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THE STEM APPROACH IN THE METHODOLOGICAL TRAINING OF FUTURE PRIMARY SCHOOL TEACHERS FOR TEACHING MATHEMATICS

Abstract. The article examines the possibilities of implementing the STEM approach in the methodological training of future primary school teachers for teaching mathematics. The relevance of modernising teacher education in accordance with the principles of the New Ukrainian School, competency-based education, and digital transformation is substantiated. Current scientific interpretations of STEM education are analysed, the role of mathematics as the integrative basis of STEM learning is clarified, and international experience in preparing future teachers for interdisciplinary instruction is reviewed.

The purpose of the study is to substantiate the potential of the STEM approach in the methodological training of future primary school teachers for teaching mathematics and to identify the main directions for its implementation in higher education institutions.

The methodological framework of the study is based on analysis, synthesis, comparison, generalisation, systematisation, comparative pedagogical analysis, and structural-logical methods. These methods made it possible to generalise national and international research findings, identify the didactic potential of the STEM approach, and develop an author's model of methodological training for future primary school teachers.

The study identifies the professional competencies developed through STEM-oriented teacher education and characterises effective methodological tools, including STEM projects, inquiry-based tasks, mathematical modelling, case-based learning, problem-based learning, digital technologies, and generative artificial intelligence. An original model of methodological training for future primary school teachers is proposed, incorporating conceptual foundations, pedagogical conditions, stages of implementation, expected outcomes, and criteria for assessing methodological readiness. Practical examples of integrated STEM tasks and educational projects aimed at developing methodological, mathematical, research, digital, and project competencies are presented.

The practical significance of the study lies in the possibility of applying the proposed model and methodological recommendations to improve teacher education curricula, mathematics teaching methodology courses, and the professional preparation of future primary school teachers.

Keywords: STEM approach; methodological training; future primary school teachers; mathematics teaching; professional competencies.

STEM-ПІДХІД У МЕТОДИЧНІЙ ПІДГОТОВЦІ МАЙБУТНІХ УЧИТЕЛІВ ПОЧАТКОВОЇ ШКОЛИ ДО НАВЧАННЯ МАТЕМАТИКИ

Анотація. У статті досліджено можливості використання STEM-підходу у методичній підготовці майбутніх учителів початкової школи до навчання математики. Обґрунтовано актуальність модернізації професійної підготовки педагогів відповідно до вимог Нової української школи, цифрової трансформації освіти та розвитку компетентнісного навчання. Проаналізовано сучасні наукові підходи до трактування STEM-освіти, визначено роль математики як інтеграційної основи STEM-навчання та охарактеризовано міжнародний досвід підготовки майбутніх учителів до використання інтегрованих освітніх технологій.

Метою дослідження є теоретичне обґрунтування можливостей STEM-підходу у методичній підготовці майбутніх учителів початкової школи до навчання математики та визначення основних напрямів його реалізації в освітньому процесі закладів вищої освіти.

Методологічну основу дослідження становлять аналіз, синтез, порівняння, узагальнення, систематизація, порівняльно-педагогічний та структурно-логічний методи, що дали змогу дослідити сучасні підходи до STEM-освіти, узагальнити вітчизняний і зарубіжний досвід професійної підготовки майбутніх учителів та обґрунтувати авторську модель методичної підготовки.

У роботі визначено професійні компетентності майбутнього вчителя, що формуються засобами STEM-підходу, охарактеризовано методичні інструменти його реалізації, зокрема STEM-проєкти, дослідницькі завдання, математичне моделювання, кейс-метод, проблемне навчання, цифрові технології та генеративний штучний інтелект. Розроблено авторську модель методичної підготовки майбутніх учителів початкової школи до навчання математики на засадах STEM, яка охоплює концептуальні положення, педагогічні умови, етапи професійної підготовки, критерії сформованості методичної готовності та очікувані результати. Запропоновано приклади STEM-завдань, навчальних проєктів і практичних видів діяльності, спрямованих на формування методико-математичної, дослідницької, цифрової та проєктувальної компетентностей майбутніх педагогів.

Практичне значення дослідження полягає у можливості використання запропонованої моделі, методичних рекомендацій і практичних завдань під час удосконалення освітніх програм підготовки майбутніх учителів початкової школи та викладання методики навчання математики у закладах вищої освіти.

Ключові слова: STEM-підхід; методична підготовка; майбутній учитель початкової школи; навчання математики; професійні компетентності.

INTRODUCTION

The problem formulation. The current stage of educational development is characterised by a transition from a subject-centred model of teaching to a competency-based, integrated, and practice-oriented one. One of the key directions for modernising the educational system of Ukraine is the implementation of the STEM approach, which corresponds to global trends in the development of science, technology, and the digital society. This issue is of particular importance in the context of implementing the concept of the New Ukrainian School (NUS), where the integration of educational content, the development of inquiry skills, critical thinking, and the ability to apply knowledge in practical activities are identified among the priority objectives of learner education.

At the same time, the results of international educational quality monitoring studies indicate the need to improve the mathematical literacy of Ukrainian schoolchildren, enhance their interest in mathematics and science, and develop their ability to solve real-life problems using mathematical tools. Achieving these objectives largely depends on the professional preparation of future primary school teachers, since it is at the primary level of education that the foundations of logical, mathematical, and algorithmic thinking are established and positive motivation for learning and cognitive activity is developed.

Under these conditions, the methodological training of future primary school teachers for teaching mathematics based on the STEM approach becomes particularly relevant. The implementation of this approach ensures the integration of mathematics with science, technology, and engineering, orientates the educational process towards inquiry-, project-, and practice-based learning, and promotes the development of creativity, teamwork skills, digital competence, and the ability to solve complex educational tasks.

The scientific novelty of the study lies in substantiating the potential of the STEM approach as a methodological foundation for improving the methodological training of future primary school teachers for teaching mathematics, identifying its didactic potential, and systematising effective directions for its implementation in the educational process of higher education institutions. The findings may be used to update the content of methodological and mathematical training courses, develop STEM-oriented lessons, practical and inquiry-based tasks, instructional materials, and improve the professional preparation of students majoring in Specialty 013 Primary Education.

Analysis of recent research and publications. The theoretical and methodological foundations of STEM education and its implementation in the educational process have been extensively investigated by Ukrainian and international researchers. Contemporary conceptual approaches to the development of STEM education in Ukraine have been substantiated by Honcharova, 2017; Polikhun et al., 2017; Balyk and Shmyher, 2021; Tanska et al., 2024, who consider STEM as an innovative educational model integrating science, technology, engineering, and mathematics.

Particular attention has been devoted to the methodological training of future teachers for implementing STEM education. Various aspects of this issue have been examined by Kysla et al., 2025; Marynchenko et al., 2024; Rakhmanina, 2024; Sahaidakivska, 2025, whose studies emphasise inquiry-based learning, interdisciplinary integration, project activities, and the use of digital technologies in teacher education. The integration of multimedia technologies and digital tools into teacher preparation has also been analysed by Kuchai et al., 2022.

International studies have confirmed the positive impact of the STEM approach on the development of mathematical literacy, inquiry competencies, engineering thinking, and students' motivation. These issues have been addressed by Kurup et al., 2019; Garcна-Carrillo et al., 2021; Mayes and Rittschof, 2021, while the strategic role of STEM education in strengthening national innovation capacity has been highlighted by the Office of the Chief Scientist, 2013. In Ukraine, the implementation of STEM education has also been supported by the methodological recommendations of the Ministry of Education and Science of Ukraine, 2017, 2019.

Despite the considerable body of research devoted to STEM education, insufficient attention has been paid to the methodological training of future primary school teachers specifically for teaching mathematics through the STEM approach.

AIM AND TASKS OF THE RESEARCH

The purpose of the study is to substantiate theoretically the potential of the STEM approach in the methodological training of future primary school teachers for teaching mathematics and to identify the main directions for its

implementation in the educational process of higher education institutions. To achieve this purpose, the following research objectives were defined: 1) to analyse contemporary scientific approaches to interpreting the essence of the STEM approach and its role in the professional preparation of future teachers; 2) to generalise the theoretical foundations of the methodological training of future primary school teachers for teaching mathematics in the context of STEM education; 3) to determine the didactic potential of the STEM approach for developing the methodological and mathematical competence of future teachers; 4) to systematise effective forms, methods, and instructional tools for implementing the STEM approach in the methodological training of future primary school teachers.

RESEARCH METHODS

The methodological framework of the study is based on a set of interrelated general scientific and pedagogical research methods: analysis, synthesis, comparison, generalisation, and systematisation were used to examine the scientific literature, identify contemporary approaches to the implementation of STEM education, and generalise the findings of previous studies; comparative pedagogical analysis was employed to analyse Ukrainian and international experience in implementing the STEM approach in the professional preparation of future primary school teachers; the structural-logical method was applied to establish the relationships among the components of methodological training and identify the possibilities for integrating the STEM approach into the process of teaching mathematics; modelling was used to substantiate the directions for implementing the STEM approach and to systematise its methodological tools in the preparation of future primary school teachers.

RESULTS OF THE RESEARCH

One of the leading directions in the modernisation of contemporary education is the implementation of the STEM approach, which ensures the integration of science, technology, engineering, and mathematics into a unified system of practice-oriented learning. Unlike the traditional subject-based model, STEM education is aimed not only at acquiring isolated knowledge but also at developing the ability to apply it to solving real-life and professional problems. Consequently, STEM is currently regarded as one of the most promising directions for educational development, meeting the demands of the digital society, the innovation-driven economy, and the labour market (Honcharova, 2017; Polikhun et al., 2017; Tanska et al., 2024)

Ukrainian researchers emphasise that the STEM approach is not merely a separate pedagogical technology but a contemporary model of organising the educational process that combines competency-based, activity-based, inquiry-based, and project-based approaches. Its key characteristics include the integration of educational content, practical orientation, the use of digital technologies, and the development of critical thinking, creativity, communication, and teamwork skills (Balyk & Shmyher, 2021; Honcharova, 2017; Marynchenko et al., 2024; Rakhmanina, 2024). The analysis of previous studies indicates that the STEM approach has evolved from integrating individual academic disciplines to creating a comprehensive educational environment in which learning is organised through inquiry, modelling, experimentation, and solving practical problems (Rakhmanina, 2024; Tanska et al., 2024)

STEM education acquired particular significance following the adoption of the Concept for the Development of Science and Mathematics Education (STEM Education) in 2020. According to the regulatory documents of the Ministry of Education and Science of Ukraine, STEM has been identified as one of the priority directions for modernising educational content by promoting interdisciplinary integration, developing key competencies, fostering inquiry skills, and implementing innovative teaching technologies (Ministry of Education and Science of Ukraine, 2017, 2019). Moreover, the principles of STEM are fully consistent with the conceptual foundations of the New Ukrainian School, particularly competency-based education, partnership pedagogy, integrated educational content, activity-based learning, and the development of transversal skills.

Mathematics occupies a special place within the STEM framework, serving as its integrative foundation. Mathematical knowledge provides the basis for data analysis, process modelling, quantitative description of phenomena, logical reasoning, and informed decision-making. Unlike traditional approaches, mathematics in a STEM environment functions as a universal tool for investigating natural, technological, and social processes. Therefore, mathematics teaching increasingly emphasises real-world problem solving, mathematical modelling, interdisciplinary connections, project-based activities, data analysis, and the use of digital tools (Rakhmanina, 2024; Tanska et al., 2024; Tretiak, 2023)

For primary education, the STEM approach is particularly promising because primary school pupils demonstrate high cognitive activity, a natural inclination toward experimentation, and genuine curiosity about the surrounding world. Consequently, integrated lessons, inquiry-based learning, engineering activities, practical tasks, modelling, and STEM projects contribute to the development of mathematical thinking, logical reasoning, creativity, communication skills, and the ability to work collaboratively (Kysla et al., 2025; Sahaidakivska, 2025; Tretiak, 2023)

International experience also confirms the effectiveness of the STEM approach in preparing learners for education and professional activity within the digital economy. Researchers emphasise that STEM learning enhances students' motivation to study mathematics, develops inquiry competencies, engineering thinking, and the ability to apply knowledge to solving complex practical problems (Garcна-Carrillo et al., 2021; Kurup et al., 2019; Mayes & Rittschof, 2021). In many countries, STEM has already become a cornerstone of national educational policy and is regarded as one of the key factors contributing to economic competitiveness and human capital development (Office of the Chief Scientist, 2013).

To summarise the differences between the traditional model of mathematics teaching and the contemporary STEM-oriented approach, their principal characteristics are presented in Table 1.

Table 1

Comparative Characteristics of Traditional and STEM-Oriented Mathematics Teaching

Criterion	Traditional Teaching	STEM-Oriented Teaching
Purpose of instruction	Acquisition of mathematical knowledge and algorithms	Development of competencies and application of mathematics to solving real-world problems
Organisation of content	Subject-based instruction	Integrated learning combining science, technology, engineering, and mathematics
Nature of learning activities	Completing exercises according to established examples	Inquiry, projects, experimentation, and modelling
Teacher's role	Source of knowledge	Organiser, facilitator, and consultant
Student's role	Performer of learning tasks	Active inquirer and collaborative team member
Types of mathematical tasks	Mainly instructional and abstract	Practical, interdisciplinary, and problem-based tasks
Use of digital technologies	Occasional	Systematic use of digital platforms, simulations, and interactive resources
Main learning outcomes	Subject knowledge and computational skills	Mathematical literacy, critical thinking, inquiry competencies, and project skills

As shown in Table 1, unlike traditional methodological preparation, which mainly focuses on mastering individual teaching methods for separate subjects, the STEM approach prepares future teachers to integrate the content of different educational domains. Particular emphasis is placed on integrating mathematics, science, and technology within the methodological training of future primary school teachers. In contemporary primary education, mathematics is increasingly used as a universal tool for measurement, analysis, modelling, and prediction, thereby ensuring effective interdisciplinary integration. Future teachers should therefore learn to design integrated lessons in which mathematical concepts are applied during scientific investigations, model construction, technological activities, and the analysis of obtained results. Such an approach enables pupils to recognise the practical value of mathematical knowledge and to develop a holistic understanding of the surrounding world (Kysla et al., 2025; Sahaidakivska, 2025; Tretiak, 2023).

One of the major advantages of the STEM approach is the development of inquiry skills among future teachers. During their professional preparation, students participate in educational investigations, analyse problem situations, design STEM projects, model experiments, and interpret research findings. These activities develop the ability to identify problems, formulate hypotheses, select appropriate research methods, analyse collected data, and justify conclusions with evidence. In their future professional practice, these competencies enable teachers to organise inquiry-based learning for primary school pupils and foster their scientific ways of thinking (Marynchenko et al., 2024; Rakhmanina, 2024; Garcна-Carrillo et al., 2021).

Another important outcome of implementing the STEM approach is the development of creativity, critical thinking, and collaboration skills. Working on integrated projects, group investigations, analyses of practical situations, and solving open-ended problems encourages students to search for alternative solutions, critically evaluate information, justify their viewpoints, and interact effectively within a team. These competencies are currently regarded as among the most essential for the professional activity of contemporary primary school teachers (Marynchenko et al., 2024; Tanska et al., 2024; Garcна-Carrillo et al., 2021; Mayes & Rittschof, 2021).

The implementation of the STEM approach substantially transforms the content of methodological training. Students learn not only how to explain mathematical concepts but also how to design integrated learning tasks, organise inquiry-based activities for primary school pupils, use digital educational resources, develop STEM projects, and ensure interdisciplinary integration in accordance with the State Standard of Primary Education. Such preparation promotes professional flexibility, readiness for innovation, and continuous professional development (Balyk & Shmyher, 2021; Kuchai et al., 2022; Kysla et al., 2025; Rakhmanina, 2024).

To summarise the impact of the STEM approach on the professional preparation of future primary school teachers, the key competencies developed through STEM-oriented education are presented in Table 2.

The effectiveness of implementing the STEM approach largely depends on the use of contemporary methodological tools that integrate theoretical preparation with the practical activities of future teachers. The methodological training of students majoring in Primary Education should focus not only on mastering methods of teaching individual mathematical topics but also on developing their ability to design an integrated educational environment, employ modern digital technologies, organise inquiry-based learning, and create educational situations closely related to authentic real-life problems (Balyk & Shmyher, 2021; Kysla et al., 2025; Rakhmanina, 2024).

Table 2

Professional Competencies of Future Primary School Teachers Developed through the STEM Approach

Professional Competency	Manifestation in Methodological Training
Methodological and mathematical competency	Designing contemporary mathematics lessons, selecting STEM tasks, and integrating mathematical content with other educational domains
Integrative competency	Combining mathematics, science, technology, and informatics while designing educational activities
Inquiry competency	Organising educational investigations, identifying problems, analysing results, and applying inquiry-based teaching methods
Project competency	Designing STEM projects, educational case studies, practice-oriented tasks, and instructional models
Digital competency	Using digital platforms, mathematical simulations, interactive resources, and online services
Engineering and design competency	Modelling objects and processes, constructing educational models, and applying elements of STEM engineering design
Critical thinking	Analysing information, evaluating alternative approaches to problem-solving, and making well-reasoned decisions
Creative competency	Generating innovative ideas, designing non-standard learning situations, and applying creative teaching methods
Communicative competency	Organising teamwork, professional interaction, and presenting project outcomes
Reflective competency	Self-assessment of professional performance, evaluation of instructional methods, and continuous improvement of pedagogical practice

One of the most effective instruments of STEM-oriented teacher preparation is the implementation of STEM projects. Project-based learning integrates mathematics with science, technology, engineering design, and information technologies. While working on projects, students learn to identify problems, plan solution strategies, select appropriate mathematical methods, analyse the obtained results, and present their own developments. Of particular educational value are projects that simulate authentic real-life contexts, such as designing ecological routes, measuring the area of school grounds, constructing building models, or investigating symmetry in architecture and Ukrainian folk art (Kysla et al., 2025; Sahaidakivska, 2025; Tretiak, 2023).

Inquiry-based tasks also play a crucial role by facilitating the transition from reproductive learning to active cognitive engagement. Unlike traditional exercises, these tasks require students to formulate hypotheses, design investigations, conduct measurements, analyse collected data, and draw evidence-based conclusions. Future teachers learn to organise inquiry activities in such a way that mathematics becomes a tool for explaining natural and social phenomena rather than merely an isolated subject of study (Marynchenko et al., 2024; Rakhmanina, 2024).

Another essential component of contemporary methodological training is mathematical modelling, which enables students to apply mathematical concepts to the analysis of real-world situations. Students complete tasks involving the construction of diagrams, drawings, charts, tables, graphs, geometric models, statistical data analysis, and prediction of outcomes. Such activities promote mathematical literacy, analytical thinking, and the ability to transfer mathematical knowledge into practical contexts (Mayes & Rittschof, 2021; Tanska et al., 2024;)

The case-study method also provides broad opportunities for the professional preparation of future teachers. Analysing pedagogical situations enables students to examine various approaches to organising mathematics lessons, evaluate their effectiveness, anticipate possible learning difficulties, and select the most appropriate methodological solutions. Case studies may involve designing integrated lessons, organising STEM projects, applying digital resources, or addressing challenging pedagogical situations arising during mathematics instruction in primary school (Marynchenko et al., 2024; Rakhmanina, 2024).

Problem-based learning is another important instructional tool that creates favourable conditions for students' active cognitive engagement. While solving open-ended educational problems, future teachers independently determine solution strategies, compare alternative approaches, justify their conclusions, and reflect on the outcomes of their learning activities. Such an approach promotes professional autonomy, critical thinking, and the ability to design innovative mathematics lessons (Polikhun et al., 2017; Tanska et al., 2024).

Digital technologies constitute an essential component of STEM-oriented methodological training. Contemporary teachers should be able to use interactive mathematical environments, dynamic geometry systems, digital simulations, online platforms, cloud-based services, and virtual laboratories. These technologies facilitate the visualisation of mathematical concepts, process modelling, inquiry-based learning, and personalised instruction. Moreover, they contribute to the development of the digital competence of both future teachers and their pupils (Kuchai et al., 2022; Kurup et al., 2019).

One of the newest directions in improving methodological preparation is the integration of generative artificial intelligence (GenAI). GenAI-based tools can be used to design STEM tasks, create practical case studies, generate mathematical problems of varying complexity, develop integrated projects, select interdisciplinary examples, prepare instructional materials, and construct assessment tasks. Furthermore, GenAI supports the generation of alternative explanations of mathematical concepts, the creation of educational scenarios and visual models, and the design of personalised learning tasks tailored to pupils' levels of preparedness. At the same time, the use of such tools requires future teachers to develop critical thinking, verify the reliability of AI-generated outputs, adhere to the principles of academic integrity, and recognise the limitations of generative models. Within professional teacher education, GenAI should therefore be regarded as a supportive methodological tool rather than a substitute for teachers' professional judgement or pedagogical creativity.

To systematise the principal methodological tools for implementing the STEM approach in the professional preparation of future primary school teachers, they are summarised in Table 3.

Table 3

Methodological Tools for STEM-Oriented Teacher Preparation

Methodological Tool	Primary Purpose	Professional Training Outcome
STEM projects	Integration of mathematics, science, and technology	Development of project and integrative competencies
Inquiry-based tasks	Organisation of educational investigations	Development of inquiry skills and scientific thinking
Mathematical modelling	Analysis of real-world processes using mathematics	Development of mathematical literacy and analytical thinking
Case-study method	Analysis of professional pedagogical situations	Development of professional thinking and decision-making skills
Problem-based learning	Solving open-ended educational problems	Development of critical thinking, creativity, and independence
Digital technologies	Use of interactive platforms, simulations, and digital resources	Development of the future teacher's digital competence
Generative artificial intelligence	Development of STEM tasks, instructional materials, projects, and case studies	Enhancement of methodological preparation and development of critical digital literacy

The conducted analysis provides a basis for developing an original model of the methodological training of future primary school teachers for teaching mathematics based on the STEM approach. The proposed model integrates competency-based, activity-based, learner-centred, inquiry-based, and STEM approaches and is aimed at developing future teachers' methodological readiness to organise contemporary mathematics instruction in primary education.

The conceptual foundation of the model is based on the premise that methodological training should not be limited to mastering individual methods of teaching mathematical content. Instead, it should develop future teachers' ability to integrate mathematics, science, technology, and informatics; employ inquiry-based teaching methods; organise STEM projects; apply digital technologies; and create an educational environment in which mathematical knowledge acquires practical significance. This approach fully corresponds to the principles of the New Ukrainian School and the Concept for the Development of STEM Education (Balyk & Shmyher, 2021; Kysla et al., 2025; Ministry of Education and Science of Ukraine, 2019; Rakhmanina, 2024).

The proposed model is built upon the interaction of four interrelated components: the target, content, procedural, and outcome components. Their essence and stages of implementation are presented in Table 4.

Table 4

Author's Model of the Methodological Training of Future Primary School Teachers for Teaching Mathematics Based on the STEM Approach

Model Component	Content
Purpose	Developing the methodological readiness of future primary school teachers to teach mathematics based on the STEM approach.
Methodological approaches	Competency-based, activity-based, learner-centred, integrative, inquiry-based, and STEM approaches.
Principles of implementation	Scientific validity, integration of educational domains, practical orientation, interdisciplinarity, inquiry-based learning, digitalisation, student-centredness, and continuous professional development.

Pedagogical conditions	Integration of the STEM component into methodological training; practice-oriented learning; application of digital technologies; organisation of project- and inquiry-based activities; development of professional reflection.
Stage 1. Motivational and orientation stage	Developing positive motivation for implementing the STEM approach and awareness of the role of integrated mathematics instruction in teachers' professional practice.
Stage 2. Theoretical and methodological stage	Mastering the theoretical foundations of STEM education, contemporary mathematics teaching methodology, integrated instruction, and digital technologies.
Stage 3. Practical activity stage	Designing STEM projects, integrated lessons, inquiry-based tasks, mathematical models, and applying digital platforms and generative artificial intelligence.
Stage 4. Reflective and evaluation stage	Self-analysis, evaluation of professional performance, refinement of methodological decisions, and planning further professional development.
Methodological tools	STEM projects; inquiry-based tasks; mathematical modelling; case-study method; problem-based learning; digital technologies; interactive platforms; generative artificial intelligence.
Expected outcomes	Well-developed methodological and mathematical, integrative, inquiry, digital, project, creative, and reflective competencies, together with readiness to implement the STEM approach in primary mathematics teaching.
Criteria for assessing methodological readiness	Motivational criterion – professional motivation and readiness for innovative activity; cognitive criterion – level of methodological and STEM knowledge; activity-based criterion – ability to design STEM lessons and apply contemporary technologies; reflective criterion – ability to conduct self-assessment, critical analysis, and continuous professional improvement.

The proposed author's model provides a holistic vision of the methodological training of future primary school teachers for teaching mathematics based on the STEM approach. Its implementation creates favourable conditions for integrating pedagogical technologies, inquiry-based learning, project activities, and digital technologies into teacher education, thereby ensuring the development of methodological readiness for implementing the STEM approach in primary school mathematics instruction. The model may serve as a theoretical and methodological foundation for improving teacher education curricula, developing instructional and methodological resources, and organising the practical preparation of future primary school teachers.

CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH

The findings of the study confirm that the STEM approach provides an effective methodological foundation for modernising the methodological training of future primary school teachers for teaching mathematics. Its implementation promotes the integration of mathematics, science, and technology, facilitates the development of inquiry, project, digital, and communicative competencies, and enhances future teachers' readiness to organise practice-oriented mathematics instruction in accordance with the principles of the New Ukrainian School. The analysis and generalisation of scientific literature made it possible to identify the principal methodological tools for implementing the STEM approach and to determine their didactic potential for the professional preparation of future teachers.

Prospects for further research are associated with the experimental validation of the proposed model in the professional preparation of future primary school teachers, the development of a system for assessing the levels of STEM competency formation, and the investigation of the potential of GenAI, adaptive digital platforms, and other innovative technologies in the methodological training of future teachers for teaching mathematics.

REFERENCES

Balyk, N., & Shmyher, H. (2021). STEM-osvita v konteksti pidhotovky maibutnikh pedahohichnykh kadriv [STEM education in the context of future teacher preparation]. Naukovi zapysky Ternopilskoho natsionalnoho pedahohichnoho universytetu imeni Volodymyra Hnatiuka. Seriia: Pedahohika, (2), 67–74.

García-Carrillo, C., Greca, I. M., & Fernández-Hawrylak, M. (2021). Teacher perspectives on teaching the STEM approach to educational coding and robotics in primary education. Education Sciences, 11(2), Article 64. https://doi.org/10.3390/educsci11020064

Honcharova, N. O. (2017). STEM-osvita v Ukraini: realii ta perspektyvy [STEM education in Ukraine: Realities and prospects]. Humanitarnyi visnyk DVNZ «Pereiaslav-Khmelnytskyi derzhavnyi pedahohichnyi universytet imeni Hryhoriia Skovorody», 37(1), 89–96.

Guo, L. (2012). New curriculum reform in China and its impact on teachers. Canadian and International Education, 41(2), 87–98. https://ir.lib.uwo.ca/cie-eci/vol41/iss2/8

Kuchai, O., Hrechanyk, N., Pluhina, A., Chychuk, A., Biriuk, L., & Shevchuk, I. (2022). World experience in the use of multimedia technologies and the formation of information culture of the future primary school teacher. International Journal of Computer Science and Network Security, 22(3), 760–768. https://doi.org/10.22937/IJCSNS.2022.22.3.100

Kurup, P., Li, X., Powell, G., & Brown, M. (2019). Building future primary teachers' capacity in STEM: Based on a platform of beliefs, understandings and intentions. International Journal of STEM Education, 6, Article 10. https://doi.org/10.1186/s40594-019-0164-5

Kysla, O. F., Koval, V. M., & Hryhorenko, V. V. (2025). Shliakhy pidhotovky maibutnikh uchyteliv do vprovadzhennia STEM-osvity u pochatkovii shkoli [Approaches to preparing future teachers for implementing STEM education in primary school]. Naukovi zapysky. Seriia: Pedahohichni nauky, 218, 127–133. https://doi.org/10.36550/2415-7988-2025-1-218-127-133

Marynchenko, Ye., Sytnikov, O., & Halisevych, V. (2024). Vykorystannia STEM-tekhnolohii ta navchalnykh zasobiv u profesiinii osviti [The use of STEM technologies and instructional tools in vocational education]. Naukovi innovatsii ta peredovi tekhnolohii, 11(39), 1435–1441. https://doi.org/10.52058/2786-5274-2024-11(39)-1435-1441

Mayes, R., & Rittschof, K. (2021). Development of interdisciplinary STEM impact measures of student attitudes and reasoning. Frontiers in Education, 6, Article 709328. https://doi.org/10.3389/feduc.2021.709328

Ministry of Education and Science of Ukraine. (2017). Methodological recommendations for implementing STEM education in general secondary and out-of-school education institutions of Ukraine (Letter of the Institute of Education Content Modernization No. 21.1/10-1470, July 13, 2017). https://zakon.rada.gov.ua/rada/show/v1470777-17#Text

Ministry of Education and Science of Ukraine. (2019). Methodological recommendations for the development of STEM education in general secondary and out-of-school education institutions in the 2019/2020 academic year (Letter of the Institute of Education Content Modernization No. 22.1/10-2876, August 22, 2019). https://osvita.ua/legislation/Ser_osv/65463

Office of the Chief Scientist. (2013). Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach. Australian Government. https://www.chiefscientist.gov.au/sites/default/files/STEM.web.pdf

Polikhun, N. I., Slipukhina, I. A., & Chernetskyi, I. S. (2017). Pedahohichna tekhnolohiia STEM yak zasib reformuvannia osvitnoi systemy Ukrainy [STEM pedagogical technology as a means of reforming the educational system of Ukraine]. Osvita ta rozvytok obdarovanoi osobystosti, (3), 5–9. http://nbuv.gov.ua/UJRN/Otros_2017_3_3

Rakhmanina, A. S. (2024). Preparation of future teachers in higher education institutions of Ukraine by means of STEM technologies (Doctoral dissertation, National University of Life and Environmental Sciences of Ukraine). https://www.nubip.edu.ua/sites/default/files/u145/dis_rahmanina.pdf

Sahaidakivska, A. M. (2025). STEM for primary school: Learning science through play [Practical guide]. https://naurok.com.ua/praktichniy-posibnik-stem-dlya-pochatkovo-shkoli-vivchaemo-nauku-cherez-gru-449966.html

Tanska, V., Maidaniuk, I., Ovcharenko, O., Denysenko, A., & Striletska, N. (2024). STEM yak innovatsiina stratehiia intehrovanoi osvity: svitovyi dosvid ta perspektyvy [STEM as an innovative strategy for integrated education: Global experience and prospects]. Perspektyvy ta innovatsii nauky, 10(44), 596–609. https://doi.org/10.52058/2786-4952-2024-10(44)-596-609

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