Торайғыров университетінің
ҒЫЛЫМИ ЖУРНАЛЫ

НАУЧНЫЙ ЖУРНАЛ
Торайгыров университета

Торайғыров университетінің ХАБАРШЫСЫ

Педагогикалық сериясы
1997 жылдан бастап шығады

ВЕСТНИК ТОРАЙГЫРОВ УНИВЕРСИТЕТА

Педагогическая серия
Издается с 1997 года

ISSN 2710-2661

№ 2 (2026)
Павлодар

НАУЧНЫЙ ЖУРНАЛ
Торайгыров университета

Педагогическая серия
выходит 4 раза в год

СВИДЕТЕЛЬСТВО
о постановке на переучет периодического печатного издания,
информационного агентства и сетевого издания
№ KZ03VPY00029269
выдано
Министерством информации и коммуникаций
Республики Казахстан

Тематическая направленность
публикация материалов в области педагогики,
психологии и методики преподавания

Подписной индекс – 76137

https://doi.org/10.48081/BGQF2048

SRSTI 14.07.07

https://doi.org/10.48081/BGQF2068

N. B. Serikbayeva[1], *A. S. Orynbekova[2] Zh. S. Zhumak[3], S. Zh. Bakhtiyarova[4], A. Zhalel[5]

[1,2]Shakarim University, Republic of Kazakhstan, Semey;
[3]Astana IT University, Republic of Kazakhstan, Astana;
[4]Makhambet Utemisov West Kazakhstan University, Republic of Kazakhstan, Oral;
[5]L. N. Gumiliyov Eurasian National University, Republic of Kazakhstan, Astana.
[1]ORCID: https://orcid.org/0000-0002-7490-7639
[2]ORCID: https://orcid.org/0000-0002-2156-1793
[3]ORCID: https://orcid.org/0009-0008-7717-4259
[4]ORCID: https://orcid.org/0000-0002-4713-9021
[5]ORCID: https://orcid.org/0000-0002-0127-990X
*e-mail: ainur-samatovna@mail.ru

INTEGRATING STEM INTO SECONDARY NATURAL SCIENCES: A SCOPING REVIEW (2019–2025)

The scoping review investigates the application of an integrated approach to STEM (Science, Technology, Engineering and Mathematics) in formal schooling in natural science subjects in secondary school between 2019 and 2025. The scoping review has followed the structure provided in the PRISMA-ScR protocol using a search of the Springer Link database which resulted in 1160 records of which ten peer-reviewed articles matched the inclusion criteria for thematic and descriptive analysis. Examination of the literature showed that the majority of integrated STEM teaching interventions associated with secondary science education were primarily found to integrate engineering design activities into the science curriculum being offered in either Physics or Chemistry using predominately project-based or design-based learning pedagogy. Evidence of increased levels of student engagement, improved understanding of the importance of interdisciplinary connections, and improved development of computational skills was consistently reported; however, evidence supporting increased student academic performance as a result of integrated STEM teaching interventions was mixed across the studies reviewed. The dominant factors reported to account for barriers to the successful implementation of *integrated STEM teaching interventions were reported to be insufficient teacher preparation and lack of resources available to support the various aspects of implementing integrated STEM. In summary, there is a great deal of promise associated with the successful implementation of integrated STEM within secondary education and creative and effective resources, including teacher professional development, assessment tools, and instructional strategies are critical to achieving this promise in a sustainable manner across education systems.*

Keywords: STEM, natural sciences, curriculum integration, secondary education, methodological framework, scoping review.

Introduction

Over the last 10 years, increased demands have been made to include science, technology, engineering, and mathematics (STEM) as part of student curricula [1]. As used here, "integration" refers to the planned linking of at least two of the STEM areas, permitting students to learn beyond a single subject area. Multidisciplinary models are used to provide opportunities for transdisciplinary problem-solving by combining multiple disciplines into one educational experience [2]. Because of the need for specialised laboratory facilities and other specific kinds of support, secondary-level natural science classes (physics, chemistry, biology, geography) also present more complex issues with respect to integration when compared to mathematics and computer science.

Additionally, the various natural science subjects offer a strong project-based educational environment for developing competencies associated with the 21st century, provided that the environments in which these subjects are taught are well-planned and structured [3]. The emergence of different policies has led to a renewed interest in reforming K-12 education through improved learning experiences for students. For example, in 2019, several jurisdictions across the U.S. adopted new iterations of the Next Generation Science Standards, while other jurisdictions such as England and Singapore integrated engineering design into the teaching of science. Furthermore, Sustainable Development Goal 4.4 has called upon education systems to provide young people with the technical competencies needed. The sudden emergence of hybrid schooling resulting from the COVID-19 emergency has increased both the motivation to adopt virtual laboratories and online collaboration as well as the challenges associated with the implementation of such an effort [4]. In contrast, existing synthesised studies are primarily focused on K-3 classrooms or conceptualise STEM as an indivisible entity, leaving a gap in documenting secondary-level natural science teachers' integrations; the manner in which they allocate resources; and measure outcomes. This scoping review fills this gap by mapping the interventions reported from 2019 to 2024, examining their pedagogical or other designs, professional development arrangements, methods of assessment and reported outcomes. The synthesised information from the scoping review provides researchers and policymakers with a methodological baseline that can be empirically supported and serves as a framework for successfully achieving scalable STEM integration within secondary-level natural science education.

Materials and methods

Review design. The evaluation utilized the five-stage framework put forth by Arksey and O'Malley and subsequently refined by Levac, Colquhoun, and O'Brien [5]. The reporting process adhered to the PRISMA–ScR checklist.

Stage 1: Identifying the research question. The guiding question was: How have peer-reviewed studies published between 2019 and 2024 described, implemented, and evaluated integrated STEM interventions in secondary natural science courses?

Stage 2: Identifying relevant studies. A comprehensive search was conducted on Springer Link on 5 February 2025. The Boolean string integrates three conceptual blocks:

«STEM education» OR «integrated STEM» OR «interdisciplinary STEM» OR «STEM curriculum» OR «STEM integration»

«physics» OR «chemistry» OR «biology» OR «geography» OR «natural science»

«secondary school» OR «grades 7–12» OR «curriculum design» OR «pedagogical strategies» OR «teacher training» OR «assessment methods» OR «methodological framework»

The search yielded a total of 1,160 records.

Stage 3: Study selection. Records were exported to Zotero, and duplicates were removed automatically. Two reviewers independently screened titles and abstracts. Subsequently, full-text screening was conducted, with any disagreements being resolved through discussion. A total of ten studies fulfilled all inclusion criteria. Figure 1 presents the PRISMA–ScR flow diagram.

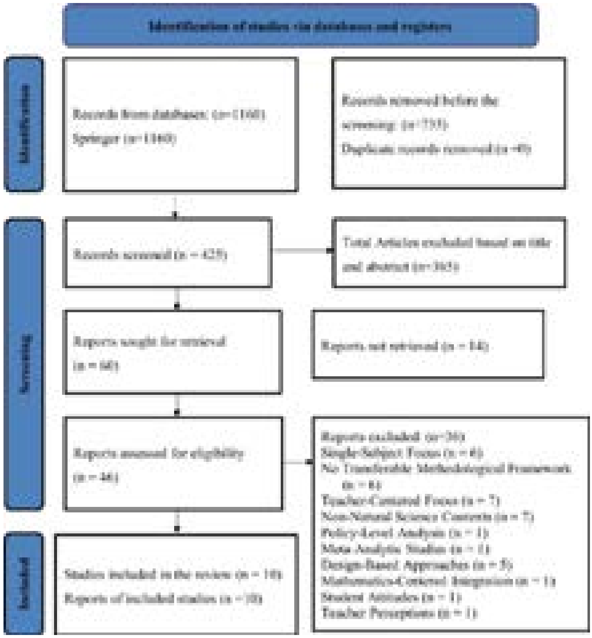

Figure 1 – PRISMA Guideline Flowchart

Inclusion criteria.

Empirical journal articles published in English from January 2019 to December 2024.

Interventions that incorporated a minimum of two STEM domains within secondary-level courses in physics, chemistry, biology, or geography.

Documented outcomes for learners or teachers.

Exclusion criteria

Conference papers, dissertations, or grey literature.

Studies that are exclusively focused on primary or post-secondary education.

Articles that do not contain a description of the instructional intervention.

Stage 4: Data charting. A structured template documented bibliographic details, country of study, study design, participant characteristics, integration model, components of professional development, assessment instruments, and outcomes. One reviewer recorded the data, while a second reviewer verified its accuracy.

Stage 5: Collating, summarising and reporting. The data were analyzed descriptively. Frequencies were computed for study design, subject focus, and outcome type. A narrative, thematic synthesis identified recurrent pedagogical features, teacher development models, and research gaps. No formal critical appraisal was undertaken, as scoping reviews aim to map rather than appraise the quality of evidence. However, the methodological limitations noted by the primary authors were documented to contextualize the synthesis.

Results and discussion

Ten studies met the inclusion criteria, and the findings of these studies are systemically organized into categories based on study characteristics, key findings, and challenges encountered. An integrated summary of all ten studies is provided in Table 1 below.

Characteristics of Studies: The studies included in this analysis are quite diverse with respect to geographic location and research design.

Geographic Distribution: The ten studies in this review covered a broad range of educational settings from different parts of the world. Of these ten studies, four focused on the integration of STEM disciplines within the United States by using three different research designs [6-9]. In addition, each of the remaining six studies (conducted in northern Europe, eastern Africa, western Africa, southern Europe, and east Asia) investigated the topic using one research design [10-15]. The geographic distribution of these ten studies is depicted in Figure 2.

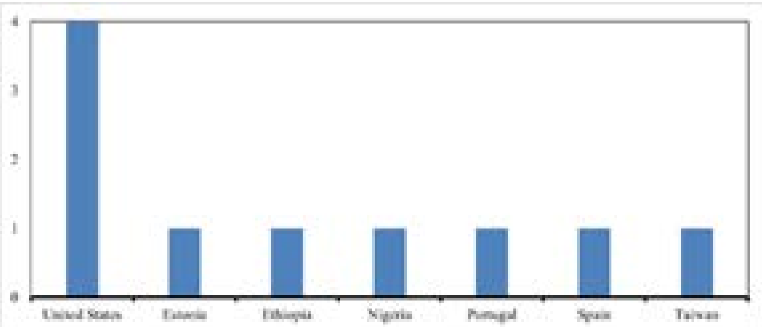

Figure 2 – Geographical Distribution of Included Studies

Design. The research employed a variety of research design across studies in order to ensure rigor in methodology while providing various evaluative perspectives. One study utilized action research design; two studies employed design-based research approaches [7], [11]; three studies utilized quasi-experimental design [10], [12], [13]; and four studies used mixed methods research designs [9], [14]. Eight of the studies applied both quantitative and qualitative methodologies for data collection and analysis. The methodology of these eight studies combined interviews, observations, and statistical analysis to evaluate the intervention rigorously. Two studies, however, focused primarily on quantitative methods to measure the effectiveness of STEM integration [12-13].

Major Findings. The findings from synthesizing the ten studies reveal consistent results in relation to: student learning, teacher professional development, technology integration, and innovative pedagogical practices.

Improved Student Learning Outcomes. Every study has documented improved student engagement and understanding of concepts. Chen and Lin [15] noted higher CAP scores and improved creativity, while Baptista and Martins [13] found that student's cognitive structures developed and decreased the number of alternative conceptions for electrical circuits. Arastoopour Irgens [9] showed a marked increase in high school student's computational thinking skills as a result of participating in a biology unit.

Technology and Computational Thinking Integration. A number of studies have reported the use of technology in the delivery of STEM education [8]. These studies used a variety of digital technologies such as domain-specific modelling language and maker projects to improve student's computational thinking skills and better comprehend physics concepts. The use of these types of resources were shown to develop students problem-solving skills, as well as the ability to use simulation and modelling tools effectively.

Teacher Professional Development and Collaborative Planning. Several researchers have reported the importance of teacher training and collaborative planning for schools. Professional development that is structured and delivered in a collaborative setting will likely increase the effectiveness of integrated STEM curriculum development and instructional delivery. By providing support that helps sustain improvements in teaching practices, ongoing support systems promote reflective instructional development.

Innovative Pedagogical Methods. Contemporary pedagogical approaches combine design thinking and context-specific problem-solving with metacognitive scaffolding. Such approaches have proven integral in connecting theoretical ideas with application in a variety of learning environments and disciplines by promoting inquiry-based learning and encouraging learner involvement in their own learning.

Assessment and Evaluation Methods. There were differences among the studies regarding assessment and evaluation methods used to assess student learning outcomes. Some included pre- and post-testing; others used rubrics to assess students, thematic initiatives to evaluate students' response to the curriculum, or psychometric assessments of student performance. All found significant evidence of improvement when students' learning outcomes after implementing the integrated STEM curriculum were measured against their peers prior to implementation of the integrated STEM curriculum. Chen & Lin reported increased creativity and better CAP scores among students who participated in maker-focused projects using Arduino and S4A. They also incorporated teacher training within an action research methodology and evaluated their implementation by examining students' CAP scores and results from participating in maker-focused competitions.

Han, Kelley, & Knowles illustrated that both students' knowledge of STEM and critical thinking skills increased when students participated in integrated biology and engineering design lessons that were co-taught by multiple teachers. Stem knowledge test and 21st century skill surveys to evaluate the outcome of the co-teaching model were used. Hutchins reported that students' understanding of physics and ability to problem constructively using computers improved after they participated in learning experiences using the C2STEM System and digital simulation/model creation. Evaluation of the Project included measuring students' gains from pre- and post-test comparisons as well as embedded assessment.

Eticha, Hunde, and Ketema reported that the implementation of guided teacher training for constituents of the context-driven problem-solving method improved students' critical thinking and metacognitive skill development. The authors measured the outcome of students' metacognitive skills and their responses with the Likert-type scale perceptions and thematic analyses. The reports by Baptista & Martins demonstrated that using technology and mathematical processes during the electrical circuit design methodology can lead to improved cognitive structures among students and a lower incidence of misconceptions among students. The authors evaluated student outcomes using WAT analysis and cognitive mapping.

Simeon et al. acknowledge the enhancement of student performance in Physics, irrespective of gender, based on their work and findings which utilised PLAT scores with ANCOVA for effect size calculation, whereas Semilarski's findings on Science self-efficacy improvement also included the use of Knowledge Visualisation Maps and Teacher's Professional Development Workshops, utilising Pre/Post Questionnaires, Confirmatory Factor Analysis (CFA) and Paired t-test testing, to evaluate outcomes. Grimalt-Álvaro et al. focused on teacher design sequences as the basis for their professional development, utilising Integrated Professional Development and rubrics and cluster analysis to determine outcomes. Yin reported an increased understanding of Computational Thinking and Maker activities based on the collaborative utilization of iterative Computation Thinking maker activities. The evaluation methodology for this study utilised both Pre/Post CT testing and Psychometrics to assess outcomes. Arastoopour-Irgens showed a substantial increase in Computational Thinking ability in Biology. Their evaluation methodology used Agent-Based modelling, as well as Pre/Post CT testing and Epistemic Network Analysis (ENA) to determine outcomes.

The challenges and limitations of these studies will certainly impede the generalizability and scalability of Integrated STEM Interventions. Chen & Lin specifically mentioned challenges associated with Limited Classroom Space; Scheduling Conflicts; Teacher's preparedness were prominent examples of challenges faced. Additionally, they pointed out limitations associated directly with the Action Research Design; and the inability to adequately support a conclusion regarding causation. Han et al., was similarly challenged by the limited qualitative sample size and restricted number of Observation Sessions related directly to COVID-19. The researcher's study demonstrated that a high degree of reliance on teacher collaboration limits the ability to generalise findings to other contexts. In this regard, the researcher found large unexplained classroom-level variance resulting from their work with teachers. Furthermore, Hutchins reported experiencing difficulties with digital simulations in Interface and Debugging [7]. There exist several tensions pertaining to the amount of scaffolding provided as opposed to allowing free exploration; negative transfer from traditional teaching practices; and the selection of a small sample size. Eticha, Hunde, and Ketema found limited training for teachers in metacognitive strategies and excessive reliance on the curriculum [11]. Their work was impeded by the lack of materials, instructional resources, large class sizes, and limitations from school systems. Baptista and Martins analysed the results of their study from a group perspective by using convenience sampling; this caused the analysis of their data to be extensive and complicated [13]. Simeon, Samsudin, and Yakob implemented a single-group design without a randomised control [12]. Their limitations were identified as a small sample size, being restricted to selected physics concepts and the existence of possible extraneous variables due to the nature of the after-school environment. Semilarski utilised a convenience sample and a 4-point Likert scale without a neutral option which limited capturing the full range of theoretical frameworks [10]. Most of the findings reported by Grimalt-Álvaro, López-Simó, and Tena [14] represent a training context rather than an actual implementation of the research in classrooms. Similar to Semilarski, their work relied on convenience sampling and minimal analyses of personal variables. Yin reported that he had used a non-random assignment of a small, self-selected sample [8]. He identified variability between informal settings and formal settings, variation in the fidelity of implementation and limitations in validation of assessment measures. Arastoopour Irgens – when analysing the final results of their research study – found to have analysed only a small portion of the complete data set, and found they did not have data related to students' prior experience with computational thinking or programming [9]. They also found variability in the writing abilities and processing of language. While analysing their data, they struggled with the automation of Discourse Coding. Thus, it is apparent that there are also a number of factors that need to be addressed in future studies to help increase the overall quality, useability, and authenticity of the integrated STEM methodology, particularly across diverse educational contexts.

This part of the paper provides a thorough examination of the ways that ten of the studies used in it answered the research questions. The discussions were organised into four subsections based on the research questions. Henderson and Sanders focused on creating a framework and strategies for integrating STEM education (science, technology, engineering and mathematics) into the study of natural science in secondary schools. Chen and Lin created an authentic project based curriculum based on the concepts of project-based learning, through a five-phase model consisting of hands-on exploration of tools such as Arduino devices and S4A for creating computer programs to control devices [15].

I would like to thank you for the opportunity to review this work. I know how hard you've both worked to develop your ideas. It has been a privilege to work with you. In addition to my own efforts, I am sure that your insights will provide a further catalyst for continued collaboration between us.

In summary, I hope you and your readers will find the review of the methodology framework and STEM teaching strategies useful. Again, I appreciate the chance to present my thoughts on the study of integration of STEM education into the teaching of natural science in secondary schools. Thank you again!

Impact on Student Learning Outcomes, Engagement, and Interdisciplinary Understanding. Each intervention carried broad implications for student achievement. Researchers Chen and Lin found that students had higher scores in CAP and greater confidence in their creative abilities when participating in the integrative instructional interventions [15]. Han et al., in turn, cited improved knowledge and problem-solving skills in STEM as well as critical thinking skills among students enrolled in integrated lessons [6]. According to Hutchins and Yin, student learning increased due to their incorporation of computational thinking in physics instruction [5]. Eticha et al. reported improved critical thinking and metacognitive skills among students in biology courses [11]. Baptista and Martins observed decreased alternative conceptions about electricity in students participating in the collaborative design process of electrical circuits [13], while significant increases in students' physics performance by gender were noted by Simeon et al. [12]. Semilarski found significantly higher levels of student self-efficacy in science among those using knowledge visualizations [10]. In their study on the teacher's role in the design process of lessons and projects, Grimalt-Álvaro et al. [14] suggested that better-designed sequences of lessons would enhance learning outcomes for students. Arastoopour Irgens confirmed that embedding computational thinking within the science curriculum significantly promoted interdisciplinary learning [9]. Collectively, these studies indicate that integrated approaches to STEM eventually lead to higher levels of learner engagement as well as promote a deeper, more connected understanding of STEM subjects.

Challenges and Barriers to Implementation. Challenges and obstacles surrounding the use of Integrated STEM approaches to learning were discovered as being prevalent in various ways when reviewing the studies that have been done over the years. For example, Chen & Lin [15] identified three main barriers; limited classroom space, scheduling issues and lack of teacher training/preparation. The limitations placed on researchers due to the type of action research methods they employed created even greater challenges for them. Han, Kelley, and Knowles identified a number of obstacles related to small qualitative sample sizes that were impacted by the Covid-19 pandemic. The pandemic impacted their ability to conduct observational sessions, and as a result, produced unknown differences by classroom level. The interface/debugging of Hutchins' work was another area in which she struggled with balancing scaffolding and free exploration. Eticha, Hunde, and Ketema indicated that they ran into additional barriers in the form of few resources, large class sizes and administrative barriers that ultimately limited their ability to fully utilise the implementation of metacognitive scaffolding [11].

Simeon, Samsudin and Yakob [12] and Baptista & Martins [13] discussed the types of limitations encountered by researchers using quasi-experimental designs. A couple of the issues reported were related to non-randomised samples and contextual factors impacting after-school sites. Semilarski et al described their struggles with instrument limitations, including usage of a 4-point Likert scale, as well as how it impacted their ability to effectively measure central ideas [10]. The authors Grimalt-Alvaro, Lopez-Simo, and Tena asserted that the findings from a training setting might not necessarily apply to the real classroom environment [14]. Yin and Arastoopour-Irgens [9] each described the challenge of working with small samples that were self-selected and inconsistencies in fidelity of implementation. These studies provide evidence that while Integrated STEM models provide certain advantages, there are multiple obstacles the researchers and educators need to address. These barriers include the resources (human and material), methodology and training/readiness of teachers to optimise the impact of Integrated STEM Education and Learning Programs.

Recommendations for a Robust, Scalable Methodological Basis. The synthesis provided a set of four interrelated recommendations that comprise a unified vision for future research and practice. Each recommendation addresses a specific area of evidence deficiency. First and foremost, continuous professional development for educators, and opportunities for collaboration, is essential. The most effective forms of intervention incorporated both structured and iterative training. These training experiences resulted in the construction of co-planning and reflective practices among teachers. However, only a small number of studies have examined the impact of co-planning and reflective practices on the implementation of instruction in classrooms over multiple units of time. Future research designs must include longitudinal mentoring cycles and report on teacher outcomes across multiple semesters in order to determine whether co-planning and reflective practices result in sustained implementation of instructional practices.

Secondly, the design of modular, adaptable frameworks for instructional delivery is a requirement for future research. Digital resources and maker experiences facilitate adaptable sequences of instruction and can be easily adapted based on feedback from learners. Unfortunately, only two studies to date have provided version histories or usability data on modular instructional resources. Researchers in the future are encouraged to develop an open-source instructional module with an associated adaptation log to allow for the fidelity and adaptability of future investigations.

Thirdly, the use of computational tools in conjunction with design-thinking methods, such as agent-based modelling and structured-design cycles, consistently supports the development of computational thinking and enhances students' capabilities to solve problems. Although there is a significant evidence gap in the area of how students are able to transfer computational thinking skills to unfamiliar contexts, future projects should pair the use of computational tools with assessments requiring students to utilise their computational thinking skills to solve new scientific problems.

Fourth, multi-faceted and balanced assessments are now known to produce superior results when compared to pre-test/post-test assessments, rubric-based performance assessments or cognitive mapping. These assessments yield a much clearer picture of how well students have learned. A standardised assessment instrument does not exist in the field, and only a limited number of studies have reported follow-up data for assessment studies; therefore, it is essential that future studies develop validated instruments that are sensitive to disciplines, and include regular follow-up assessments to document retention and growth.

Across all four areas, funding remains the primary barrier to scale, and specific funding for teacher release, low-cost digital laboratories, and a repository of common assessments will alleviate this barrier and support the creation of comparable bodies of evidence.

Implications for Practice. We have found evidence from our review that there is a positive impact on student learning and instruction by integrated STEM education in the natural sciences; below are five recommendations for practitioners:

1. Encourage the use of 21st-century instructional strategies such as design thinking, maker-centred, and contextualised problem-solving methods to successfully integrate theoretical concepts into practice.

2. Enhance teacher professional development through structured training and collaborative planning opportunities to enhance teachers' ability to integrate the curriculum.

3. Strategically integrate the technological resources (digital tools, simulation platforms and computational modules) that are available to develop computational thinking and problem-solving skills.

4. Use a comprehensive set of assessments to effectively monitor student progress, including pre-tests and post-tests, rubric evaluations, and performance assessments, to inform instructional strategies.

5. Understand and address resource limitations and use this information to make implementation modifications based on the local context.

Conclusion

This scoping review synthesised evidence from 10 studies carried out in a variety of geographic contexts with different research methodologies. Results indicated that integrated STEM models (i.e., Maker-centred Project-Based Learning (PBL), Design Thinking, Computational Thinking Integration, and Metacognitive Scaffolding) greatly enhanced students' engagement, conceptual understanding, and interdisciplinary learning in Natural Science. Also identified was the importance of teacher professional development and collaborative planning for effective implementation of these methods. Despite this, several issues limited these studies such as a lack of resources, methodological limitations, and variability of teacher preparedness. Therefore, additional studies should be performed to develop more rigorous, scalable, and adaptable models for integrating STEM into secondary science education. The overall conclusion drawn from this review was that it provided a strong methodological foundation for integrating STEM into secondary science education and provided recommendations for subsequent studies.

References

1 **Bybee, R. W.** The case for STEM education: Challenges and opportunities. – 2013.

2 **Stohlmann, M., Moore, T. and Roehrig, G.** Considerations for teaching integrated STEM education // Journal of Pre-College Engineering Education Research (J-PEER). – 2012. – Vol. 2. – No. 1. – P. 4. – https://doi.org/10.5703/1288284314653.

3 **Bell, S.** Project-based learning for the 21st century: Skills for the future //The clearing house. – 2010. – Vol. 83. – № 2. – P. 39–43. – https://doi.org/10.1080/00098650903505415.

4 **Yin, Y., Hadad, R., Tang, X. and Lin, Q.** Improving and assessing computational thinking in maker activities: The integration with physics and engineering learning //Journal of Science Education and Technology. – 2020. – Vol. 29. – No. 2. – P. 189-214. – https://doi.org/10.1007/s10956-019-09794-8.

5 **Levac, D., Colquhoun, H. and O'Brien, K. K.** Scoping studies: advancing the methodology //Implementation science. – 2010. – Vol. 5. – № 1. – P. 69. – https://doi.org/10.1186/1748-5908-5-69.

6 **Han, J., Kelley, T. and Knowles, J. G.** Building a sustainable model of integrated stem education: investigating secondary school STEM classes after an integrated STEM project //International Journal of Technology and Design Education. – 2023. – Vol. 33. – № 4. – P. 1499–1523. – https://doi.org/10.1007/s10798-022-09777-8.

7 **Hutchins, N. M.** C2STEM: A system for synergistic learning of physics and computational thinking //Journal of Science Education and Technology. – 2020. – Vol. 29. – № 1. – P. 83–100. – https://doi.org/10.1007/s10956-019-09804-9.

8 **Dhawan, S.** Online learning: A panacea in the time of COVID-19 crisis // Journal of educational technology systems. – 2020. – Vol. 49. – № 1. – P. 5–22. – https://doi.org/10.1177/0047239520934018.

9 **Arastoopour Irgens, G.** Modeling and Measuring High School Students' Computational Thinking Practices in Science //Journal of science education and technology. – 2020. – Vol. 29. – № 1. – P. 137–161. – https://doi.org/10.1007/s10956-020-09811-1.

10 **Semilarski, H., Soobard, R., Holbrook, J. and Rannikmäe, M.** Expanding disciplinary and interdisciplinary core idea maps by students to promote perceived self-efficacy in learning science //International Journal of STEM Education. – 2022. – Vol. 9. – № 1. – P. 57. – https://doi.org/10.1186/s40594-022-00374-8.

11 **Eticha, M. D., Hunde, A. B. and Ketema, T.** Designing a context-driven problem-solving method with metacognitive scaffolding experience intervention for biology instruction //Journal of Science Education and Technology. – 2024. – Vol. 33. – № 6. – P. 811–822. – https://doi.org/10.1007/s10956-024-10107-x.

12 **Simeon, M. I., Samsudin, M. A. and Yakob, N.** Effect of design thinking approach on students' achievement in some selected physics concepts in the context of STEM learning //International Journal of Technology and Design Education. – 2022. – Vol. 32. – № 1. – P. 185–212. – https://doi.org/10.1007/s10798-020-09601-1.

13 **Baptista, M. and Martins, I.** Effect of a STEM approach on students' cognitive structures about electrical circuits //International Journal of STEM Education. – 2023. – Vol. 10. – № 1. – P. 15. – https://doi.org/10.1186/s40594-022-00393-5.

14 **Grimalt-Álvaro, C., López-Simó, V. and Tena, È.** How Do Secondary-School Teachers Design STEM Teaching–Learning Sequences? A Mixed Methods Study for Identifying Design Profiles //International Journal of Science and Mathematics Education. – 2025. – Vol. 23. – № 1. – P. 235–260. – https://doi.org/10.1007/s10763-024-10457-3.

15 **Chen, C.-S. and Lin, J.-W.** A practical action research study of the impact of maker-centered STEM-PjBL on a rural middle school in Taiwan //International Journal of Science and Mathematics Education. – 2019. – Vol. 17. – № Suppl 1. – P. 85–108. – https://doi.org/10.1007/s10763-019-09961-8.

Received 12.03.25.
Received in revised form 06.04.26.
Accepted for publication 15.05.26.

Н. Б. Серикбаева[1], **A. S. Orynbekova*[2],
Ж. С. Жұмақ[3], *С. Ж. Бахтиярова*[4], *А. Жалел*[5]
[1,2]Шәкәрім университеті,
Қазақстан Республикасы, Семей қ.;
[3]Astana IT university,
Қазақстан Республикасы, Астана қ.;
[4]Махамбет Өтемісов атындағы Батыс Қазақстан университеті,
Қазақстан Республикасы, Орал қ.;
[5]Л. Н. Гумилев атындағы Еуразия ұлттық университеті,
Қазақстан Республикасы, Астана қ.
12.03.25 ж. баспаға түсті.
06.04.26 ж. түзетулерімен түсті.
15.05.26 ж. басып шығаруға қабылданды.

ЖАРАТЫЛЫСТАНУ ПӘНДЕРІНЕ STEM ТӘСІЛДЕРІН КІРІКТІРУ: 2019–2025 ЖЫЛДАРДАҒЫ ЗЕРТТЕУЛЕРГЕ ШОЛУ

Бұл шолу мақала 2019–2025 жылдар аралыгында орта мектептегі жаратылыстану пәндерін оқытуда STEM-нің (ғылым, технология, инженерия және математика) интеграцияланған тәсілінің формалды білім беру жүйесінде қолданылуын зерттейді. Шолу PRISMA-ScR протоколының құрылымына сәйкес жүргізіліп, *Springer Link дерекқорында жасалған іздеу нәтижесінде 1 160 жарияланым анықталды, олардың ішінен он (10) рецензияланған мақала іріктеу критерийлеріне сәйкес келіп, тақырыптық және сипаттамалық талдауға алынды. Әдебиеттерді талдау орта мектептегі STEM-ді кіріктіріп оқытуға бағытталған интервенциялардың басым бөлігі физика немесе химия пәндерінің оқу бағдарламаларына инженерлік жобалау әрекеттерін енгізуге негізделгенін және көбінесе жобалық немесе дизайнға негізделген оқыту педагогикасын қолданғанын көрсетті. Зерттеулерде оқушылардың оқу үдерісіне қатысу деңгейінің артуы, пәнаралық байланыстардың маңызын терең түсінуі және есептеу дағдыларының дамуы жүйелі түрде байқалғанымен, интеграцияланған STEM оқытуының оқу жетістіктеріне әсері бойынша дәлелдер біркелкі болмады. Интеграцияланған STEM-ді табысты іске асыруға кедергі келтіретін негізгі факторлар ретінде мұғалімдердің жеткіліксіз дайындығы және STEM-ді енгізудің әртүрлі аспектілерін қолдауға арналған ресурстардың тапшылығы жиі аталды. Қорытындылай келе, интеграцияланған STEM-нің орта білім беруде тиімді жүзеге асырылуы үлкен әлеуетке ие, алайда бұл әлеуетті білім беру жүйелерінде тұрақты түрде іске асыру үшін мұғалімдердің кәсіби дамуын, сенімді бағалау құралдарын және тиімді оқу стратегияларын қамтитын креативті әрі нәтижелі ресурстардың маңызы зор.*

Кілттік сөздер: STEM, жаратылыстану, оқу бағдарламасын интеграциялау, орта білім, әдіснамалық негіз, скопингтік шолу.

**Н. Б. Серикбаева[1], *А. С. Орынбекова[2]*
Ж. С. Жұмақ[3], С. Ж. Бахтиярова[4], А. Жалел[5]
[1,2]Университет Шакарима,
Республика Казахстан, г. Семей;
[3]Astana IT university,
Республика Казахстан, г. Астана;
[4]Западно-Казахстанский университет имени М. Утемисова,
Республика Казахстан, г. Урал;
[5]Л. Н. Гумилев атындағы Еуразия ұлттық университеті,
Республика Казахстан, г. Астана.
Поступило в редакцию 12.03.25.
Поступило с исправлениями 06.04.26.
Принято в печать 15.05.26.

ИНТЕГРАЦИЯ STEM-ПОДХОДОВ В ПРЕПОДАВАНИЕ ЕСТЕСТВЕННО-НАУЧНЫХ ДИСЦИПЛИН В СРЕДНЕЙ ШКОЛЕ: ОБЗОР 2019–2025 ГОДОВ

В данном обзоре исследуется применение интегрированного подхода STEM (наука, технологии, инженерия и математика) в формальном школьном образовании по естественно-научным предметам в средней школе в период с 2019 по 2025 годы. Обзор выполнен в соответствии со структурой протокола PRISMA-ScR на основе поиска в базе данных Springer Link, в результате которого было выявлено 1 160 публикаций, из них десять (10) рецензируемых статей соответствовали критериям включения и были отобраны для тематического и описательного анализа. Анализ литературы показал, что большинство интервенций по интеграции STEM в средней школе основывались на включении инженерно-дизайнерской деятельности в учебные программы по физике или химии с преимущественным использованием проектного или дизайн-ориентированного обучения. В исследованиях последовательно фиксировались повышение уровня вовлечённости учащихся, более глубокое понимание значимости междисциплинарных связей и развитие вычислительного мышления, однако данные о росте академической успеваемости учащихся носили неоднозначный характер. В качестве основных барьеров успешной реализации интегрированных STEM-интервенций чаще всего отмечались недостаточная подготовка учителей и ограниченность ресурсов для поддержки различных аспектов внедрения STEM. В целом интегрированный STEM обладает значительным потенциалом для развития среднего образования, однако для устойчивой реализации данного потенциала необходимы креативные и эффективные ресурсы, включая профессиональное развитие учителей, надёжные инструменты оценки и продуманные учебные стратегии на уровне образовательных систем.

Ключевые слова: STEM, естественные науки, интеграция учебных программ, среднее образование, методологические рамки, скопинг-обзор.

Теруге 15.05.2026 ж. жіберілді. Басуға 30.06.2026 ж. қол қойылды.
Электронды баспа
26,3 Kb RAM
Шартты баспа табағы 50,81
Таралымы 300 дана. Бағасы келісім бойынша.
Компьютерде беттеген З. Ж. Шокубаева
Корректорлар: А. Р. Омарова, Д. А. Кожас
Тапсырыс № 4566

Сдано в набор 15.05.2026 г. Подписано в печать 30.06.2026 г.
Электронное издание
26,3 Kb RAM
Усл.п.л. 50,81. Тираж 300 экз. Цена договорная.
Компьютерная верстка З. Ж. Шокубаева
Корректоры: А. Р. Омарова, Д. А. Кожас
Заказ № 4566

«Toraighyrov University» баспасынан басылып шығарылған
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.

«Toraighyrov University» баспасы
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.
8 (7182) 67-36-69
e-mail: kereku@tou.edu.kz
www.pedagogic-vestnik.tou.edu.kz