junior Academy of Sciences of Ukraine (JAS) in particular. The JAS is involved in a wide range of activities, such as running a STEM centre, organizing an Olympiad movement that encourages young people to develop their scientific skills, and starting a research project competition and network of children's science museums. In addition, the methodological developments and activities of the Institute of Gifted Child and other educational organisations play a significant role in promoting science among students and raising their educational level. Overall, Ukraine's scientific and academic community significantly contributes to the country's progress by implementing innovative approaches and projects in the field of education.

Experts believe that international cooperation, research, teacher education at all levels, policy-making and joint efforts by academia and industry are the priorities in the development of scientific education. The basis for implementing scientific education is research-oriented approaches, such as IBSE, STEM/STEAM, project-based and problem-based learning. Building a network of secondary specialized education institutions and science centres in collaboration with academic institutions, research organizations, industry, and business is crucial. Expanding the network of science museums and interactive programmes will help integrate science education into the school curriculum. At the legislative level, it is necessary to stimulate educational and scientific initiatives of universities, research institutions, museums and businesses and hold mass events to promote science. Creating educational communities for sharing ideas, updating curricula, and professional development of teachers are key areas. Particular attention should be paid to improving the activities of the Junior Academy of Sciences, expanding its network and cooperation with higher educational and research institutions. It is important to create Youth Science Centres (YSCs) in all regions of Ukraine and provide them with modern equipment and highly qualified personnel with the relevant specialities.

Experts emphasise the need to apply a balanced approach to the development of curricula, programmes, textbooks, and teacher training to ensure the successful development of scientific education. It is essential to take into account the demands of educational institutions and society, actively use digital technologies, participate in international projects, and ensure inclusiveness and gender equality. Adequate funding and the adoption of law regulating the activities of the Junior Academy of Sciences of Ukraine are essential steps. For the successful integration of scientific education into schools and extracurricular institutions, it is necessary to provide them with modern facilities and resources, highly qualified staff, and social security for employees.

GENERAL CONCLUSIONS AND SUGGESTIONS

According to the findings of the scientific education monitoring program in Ukraine, since 2016, our country has been actively integrating its educational system with the democratic West. This is demonstrated by the adoption of contemporary academic standards,

the accomplishment of worldwide recognition, the introduction of democratic methods and novel educational ideas like STEM education and the New Ukrainian School. Curriculum revisions that prioritize project-based and interactive learning give students the tools they need to succeed in an increasingly globalised world.

The teachers' survey indicated that while they had a good attitude toward inquiry-based learning, several challenges impede its implementation, including inadequate facilities and resources and low motivation due to inadequate pay. While most educators agree that inquiry-based learning is a good idea, they also emphasize the need for more funding and professional development.

According to the professional evaluation, scientific education in Ukraine is still in its infancy and is confronting numerous obstacles, particularly in light of the ongoing conflict. This includes the destruction of infrastructure, migration of qualified personnel, and a decrease in funding and the number of scientific publications. Despite these challenges, the activities of the Junior Academy of Sciences, the creation of the STEM Coalition, the launch of specialised science-oriented educational programs, the opening of the UNESCO Chair on Science Education, and the methodological developments of the scientific institutions at the National Academy of Educational Sciences of Ukraine are significant achievements in promoting science and encouraging research projects among students.

Priorities for the development of scientific education include international cooperation, increased funding for the academic sector, professional development of teachers, policy development, and the unification of efforts between academia and industry. Critical areas include the introduction of IBSE, STEM/STEAM, project-based and problem-based learning, the development of a network of secondary specialised educational institutions, the creation of science centres and the expansion of the network of science museums. At the legislative level, it is necessary to stimulate educational and scientific initiatives and provide modern facilities and resources, highly qualified professionals, and social security for employees.

This analysis demonstrates the need for a comprehensive approach to the development of scientific education in Ukraine but also indicates the significance of further efforts to tackle existing challenges and improve the educational system. For the development of scientific education in Ukraine, it is necessary to implement measures aimed at eliminating existing problems and creating favourable conditions for integrating innovative approaches into the educational process. We propose to focus on the following aspects:

1. Enhancement of facilities and resources. To ensure high-quality scientific education, it is necessary to provide educational institutions with modern equipment and technologies. This includes upgrading laboratories, providing computer labs, interactive whiteboards, and other technologies. Public investment and grants can play a vital role in this process. International foundations and the private sector should also be involved in funding educational projects.

2. Creation of cross-cutting modern curricula and instructional resources. It is necessary to create and implement cross-cutting educational programmes that cover innovative models of scientific education, meet international standards, and include interactive teaching methods, as well as project and problem-based learning. Cross-cutting programmes help to create a holistic and coherent learning system, they promote the development of complex thinking, increase motivation to learn, and provide a deeper grasp of subjects through their integration and practical application. Such programmes should be developed in cooperation with international experts and academic institutions. Instructional resources should be made available to teachers in digital format and regularly updated in line with the latest scientific findings.

3. Advanced training of teachers and ensuring their motivation. Successful implementation of scientific education requires systematic professional development of

teachers. Regular training courses, seminars, workshops and refresher courses with a focus on modern teaching methods, innovative technologies and project-based learning are vital to this process. Launching support and mentoring systems where experienced teachers can share their knowledge with younger colleagues is also important. Encouraging educators is essential. To do so, it is necessary to provide adequate working conditions, including fair salary, social security (health insurance, pensions), and opportunities for professional growth. Additional financial incentives, such as bonuses and grants for achievements in research and education, will also help to increase teacher motivation.

4. Creating a network of science centres and museums. Developing a network of science centres and interactive museums in different regions of Ukraine is a key focus for developing scientific education and promoting science among young people. For this purpose, it is necessary to create Youth Science Centres (YSCs) in all country regions. These facilities must have all the tools needed for conducting scientific research and experiments, as well as modern equipment. The YSCs ought to develop into hubs of innovation where students can obtain cutting-edge tools, expert guidance, and scientific information. For the effective functioning of the Youth Science Centres, it is imperative to provide them with the necessary resources, including modern scientific equipment, laboratory tools, computer systems, and software. This will allow students to conduct their own research, participate in international projects and competitions, and develop skills necessary for future professional activities. Youth science centres should cooperate with higher education institutions, research institutes, and laboratories. Such cooperation will allow leading scientists, engineers, and teachers to work with students, which will help improve the quality of scientific education. It is also essential to develop internship and practice programmes for students of scientific institutions, which will help them gain experience and decide on their future profession.

The creation of interactive science museums is another essential tool for promoting science among young people. Such museums should offer visitors a variety of exhibitions, demonstrations of scientific experiments, interactive stands and laboratories where everyone can conduct experiments on their own. This not only increases interest in science but also contributes to a better understanding of complex scientific concepts through hands-on experience.

The YSCs and science museums should regularly implement educational programmes, hold seminars, and deliver lectures and workshops for students, teachers, and the general public. Holding scientific conferences, competitions, festivals, and other events will facilitate sharing knowledge and experiences and encourage students to participate in research actively. It is also necessary to involve international experts and organisations in these events, which will allow for the exchange of best practices and innovations in scientific education. Ensuring adequate working conditions for scientists and teachers employed by YSCs and science museums is crucial for their successful operation. Satisfactory working conditions mean fair salaries, social security, opportunities for professional development and career growth. It is also essential to provide a system of grants and scholarships for students who demonstrate high achievements in scientific activities, which will help to increase their motivation and interest in science. It is vital to provide the YSCs and science museums with digital technologies to make scientific education more accessible and interactive. Virtual laboratories, online courses, webinars, and other digital resources will enable students from different parts of the country to receive high-quality science education regardless of their place of residence. This will also facilitate the development of distance learning and the integration of Ukrainian science into the global educational space. Industry and business representatives must work together to guarantee the YSCs and science museums continue to grow sustainably. This could include joint projects, research funding, student internships, and support for scientific initiatives. Such cooperation will facilitate the integration of science and

business, the development of innovations, and the training of qualified personnel for various sectors of the economy. It is necessary to provide legislative support for the activities of the YSC and science museums, including the adoption of relevant regulations governing their activities and providing funding. Government authorities should create favourable conditions for the development of scientific education by providing benefits and other incentives for organisations and enterprises that invest in educational projects.

5. Integration of research-based approaches into the educational process. Integrating research-, invention- and entrepreneurship-based approaches into the curriculum is an essential step for developing scientific education. This includes the introduction of IBSE (Inquiry-Based Science Education), STEM/STEAM (Science, Technology, Engineering, Arts, Mathematics), and project-based and problem-based learning, which promote students' critical thinking, creativity and practical skills. It is important to provide teachers with the necessary methodological materials and tools to effectively implement these approaches.

6. Stimulation of legislative initiatives. It is critical to adopt laws that support scientific education. They should include a law that would streamline the activity of the Junior Academy of Sciences of Ukraine, as well as legislative initiatives that encourage research and education projects at universities, research institutions, and schools. Privileges and incentives for businesses investing in scientific education could also contribute to the development of this area.

7. Expansion of international cooperation. International cooperation is an essential aspect of the development of scientific education. This shall include participation in international projects, exchange programmes, scientific conferences and competitions. Cooperation with international organisations, such as UNESCO and UNICEF, allows us to adopt best practices and integrate them into the Ukrainian educational system. Maintaining links with research institutions and universities in other countries for joint research and projects is also important.

8. Inclusiveness and gender equality. Ensuring equal access to scientific education for all students, regardless of their social, economic or physical status, is essential for the field's sustainable development. Inclusive programmes should take into account the needs of children with special educational needs and facilitate their full integration into the learning process. Gender equality is also an important component, so it is necessary to encourage girls to participate in STEM fields and create equal conditions for their education and development.

9. Promoting science and engaging young people. Young people's interest in science can be raised by promoting it through large-scale events like science festivals, contests, Olympiads, interactive exhibitions, and demonstrations. It is also important to involve the media in covering scientific achievements and projects and to create popular science programmes and resources that will promote the development of a scientific culture in society.

10. Cooperation with business and industry. Collaboration with business and industry can provide additional resources and opportunities for the development of scientific education. This can include joint projects, internships for students and trainees, research funding, and business representatives' participation in curricula as mentors or advisors. Such cooperation will help ensure that curricula are relevant to labour market needs and contribute to the training of qualified personnel for various sectors of the economy.

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