Standardization of STEM education in Ukraine: sustainable development in times of crisis

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Abstract

The text of the abstract should be maximum of 350 words and written in italicized text, using Arial 10-point. The paragraph should be fully justified. Please leave one blank line after the abstract, then start writing the main text. This study substantiates the role of standardization in mitigating the destructive impact of crises on the development of STEM education in Ukraine, fostering national innovative transformations and ensuring their sustainability.

The article examines successful international practices in STEM standardization and assesses the feasibility of their adaptation to the Ukrainian context. It emphasizes that transitioning to large-scale, standardized STEM education is an investment in human capital and a key factor in developing an innovative, competitive society capable of effectively responding to complex emergency challenges.

The research discusses the obstacles to standardizing STEM education in Ukraine and offers strategic recommendations for overcoming them. Our study focuses on analyzing diverse STEM programs, specifically investigating the balance between innovation, variability, and standardization, the application of the CO-STEM-PBL pedagogical methodology, and integrated assessment approaches. The authors offer a comparative study of existing programs in Ukraine and approaches to implementing STEM education tasks within the framework of the New State Standard in Ukraine in 2021-2025.

The development of national model STEM curricula is crucial for ensuring quality during large-scale implementation, guaranteeing accessibility, promoting universal design, and achieving unified learning outcomes. The authors identify the pivotal role of national model STEM programs in standardizing education by: establishing a core content framework and defining STEM competencies across all educational levels: preschool, primary, and secondary school; ensuring horizontal and vertical coherence for seamless transitions between educational levels; maintaining educational quality nationwide, thereby reducing disparities between regions and institutions—a critical factor given the current variability in technical resources, staffing, and security conditions.

Finaly, STEM programs serve as a guideline for the development of relevant professional development programs for teachers.

Keywords: *Ukrainian STEM-education, STEM-curricula, STEM-programs*

1. Introduction

In the ever-changing landscape of education, the role of STEM has been the subject of extensive debate and research. STEM-based learning methods that integrate engineering design, mathematical thinking, scientific research, and technological literacy are crucial to harnessing the achievements of past industrial revolutions and preparing a workforce capable of addressing problems and challenges associated with uncertainty. These arguments point to the need to rethink STEM education for 21st century citizens who are focused on the prospects of 2050. In the earlier study *"STEM Education in Ukraine in the Context of Sustainable Development" [1],* the authors consider STEM as a tool for achieving the Sustainable Development Goals. It was emphasized that the STEM approach in schools should be based on principles of transdisciplinary, motivation, inclusivity, and patriotic education. The study stressed the need to establish educational STEM hubs that would unite schools, higher education institutions, businesses, and communities.

In the last decade of the 21st century, a significant paradigm shift occurred toward a post-classical understanding of STEM, extending beyond the integration of the original “four pillars.” This educational innovation became open to integration with the humanities, economics, entrepreneurship, arts, healthcare, design, linguistics, and even sports. Consequently, there is a diversity of STEM model (acronyms), such as STEAM (STEM plus Arts), STEMM (STEM plus Medicine), STEAMED (STEM, Arts, Education, and Design) [6], and STREAM (STEAM with Robotics or Reading), among others [7]. The Co-STEM-PBL (Community-STEM Project-Based Learning) approach engages mathematics and science teachers in project-based learning that takes into account community opportunities, voices, and needs. Emphasizing community involvement increases the impact of STEM education in local contexts [8]. E-STEM (Environmental STEM) highlights the importance of sustainable development and the integration of environmental education with STEM disciplines, facilitating collaboration among learners, teachers, specialists/experts, and researchers in “green” STEM activities and the acquisition of authentic learning experiences [9].. A review of these approaches is important for further evaluation of their use in the Ukrainian educational space and selecting theoretical and conceptual frameworks for the standardization of STEM education. The standardization of STEM education in Ukraine is considered by the authors as a “stabilization framework” in conditions of limited resources and educational losses, a “guarantor of quality” in conditions of variability of crisis challenges.
It includes the formation of a conceptual apparatus; development of a regulatory framework (concepts, standards, regulations), standards and programs, requirements for infrastructure support; definition of pedagogical strategies and methods of assessing learning outcomes; content; development of professional standards, etc. Currently, there is not enough research devoted to determining the leading factors of standardization of STEM education, which determines the choice of the topic of the publication by the authors.
The hypothesis of our study is the assumption that the key factor of standardization of STEM education in conditions of crisis is the development and implementation of model curricula that provide a content framework of STEM education.

2. Standardization of Ukrainian STEM Education

The phased implementation of new State Standards, covering primary, basic secondary, and specialized secondary education, has made a significant contribution to the formal regulation and transition toward the widespread adoption of Ukrainian STEM education. The implementation of the latest concepts (referring to standards, typical curricula, and model programs) aims to support the reform of the Ukrainian school system by emphasizing principles of cross-disciplinary integration. These principles determine the structure of STEM education within the formal education framework in Ukraine [10]. Primary STEM education, conducted in preschool institutions and elementary schools, fosters curiosity, sustains interest in learning and knowledge-seeking, encourages engagement in simple research and construction activities, and develops foundational reading skills as a basis for cognitive flexibility. As early as 2020, an alternative preschool program titled “Paths to the Universe” (STREAM education) was developed by K. Krutiy [11]. Until 2024, elementary education lacked specialized STEM programs; however, integrated courses such as “I Explore the World” broadly conveyed the idea of combining scientific, informatics, and mathematical education – essentially employing STEM approaches to child development. These courses were based on thematic learning principles (e.g., R. Shiyan’s program, where one week focuses on one theme studied through multiple disciplines). In 2024, the Ministry of Education and Science approved the elective course “STEM-START” developed by I. Potapenko [12].
Basic STEM education in grades 5–9 of secondary school and in extracurricular settings focuses on engaging students in research, invention, project activities, and the practical application of acquired knowledge and skills to solve societal and community problems and achieve Sustainable Development Goals. This phase encourages progression to further specialized education. Typical curricula for grades 5–9 and 10–12 include provisions for teaching interdisciplinary integrated STEM courses in grades 5–6 and 7–9. In 2021, by orders of the Ministry of Education and Science of Ukraine, interdisciplinary integrated courses such as “STEM” and “Robotics” were officially included in the list of subjects for adaptation and specialized study cycles.
Model curricula for interdisciplinary integrated STEM and robotics courses have been developed for the adaptation cycle by authors including Buturlina & Artemieva [13], Sokol & Chentsova [14], and for the subject study cycle by Buturlina et al. [15], Zasekina, Korshunova & Vasilashko [16], Levchenko et al. [17], Sokol & Chentsova [18]. These curricula facilitate the phased rollout of mass STEM education implementation by providing educators with comprehensive teaching and methodological materials.

Current legislation regulating the reform of specialized education and the establishment of a new generation of academic and vocational lyceums defines the framework for the profile level of STEM education. The State Standard for Specialized Secondary Education and the Model Educational Program propose the creation of STEM clusters in grades 10–12 of academic lyceums and the modernization of workshops in vocational technical education. The development of this STEM education segment in Ukraine is connected to the dramatic optimization of the network of academic and vocational lyceums, set against the backdrop of significant youth outflow from the country during the period of military aggression. The state education policy aims to overcome the consequences of the wartime crisis by ensuring a critical mass of specialists capable of supporting economic competitiveness, defence capabilities, and the reconstruction of post-war communities. The orientation towards new quality results and modern approaches to national human capital development is anchored in the programs Education 4.0: Ukrainian Dawn and Education for Life [19]. These programs define education as a cornerstone for consolidating Ukrainian society and achieving transformational changes, including the digital transformation of education and science; aligning the education system with the human resource demands of Industry 4.0, where people and technologies unite to unlock new possibilities; and advancing science and technology through the development of STEM programs and their associated ecosystems.

In our study, we will focus on programs for grades 7-9 of the interdisciplinary integrated STEM course, which is implemented in the second cycle of basic secondary education, in the cycle of subject study. What unites all three of these programs is their interdisciplinary nature, practical use of the knowledge acquired by the applicant from various STEM fields to solve complex problems, reliance on problem-based learning, active work, and involvement of the applicant's subjectivity (agency). programs are aimed at developing key competencies required in the modern world and cross-cutting skills. All programs have a **modular structure,** which allows them to be flexibly adapted to the needs of a particular educational institution and the interests of students. They have a common goal of developing students' key STEM competencies. They differ in emphasis, structure, and approaches to implementation. Buturlina's and Zasekina's programs are more focused on knowledge integration and research activities. The Levchenko program additionally emphasizes entrepreneurship and innovation, as well as sustainable development goals. The choice of a particular program depends on the needs and capabilities of the educational institution, the readiness of teachers, and the availability of resources. It is important to consider the potential risks and drawbacks of each program and develop strategies to overcome them.

Table 1*. Comparative analysis of STEM model curricula.*
*Grades 7-9 (*interdisciplinary integrated course*)*

Model curricula STEM. Grades 7-9 (interdisciplinary integrated course)		
Buturlina O. *et al.*,[15]	Zasekina T. *et al.*,[16]	Levchenko F. *et al.*,[17]
Objective		
Formation of STEM-identity of students, development of STEM-competencies, increase of motivate motivation to study natural sciences, technologies, engineering and mathematics. preparation of students for future professional activities in STEM-areas. Implementation of interdisciplinary STEM projects aimed at achieving the Sustainable Development Goals. Development of design thinking, support for invention, entrepreneurship and scientific and technical creativity	Personal development of students, who have certain skills in nature study, are able to assess the impact of sciences, engineering and technology on sustainable development of society and possible consequences of human activity in nature, confidently use digital tools and technologies to solve educational and practical problems, and are capable of independent and team problem solving, decision making, critical thinking and creativity.	The program clearly defines the goal of STEM education as the development of a personality capable of entrepreneurship and innovation, critical thinking, problem solving, and responsible activities in society. The program offers a wide range of learning activities, including discussion, research, design, modeling, experiments, and presentations.
Content lines		
Module topics (7th Grade)		

1. 1. Human-Society *"Diversity of food"* 2. Human-Technology *"Green transition of the Blue Planet"* 3. Human-Nature *"How do they breathe?"* 4. Human-Sign *"Millions underfoot"* 5. Human-Image *"Techno Park"*	1.Artificial intelligence. 2.Energy and movement. 3.Technical solutions. 4.Ecology. Systems.	1.Society's needs and sustainable development. *"Human needs"* 2. Health and personal development. *"Nutrition".* 3. Ecosystems and human impact on the environment *"Helping animals".* 4. STEM Science *"Observation of natural phenomena".* 5. STEM Technology *"Souvenirs".* 6. STEM Engineering "*Mechanical robots*". 7. STEM Mathematics *"Mathematics and art"*
Assessment. Groups of learning outcomes.		
1. **Research capacity** (phenomena, objects, problems, information). Investigates nature, phenomena, patterns 2. **Digital literacy** Works with information and data. Searches, investigates, analyzes, critically evaluates, interprets, generalizes, uses safely, creatively uses, creatively transforms. 3. **Creativity.** The ability to create product (material/informational) to solve problems, satisfaction of personal and social needs and creative self-realization. 4. **Vision of the future. Entrepreneurship,** The ability to plan for the future based on their strengths, talents, abilities, interests and needs of the society, investigate types of professional activities.	1.**Identifies problems, develops strategies, action plans to** solve problems. 2.**Creates information and material products** for effective problem solving and creative expression. 3.**Effectively uses equipment, technologies and materials** without harming the environment. 4.**Demonstrates entrepreneurship.**	1. **Gaining experience in problem solving** (individually and in cooperation with others). 2. **Development of critical and systemic thinking, creativity,** initiative; gaining experience of cooperating with others. 3. **Awareness of the role of science, engineering and technology in ensuring sustainable development of society**; assessment of factors and activities that pose a threat to personal and social life, health, and well-being.
Advantages		
1. **Clear cross-cutting content lines:** The program structures the content by cross-cutting content lines, such as "Human and Nature", ""Human and Society", ""Human and Technology". This is the basis for real integration and a focus on practical application. Students explore the problems faced by professionals in various fields of human activity. 2. **Emphasis on developing "systematic thinking":** The program clearly states the development of "systematic, critical, logical thinking" through "the application of systems analysis tools". And it provides a methodological basis for achieving this goal. 3.**Active role of the student**	**1. Focus on forming a holistic picture of the world and complex problem solving:** "Formation of a holistic picture of the world and gaining experience in solving problems that require the integrated application of knowledge and skills from different educational fields." The student will be able to understand how everything works together in real life, not just in textbooks. 2. **Emphasis on research and interaction with the real world:** Zasekina's program places a strong emphasis on "research, design, modeling, construction activities." This means that applicants will not just learn theory, but will be able to explore, create, and see how	1. **The program is generally well aligned with the goals and objectives of** STEM education, focusing on the practical application of knowledge and the development of key competencies. 2. **Modular structure, content lines focused on the needs of society, health, ecosystem.** 3. **Cross-cutting topics: professions, contribution of Ukrainian scientists, sustainable development goals.** 4. **The program can be taught as a set of additional modules to the subjects of the main disciplines.** Teachers can develop their curricula by supplementing them with STEM modules. In this case, the STEM modules are taught by teachers of the relevant subject. An effective approach at

in the learning process, agency. Buturlina's program explicitly defines the role of the teacher as one who "creates conditions," "guides," and "helps students realize their own responsibility." This is in line with modern pedagogical approaches and encourages the development of their own facilitation skills. 4.**Detailing of learning outcomes by year:** the program clearly delineates the expected learning outcomes **by year**. This is useful for lesson planning, assigning current grades, and tracking student progress within each class period.	it relates to the world around them. 3. **Use of digital tools:** Practical tasks show how to apply various digital tools and means for project implementation. 4. **Formation of "competence to assess the impact of science and technology on society":** The training is aimed at developing a responsible attitude towards the use of science and technology.	the stage of starting to implement STEM education at school, allowing schools to adapt STEM education to the available resources and capabilities of teachers. Provides a smoother transition to STEM-oriented education without requiring significant changes in the curriculum. Allows teachers to gradually master STEM approaches, starting with the integration of individual modules into their subjects.
	Disadvantages	
1.**High requirements for teacher qualifications.** Possession of subject competencies from many subject areas. 2.**The need for modern equipment** for research and project implementation 3.**Complexity of assessment.** Preference is given to formative assessment based on a portfolio of completed projects, etc. **4.Risk of superficial mastery of knowledge and skills** in various fields of science and technology.	1. **Dependence** on the availability of appropriate equipment: Schools need to be properly equipped to conduct research and use digital technologies. 2. Potential **difficulty** in balancing the depth of study of individual subjects: An integrated approach may require careful planning to ensure that the basic knowledge of each discipline is sufficiently covered. 3. **Assessment** the level of STEM competencies and research skills requires the development of comprehensive assessment approaches. 4. **Lack of teacher readiness** can lead to formal implementation of the program, when integration is superficial and projects are reproductive. 5. **Risk** that learning will be disconnected from real life.	1.Superficiality of integration, loss of key STEM ideas. **Fragmentation of knowledge.** Students may not see the connection between what they learn in math class and what they do in technology class. 2. Difficulty **in coordinating teachers** who will teach parts of the course to ensure coherence and achieve the common goal, the expected learning outcomes of the program. 3. Complexity of assessment in case of distributed teaching of modules. 4. **Lack of teacher readiness** to effectively integrate STEM-modules into their subjects. 5. **Limitations of opportunities** and difficulties in implementing projects that require the application of knowledge from different disciplines if STEM is taught in separate blocks.
	Decisions	
Engaging multidisciplinary teams of teachers as mentors and consultants Update the material and technical base Ensure a balance between integration and learning of basic knowledge.	Implementing projects that are relevant to students and take into account the local context. Differentiated approach and support for all students Development clear assessment criteria and tools.	Ensure a balance between learning and other activities. Carefully plan the learning process and organize teacher collaboration. Take into account the needs and capabilities of all students.

The widespread implementation of model STEM curricula plays a crucial role in developing the national STEM ecosystem. These curricula ensure unity and consistency of STEM education content across all levels (preschool, primary, basic secondary, upper specialized, vocational, and higher education); they establish standardized requirements for expected learning outcomes and the set of STEM competencies that learners must develop. For general secondary education, the adoption and widespread use of such curricula are critical for standardizing STEM education, equalizing its quality nationwide, and reducing personnel, infrastructure, and digital disparities between regions and educational institutions, especially under crisis conditions.

Embedded in the State Standards for basic and specialized secondary education, these curricula provide a foundational framework of content, ensure horizontal and vertical alignment of learning, and enable students to transition smoothly between STEM education levels, mastering increasingly complex concepts. Specialized STEM model curricula designed for primary school students open up opportunities for mass STEM education, positioning schools as places where young people are prepared for the challenges of the future. Combined with continuous infrastructure improvements, STEM laboratories/centers and resource optimization, the programs highlight the school's ability to implement transformative innovative solutions. Training under specialized STEM model programs (grades 5-6 and 7-9) eliminates critical gaps in STEM education and bridges the gap between primary and secondary (specialized) schools, where it is transformed into STEM clusters. This is particularly important in the context of the growing popularity of STEM education and the desire of an increasing number of educational institutions of various levels and types to introduce such innovation.

The successful implementation of this Ukrainian project is based on several key assumptions set out in the programs themselves. First, the STEM-program provides for the further development of students' interest in studying STEM subjects who indicate a strong willingness to participate in STEM projects, and 90% of parents demonstrate their full support. Secondly, it is expected that this interest, supported at the state level by policies for the development of STEM education, will lead to a significant number of young people obtaining professional and higher education in STEM fields, with a subsequent choice of STEM professions.

Thirdly, when the STEM program moves into the subject study cycle, grades 7-9, taking into account the psychological characteristics of adolescents and their personal growth, the authors of the program aim to form a STEM identity based on the STEM competencies acquired during the course of study.

Fourthly, STEM programs provide for the active involvement of students in community life. For example, in grade 6, when studying the topic ‘Drivers of the Economy’, they conduct research on the economy of their region, determining what is the driver in their communities. In Grade 7, the module ‘Millions Underfoot’ allows them to study the resources of the community and compile its profile, which, using modern strategic planning tools and based on SWOT analysis, sets SMART goals and proposes their own solutions for promoting goods and services produced in this territory, builds business models for future enterprises, based on the needs and available resources for community economic development, and develop strategies to improve community recognition (brand development, identity, advertising media products). In addition, it is expected that students who are motivated to develop their own city or town will stay, settle in communities in the future, return home to create new businesses, jobs, and added value in their territory, applying their own STEM potential, while parents and the community will support these initiatives and reinforce the importance of STEM education. STEM curricula are easily adaptable to the local context, and the use of problem-based and cooperative project-based learning ensures the implementation of the C-STEM-PBL model and collaborative learning. The integration of STEM into educational practices is presented as a key step towards promoting a knowledge-based economy and achieving the Sustainable Development Goals (SDGs). Finally, the STEM program assumes that communities will perceive this educational initiative as part of human resource development policy, include STEM in strategic documents on community development, participate in the financing of STEM-activities, STEM-labs, and open specialized lyceums in the field of STEM clusters.

All of the above requires the necessary resources: material and technical (state-of-the-art infrastructure), informational (teaching and methodological support, programs, textbooks, etc.), and human (a generation of teachers ready to teach STEM). Obviously, the implementation of STEM programs requires additional training and retraining of teachers.

In summary, the development of model STEM curricula in the New Ukrainian School reform is an innovative initiative that promotes the institutionalization and standardization of STEM education in Ukraine and its widespread implementation. Using the State Standard for Basic Secondary Education and the Model Educational Program as their solid institutional foundation, establishing strategic partnerships and maintaining a commitment to educational excellence, these programs aim to meet the growing demand for specialized STEM education among a wide range of educators. An active position in the development of STEM not only enhances Ukraine's reputation in the European educational space as a center of academic excellence, but also aligns with national goals for scientific research, innovation, workforce development and economic progress.

The development of teaching materials, appropriate textbooks for students, and manuals for teachers has a significant impact on the quality of mass implementation of STEM and the universality of its

design based on the principle of 'low threshold, high ceiling.' STEM projects with an entrepreneurial background, the integration of STEM disciplines and economic knowledge with a focus on achieving the Sustainable Development Goals, and the use of well-structured pedagogical scenarios and STEM project case studies will be attractive to students and teachers. Despite the lack of material and technical resources for integrated STEM education, students demonstrate a high level of trust in the teaching work of teachers and a positive attitude towards activity-based, problem-oriented, integrated approaches to learning. Research conducted in Ukraine over the past five years and differences in interpretation highlight the need to develop a common understanding of pedagogical approach standards to the implementation of STEM.
The main arguments in favour of standardization are that it ensures stability in crisis conditions, which Ukraine has experienced over the last 10 years, and is an important factor in the mass implementation of STEM education and ensuring its accessibility; it shapes the adaptability of education to change and, finally, emphasizes the link between mass STEM education and the formation of a sustainable and innovative society.

CONCLUSIONS

Specialized model curricula play a key role in standardizing STEM education, which manifests itself in several ways:
• ensuring unity and consistency, model programs establish a basic framework for content, expected learning outcomes and key competencies that should be developed in students at different levels of STEM education (preschool, primary, lower secondary, upper secondary).
• horizontal and vertical coordination of learning, allowing students to move smoothly between educational levels and successfully master more complex concepts;
• model STEM curricula contribute to the equalization of STEM education quality at the national level, reducing gaps between regions and educational institutions, which is essential given the variability of material and technical resources, staffing, and safety conditions.
• model programs offer recommended methodological approaches to teaching STEM based on integration, project activities, research-based learning, and practical application of knowledge. This is the basis for the formation of complex skills;
• specialized model STEM curricula clearly define which competencies (engineering thinking, research and scientific literacy, creativity, problem-solving, digital literacy) should be developed and what learning outcomes are expected.
• model curricula provide teachers with sufficient academic freedom and autonomy to adapt content to local conditions, student interests, and available resources, implementing the C-STEM-PBL model. This encourages the search for effective solutions within the established framework.
• STEM programs serve as a guideline for the development of relevant professional development programs for teachers.
Thus, specialized model curricula are the foundation for the standardization of STEM education, ensuring consistency, quality, continuity, accessibility, mass appeal, competence orientation and innovation. They form a holistic STEM education ecosystem that meets the needs of modern Ukrainian society in times of crisis and prepares Ukrainian youth for life and professional activity in a rapidly changing world.

REFERENCES

[1] Buturlina O., Dovhal S., Hryhorov H., Lysokolenko T., and Palahuta V., "STEM education in Ukraine in the context of sustainable development," *European Journal of Sustainable Development*, vol. 10, no. 1, p. 323, 2021. https://doi.org/10.14207/ejsd.2021.v10n1p323 (in English).
[2] Bybee R. W., *The Case for STEM Education: Opportunities and Challenges*. Arlington, VA: NSTA Press, 2013 (in English).
[3] Hwang J., Choo S., Morano S., Liang M., and Kabel M. "From silos to synergy in STEM education: Promoting interdisciplinary STEM education," *Learning Disabilities Research and Practice*, vol. 39, no. 3, pp. 117–131, 2024. https://doi.org/10.1177/09388982241245452 (in English).
[4] Lee K., "STEM as integration-maximising learning opportunities," in *Locating Technology Education in STEM Teaching and Learning*, pp. 17–38. Cham: Springer Nature, 2024 (in English).

[5] Razi A. and Zhou G. "STEM, iSTEM and STEAM: What is next?" *International Journal of Technology in Education*, vol. 5, no. 1, pp. 1–29, 2022. https://doi.org/10.46328/ijte.119 (in English).
[6] Jolly A. *STEM by Design: Strategies and Activities for Grades 4–8*. London: Routledge, 2017 (in English).
[7] Belbase S., Mainali B., Kasemsukpipat W., Tairab H., Gochoo M., and Jarrah A. "At the dawn of science, technology, engineering, arts, and mathematics (STEAM) education: Prospects, priorities, processes, and problems," *International Journal of Mathematical Education in Science and Technology*, vol. 53, no. 11, pp. 2919–2955, 2022. https://doi.org/10.1080/0020739X.2021.1922943 (in English).
[8] Nava I. and Park J., "Pre-service STEM teachers and their enactment of community-STEM-project based learning," *Journal of Higher Education Theory and Practice*, vol. 21, no. 9, 2021. https://doi.org/10.33423/jhetp.v21i9.4602 (in English).
[9] He Q., So W. M., Tsang Y.F., and Wan Z.H., "Environment-centred STEM learning for primary students: School-STEM professional collaboration," in *Cross-disciplinary STEM Learning for Asian Primary Students*, pp. 129–146. London: Routledge, 2024 (in English).
[10] Cabinet of Ministers of Ukraine, *State Standard of Basic Secondary Education (Resolution No. 898, as Amended), September 30, 2020*. Available: https://zakon.rada.gov.ua/laws/show/898-2020-%D0%BF#n16 (in Ukrainian).
[11] Ministry of Education and Science of Ukraine, *Alternative Program "STREAM Education, or Paths to the Universe" (Letter No. 22.1/12-G-274, July 14, 2020)* (in Ukrainian).
[12] Potapenko I., *Elective Course Program "STEM-Start" for Grades 1–4 of General Secondary Education Institutions (Approval No. 2.0131-2024)*, 2024 (in Ukrainian).
[13] Buturlina O. and O. Artemieva O. *Model Educational Program for the Interdisciplinary Integrated Course "STEM" for Grades 5–6 of General Secondary Education Institutions*. Kyiv: Ministry of Education and Science of Ukraine, 2022. Available:https://mon.gov.ua/storage/app/media/zagalna%20serednya/Navchalni.prohramy/2021/14.07/Model.navch.prohr.5-9.klas.NUSH-poetap.z.2022/Mizhhal.intehr.kursy/STEM.5-6.kl.Buturlina.Artyemyeva.04.10.pdf (in Ukrainian).
[14] Sokol I. and O. Chentsov O. *Model Educational Program "Robotics. Grades 5–6" for General Secondary Education Institutions*. Kyiv: Ministry of Education and Science of Ukraine, 2021. Available:https://mon.gov.ua/staticobjects/mon/sites/1/zagalna%20serednya/Navchalni.prohramy/2021/14.07/Model.navch.prohr.5-9.klas.NUpoetap.z.2022/Mizhhal.intehr.kursy/Robototekhn.5-6.kl.Sokol.Chentsov.04.10.pdf (in Ukrainian).
[15] Buturlina O. *et al.*, *Model Educational Program "STEM. Grades 7–9 (Interdisciplinary Integrated Course)" for General Secondary Education Institutions*. Kyiv: Ministry of Education and Science of Ukraine, 2024. Available:https://mon.gov.ua/static-objects/mon/sites/1/zagalna%20serednya/Navchalni.prohramy/2024/Model.navch.prohr.5-9.klas-2024/27.08.2024/03/stem-7-9-kl-buturlina-ta-in-27082024.pdf (in Ukrainian).
[16] T. Zasekina T., Korshunova O., and Vasylashko I., *Model Educational Program "STEM. Grades 7–9 (Interdisciplinary Integrated Course)" for General Secondary Education Institutions*. Kyiv: Ministry of Education and Science of Ukraine, 2024. Available: https://mon.gov.ua/static-objects/mon/sites/1/zagalna%20serednya/Navchalni.prohramy/2024/Model.navch.prohr.5-9.klas-2024/27.08.2024/03/stem-7-9-kl-zasyekina-ta-in-27082024.pdf (in Ukrainian).
[17] Levchenko F. *et al.*, *Model Educational Program "STEM. Grades 7–9 (Interdisciplinary Integrated Course)" for General Secondary Education Institutions*. Kyiv: Ministry of Education and Science of Ukraine, 2024. Available: https://mon.gov.ua/static-objects/mon/sites/1/zagalna%20serednya/Navchalni.prohramy/2024/Model.navch.prohr.5-9.klas-2024/10.09.2024/stem-5-9-kl-levchenko-ta-in-10-09-2024.pdf (in Ukrainian).
[18] Sokol I. and Chentsov O. *Robotics: Program of the Interdisciplinary Integrated Course for Grades 7–9*. Kyiv: Ministry of Education and Science of Ukraine, 2024. Available: https://mon.gov.ua/staticobjects/mon/sites/1/zagalna%20serednya/Navchalni.prohramy/2024/Model.navch.prohr.5-9.klas-2024/10.09.2024/robototekhnika-7-9-kl-sokol-ta-in-10092024.pdf (in Ukrainian).
[19] Ministry of Education and Science of Ukraine, *Education for Life: Comprehensive Policy for the Implementation of the New Ukrainian School Reform*. Kyiv: Ministry of Education and Science of Ukraine, n.d. Available: https://educationforlife.mon.gov.ua (in Ukrainian).