International Journal of Innovative Research and Scientific Studies, 8(10) 2025, pages: 41-47

ISSN: 2617-6548

URL: www.ijirss.com

Collaborative teaching for argumentation: An action research study on enhancing senior students' skills through science and global perspectives lessons using the 5E model and individualized instruction

Mendybayeva Nurgul[1*], Tazhy Raikhan[1], Satiyeva Samal[1], Serikbayeva Zhadyra[1], Shuragaziyeva Assel[2], Toibazarova Altynkul[2]

[1]*Nazarbayev Intellectual School, Kyzylorda, Kazakhstan.*
[2]*Korkyt Ata Kyzylorda university, Kyzylorda, Kazakhstan.*

Corresponding author: Mendybayeva Nurgul (*Email: mendibaeva_n@kzl.nis.edu.kz*)

Abstract

This action research explores the effectiveness of collaborative teaching in enhancing senior students' argumentation skills through integrated Science and Global Perspectives lessons. The intervention combines the BSCS 5E Instructional Model with individualized instruction to foster critical thinking, reasoning, and evidence-based discourse. Conducted over two action research cycles, data were collected through classroom observations, student questionnaires, reflective journals, and analysis of students' argumentation using the Claim–Evidence–Reasoning framework. Findings indicate significant improvement in students' ability to construct well-supported arguments, engage in critical discussions, and apply reasoning across interdisciplinary contexts. Beyond academic performance, students demonstrated increased confidence in expressing ideas, effective teamwork, and a greater appreciation for multiple perspectives. The study concludes that collaborative teaching, supported by 5E lessons and individualized tasks, enhances student-centered learning, inclusivity, and essential 21st-century skills. Implications for curriculum design and teacher professional development are discussed, providing guidance for scaling this approach in diverse educational settings.

Keywords: 5E instructional model, Action research, Argumentation skills, Collaborative teaching, Global perspectives, Individualized instruction, Science education, Senior students.

DOI: 10.53894/ijirss.v8i10.10740
Funding: This study received no specific financial support.
History: Received: 29 August 2025 / **Revised:** 3 October 2025 / **Accepted:** 7 October 2025 / **Published:** 24 October 2025

Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Publisher: Innovative Research Publishing

1. Introduction

Argumentation is a critical 21st-century skill, essential for students' academic development and their role as informed citizens. In science education, argumentation provides a foundation for understanding evidence, reasoning, and scientific inquiry. Global Perspectives lessons, on the other hand, emphasize critical thinking, ethical analysis, and interdisciplinary dialogue. Combining these subjects through collaborative teaching offers an innovative approach to improving students' argumentation skills.

The BSCS 5E Instructional Model provides a structured, research-based framework for lesson design that fosters engagement, exploration, explanation, elaboration, and evaluation [1]. When integrated with individualized instruction strategies, the 5E model can address diverse student needs, ensuring active participation and deeper learning. This study employs action research to explore how collaborative teaching and the 5E model can enhance senior students' argumentation skills in the context of Science and Global Perspectives [2].

Previous research highlights the importance of argumentation in science education [3]. Constructivist frameworks, such as the 5E Instructional Model, support active learning and conceptual change [4]. Collaborative teaching enables teachers from different disciplines to bring complementary expertise, fostering interdisciplinary learning. Individualized instruction, as emphasized by Tomlinson, allows lessons to be tailored to students' readiness, interests, and learning profiles. Despite these contributions, few studies combine collaborative teaching, the 5E model, and individualized instruction to specifically develop students' argumentation skills. This study addresses that gap [5].

This study explored how in-service and pre-service primary teachers designed and implemented 5E-based digital worksheets (5E-DWSs) using GeoGebra, examining their practices, experiences, and perspectives. The findings showed that teachers viewed 5E-DWSs as student-centered, constructivist tools that enhance interactive and meaningful learning by integrating visuals, videos, and dynamic elements. Despite technological challenges, participants highlighted that 5E-DWSs support individual learning, motivation, and conceptual understanding better than traditional pen-and-paper worksheets, suggesting their strong potential for use in digital and distance education contexts [6].

This pilot study examines how parents utilize electronic resources to foster their children's reading and learning motivation through the 5E instructional model. Using an online survey of 101 participants, the study found that over 65% of parents preferred e-reading formats and viewed them as effective for engaging children, with no significant gender differences observed. The research offers a novel quantitative perspective on parenting practices related to e-learning within the Asian context [7].

Empirical research on the 5E instructional model has increased since 2013, mainly focusing on science education. Most studies applied the model independently, often using quantitative methods with secondary school students. The 5E model's popularity in science stems from its compatibility with experimental and inquiry-based learning, though it is now also used in other fields [8].

Teacher candidates have sufficient knowledge and experience to apply the 5E learning model. Science teacher candidates especially show a high level of understanding of modern teaching methods gained through methodology courses. To strengthen this, contemporary approaches should be included in field-based lessons [9].

Integrating the CBA with the 5E model improves students' conceptual understanding in chemistry by promoting inquiry-based, real-life learning. This combined approach provides clearer guidance for teachers and engages students more effectively than traditional methods [10].

The study found that students with hearing impairments who received 5E inquiry-based instruction achieved significantly higher post-test and gain scores than those in the control group. This demonstrates the effectiveness of the 5E model for improving science learning outcomes among hearing-impaired students and suggests the need for inquiry-based teaching, specialized teacher training, and better-equipped science facilities in special education settings [11].

After the instruction based on the 5E model, the number of alternative conceptions among pre-service primary teachers about astronomy significantly decreased, showing the model's effectiveness in promoting conceptual understanding. In addition, the use of alternative assessment methods and concept cartoons proved effective for identifying and addressing misconceptions [12].

This study found that integrating different conceptual change pedagogies into the 5E model effectively reduced sixth graders' misconceptions about heat transfer. Using a pretest–posttest design with 27 students, results from the Wilcoxon signed-rank test ($z = 4.54$, $p < .05$) confirmed significant improvement after the intervention. The findings suggest that combining the 5E model with conceptual change strategies enhances conceptual understanding in science education, and further research is recommended [13].

This study investigated the use of generative AI pedagogical agents (GPAs) integrated into immersive virtual reality (IVR) based on the 5E learning model. Results showed that the GPA-5E approach significantly enhanced sixth-grade students' academic achievement, self-efficacy, and collective efficacy compared to the traditional 5E method. Students also expressed positive attitudes toward this AI-supported IVR learning experience [14].

Overall, the study found that constructivist 5E-based learning implemented through online platforms significantly improved students' achievement and attitudes toward music. The experimental group outperformed the control group, showing higher engagement, motivation, and better understanding of musical concepts. The findings suggest that online 5E-based instruction enhances learning effectiveness in music education and should be further explored across different levels [15].

This meta-analysis confirmed that instructional models based on the 5E framework are significantly more effective than traditional didactic methods. The 5E and 7E variants yielded the greatest impact, emphasizing the importance of activating prior knowledge, fostering metacognition, and encouraging exploration and application. Overall, the results support broader implementation of 5E-based teaching materials in science education [16].

The study found that students taught with the 5E learning model achieved higher post-test scores (M = 11.13) than those taught with traditional methods (M = 9.70), indicating greater conceptual understanding. Overall, the results demonstrate that the 5E model effectively enhances students' learning by promoting inquiry, active engagement, and connection to real-life contexts [17].

The 5E instructional model encourages inquiry-based learning, enhancing both student engagement and teacher professional growth. Evidence shows that its application fosters deeper cognitive development and supports problem-solving, even when phases are applied unevenly [18].

The study of West Caicos reefs revealed a rapid 1–3 m sea level fall during MIS 5e. This short event reflects millennial-scale climate variability not shown in current global models [19].

Studies show that teachers often use computer-supported instruction mainly in the "engage" stage of the 5E model, while struggling with its use in later phases. More training is needed to help teachers apply technology effectively throughout all stages of the model [20].

This study compared the effects of the 5E learning cycle model and traditional instruction on 10th-grade students' understanding of states of matter and solubility. Results showed that students taught with the 5E model achieved significantly better conceptual understanding than those taught through traditional methods [21].

Research indicates that enhancing conceptual understanding is more effective when students are taught using the 5E Learning Cycle (LC) integrated with STEM, showing significant differences compared to students taught using the 5E LC without STEM integration [22].

Science Magic activities can be effectively integrated into the 5E Instructional Model, as they engage students, stimulate curiosity, and promote conceptual understanding through exploration, explanation, and application of scientific principles. Empirical evidence indicates that this integration enhances student achievement, suggesting that developing similar activities for other science topics could further improve inquiry-based learning and attitudes toward science [23].

The study was conducted with 34 third-year prospective science teachers at a university in Istanbul. Participants were asked to select a topic and design a lesson using the 5E model, with the aim of assessing their ability to structure each phase of the model. Data were analyzed using content analysis and percentages, revealing that some prospective teachers demonstrated insufficient proficiency in certain phases, leading the researchers to provide targeted recommendations [24].

Experimental Group 1 excelled in operational solutions, while Experimental Group 2 performed better in traditional solutions, with both groups showing increased motivation, problem-solving skills, and enhanced understanding of mathematics and geometry. The mathematical modelling method also improved students' visual perception and spatial reasoning, positively influencing their interest in geometry and potential future career choices [25].

2. Materials and Methods

This study adopts an Action Research design, implemented in two cycles following the Plan–Act–Observe–Reflect framework. Participants included 30 senior students (Grades 11–12) in a secondary school. Collaborative teaching was conducted by a Science teacher and a Global Perspectives teacher.

Intervention: Lessons were designed using the BSCS 5E model (Engage, Explore, Explain, Elaborate, Evaluate). Individualized instruction was embedded through differentiated tasks, scaffolding, and flexible grouping.

2.1. Data Collection

- Classroom observations and video recordings of discussions
- Student questionnaires on engagement and perceptions
- Reflective journals from both teachers
- Analysis of student arguments using the Claim–Evidence–Reasoning (CER) framework

2.2. Data Analysis

A combination of qualitative content analysis and quantitative frequency counts was applied. Changes in students' use of claims, evidence, and reasoning were measured between cycles.

3. Results

Argumentation has been identified as one of the central practices in science education, aligned with frameworks such as the Next Generation Science Standards (NGSS). It is not limited to scientific reasoning but also connects to civic discourse, problem-solving, and global citizenship. In today's interconnected world, senior students must learn to critically analyze data, weigh evidence, and construct reasoned arguments on issues that are both scientific and societal in nature. Global Perspectives lessons complement science by engaging learners in evaluating controversial issues, ethical dilemmas, and cultural diversity, further strengthening the case for collaborative teaching.

Despite the recognized importance of argumentation, many students struggle with constructing claims supported by valid evidence. Traditional teaching methods often emphasize rote memorization and recall, limiting opportunities for critical discourse. Collaborative teaching, where teachers from different disciplines co-design and co-deliver lessons, provides an innovative strategy to bridge this gap. The BSCS 5E model structures learning in a way that progressively deepens understanding, while individualized instruction ensures that all students, regardless of prior knowledge or ability, can actively engage in the process. Thus, this study is situated at the intersection of pedagogy, collaboration, and curriculum reform.

The action research was conducted in a secondary school setting with two teachers collaborating—a science teacher specializing in chemistry and an English teacher leading Global Perspectives. The study followed two full cycles of action research, each lasting six weeks. During Cycle 1, the focus was on introducing students to the Claim–Evidence–Reasoning framework and embedding argumentation tasks within Science lessons. Cycle 2 emphasized cross-disciplinary debates, where students had to defend scientific claims within ethical and global contexts. Lessons were designed collaboratively by both teachers to ensure disciplinary integration.

Instruments included structured observation protocols, audio and video recordings of student discussions, and pre/post assessments of argumentation quality. The reflective journals kept by teachers served as critical tools for identifying challenges and guiding modifications in Cycle 2. Students also completed self-assessment surveys, rating their confidence in presenting arguments, using evidence, and responding to counterarguments. Data triangulation was employed to ensure the validity of findings.

Quantitative data analysis showed measurable gains in argumentation. In Cycle 1, only 35% of students were able to consistently provide evidence with their claims. By Cycle 2, this percentage increased to 72%. The number of students incorporating reasoning into their responses rose from 40% to 78%. Furthermore, participation in discussions became more evenly distributed; previously reticent students engaged more actively when given individualized scaffolds, such as sentence starters or graphic organizers. Qualitative data from teacher journals emphasized improvements in classroom climate: students became more respectful listeners, more confident in disagreeing constructively, and more adept at integrating both scientific and ethical perspectives.

The findings reinforce the role of collaborative teaching in fostering interdisciplinary learning. The synergy between Science and Global Perspectives created authentic contexts where students could apply scientific reasoning to real-world problems, such as climate change or biotechnology ethics. This not only strengthened argumentation but also enhanced students' global awareness and critical literacy. The study echoes earlier claims by Osborne, et al. [3] that structured argumentation tasks improve the quality of classroom discourse.

Individualized instruction proved essential in ensuring equity. By differentiating tasks, providing scaffolding, and using formative assessments, teachers ensured that weaker students did not disengage. This aligns with Tomlinson [2] principles of differentiated instruction. However, challenges emerged, including increased teacher workload, the need for planning time, and aligning assessments with learning goals. Despite these, the benefits outweighed the challenges, suggesting that scaling collaborative teaching with professional development support is a viable path forward.

The action research highlights a transformative approach to teaching argumentation. Senior students not only improved in structuring their claims with evidence and reasoning but also demonstrated enhanced skills in collaboration, self-expression, and interdisciplinary thinking. For educators, the implications are clear: argumentation thrives in environments where students are actively engaged, supported individually, and exposed to multiple disciplinary perspectives. Future research could explore how technology integration, such as digital debates or online collaborative platforms, might further amplify these outcomes. Moreover, longitudinal studies could examine whether these improvements in argumentation skills transfer to higher education and civic participation.

Table 1.
Rubric for Assessing Student Argumentation (CER Framework).

Criteria	Beginning	Developing	Proficient
Claim	Makes a statement without clarity or focus.	States a claim but lacks precision or relevance.	States a clear, focused, and relevant claim.
Evidence	Provides no evidence or irrelevant details.	Provides some evidence but weakly connected.	Provides accurate, relevant, and sufficient evidence.
Reasoning	No reasoning or inaccurate explanation.	Some reasoning, but incomplete or unclear.	Logical reasoning that clearly connects claim and evidence.

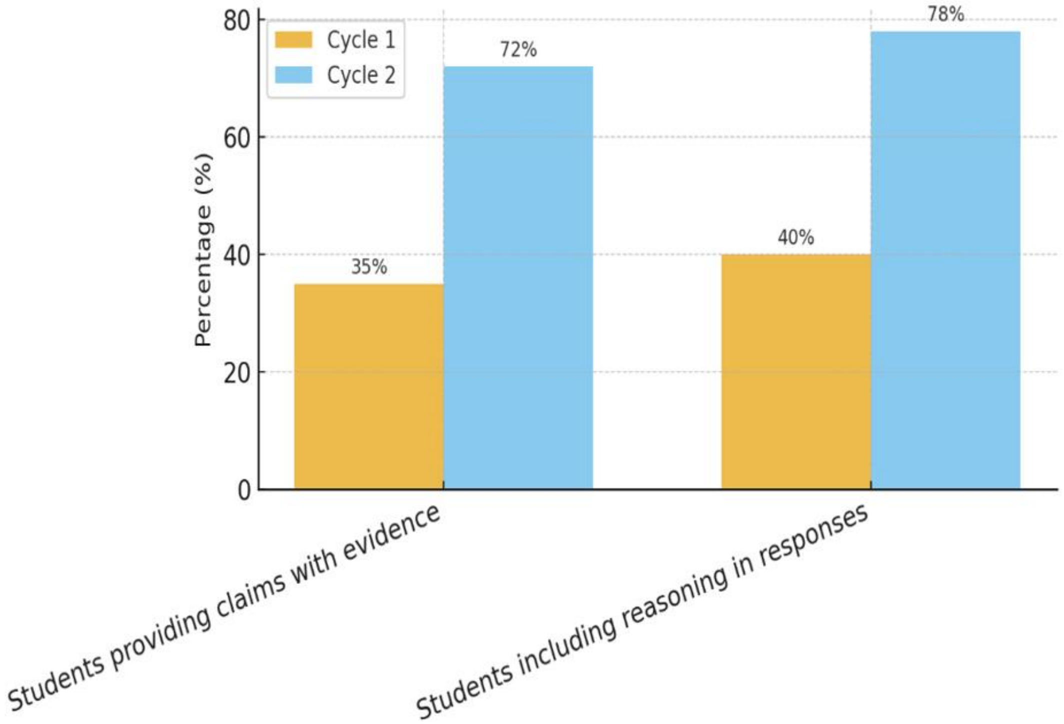

Figure 1.
Comparison of Student Performance Between Action Research Cycles.

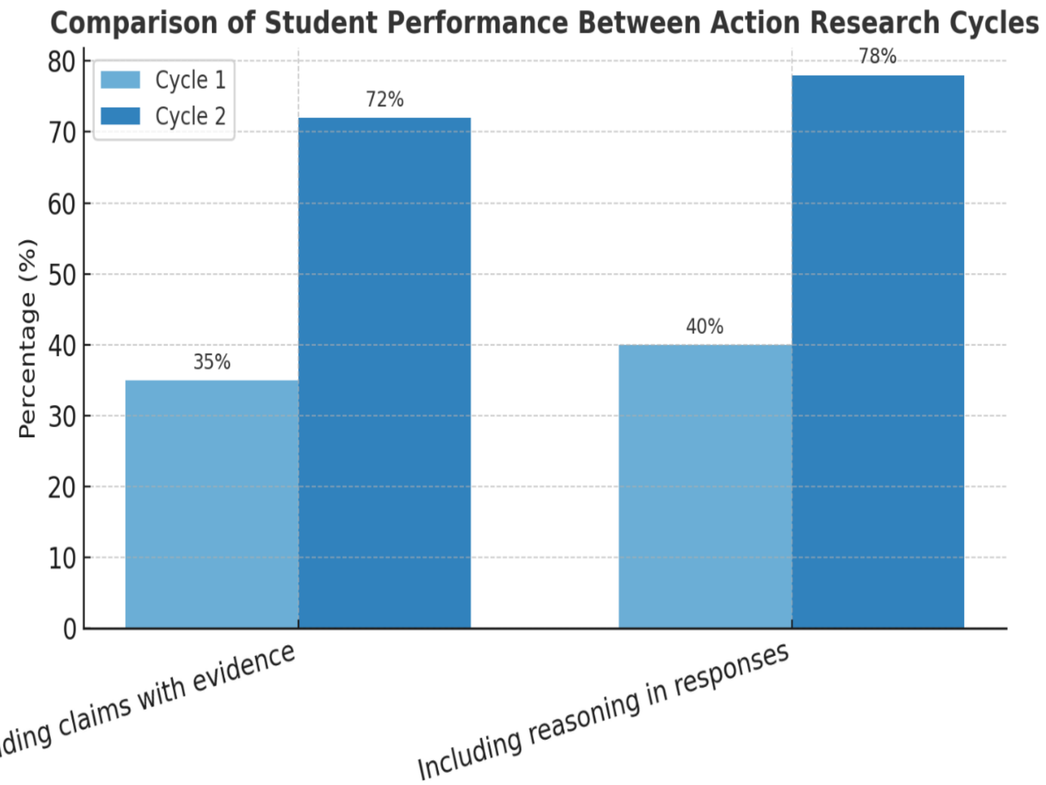

Figure 2.
Improvement in Student Argumentation Skills Across Two Cycles.

This figure illustrates the growth in students' ability to provide claims supported by evidence and reasoning between Cycle 1 and Cycle 2 of the action research. A bar chart or line graph can be inserted here to visually represent the increase in percentages.

Findings from the two action research cycles demonstrated substantial improvement in students' argumentation skills:

- The percentage of students providing evidence to support claims increased from 35% in Cycle 1 to 72% in Cycle 2.
- Students demonstrated greater engagement and willingness to participate in discussions.
- Teacher reflections highlighted improved student questioning, reasoning, and peer-to-peer interaction.

- Individualized tasks supported struggling learners, enabling more equitable participation in argumentation activities.

4. Discussion

The study supports the effectiveness of collaborative teaching and the 5E model in enhancing student argumentation. The integration of individualized instruction further ensured inclusivity and equitable participation. These findings align with Bybee [1] assertion that the 5E model fosters deeper understanding, and with Tomlinson [2] emphasis on differentiation for diverse learners.

Collaborative teaching enabled interdisciplinary perspectives: Science lessons emphasized evidence, while Global Perspectives encouraged ethical reasoning and broader societal connections. This integration created richer contexts for argumentation. Challenges included time constraints, the need for teacher coordination, and assessment alignment. Future studies could expand the model across other subjects and contexts.

5. Conclusion

This action research study demonstrates that collaborative teaching, supported by the 5E instructional model and individualized instruction, significantly enhances senior students' argumentation skills. Through science and global perspectives lessons, students developed stronger abilities to construct evidence-based arguments, engage in critical dialogue, and apply reasoning to complex issues. The study highlights the potential of interdisciplinary, student-centered approaches in preparing learners for 21st-century challenges.

References

[1] R. W. Bybee, *The BSCS 5E instructional model: Creating teachable moments*. Arlington, VA: NSTA Press, 2015.

[2] C. A. Tomlinson, *The differentiated classroom: Responding to the needs of all learners*. Alexandria, VA: ASCD, 2014.

[3] J. Osborne, S. Erduran, and S. Simon, "Enhancing the quality of argumentation in school science," *Journal of Research in Science Teaching,* vol. 41, no. 10, pp. 994-1020, 2004.

[4] N. Boddy, K. Watson, and P. Aubusson, "A trial of the five Es: A referent model for constructivist teaching and learning," *Research in Science Education,* vol. 33, no. 1, pp. 27-42, 2003.

[5] S. Erduran and M. P. Jiménez-Aleixandre, *Argumentation in science education: Perspectives from classroom-based research*. Springer: Berlin, Heidelberg, 2007.

[6] S. Esen, S. Geçer, and H. Çetin, "5E learning cycle supported mathematics digital worksheets in primary schools: A case study," *Education and Science,* vol. 48, no. 216, pp. 1–38, 2023. https://doi.org/10.15390/EB.2023.11645

[7] L. S. N. Cheung, D. K. Chiu, and K. K. Ho, "A quantitative study on utilizing electronic resources to engage children's reading and learning: Parents' perspectives through the 5E instructional model," *The Electronic Library,* vol. 40, no. 6, pp. 662-679, 2022. https://doi.org/10.1108/EL-09-2021-0179

[8] Z. Koyunlu Ünlü and İ. Dökme, "A systematic review of 5E model in science education: Proposing a skill-based STEM instructional model within the 21-st century skills," *International Journal of Science Education,* vol. 44, no. 13, pp. 2110-2130, 2022. https://doi.org/10.1080/09500693.2022.2114031

[9] S. Açişli, S. A. Yalçin, and Ü. Turgut, "An evaluation of activities designed in accordance with the 5E model by would-be science teachers," *Procedia-Social and Behavioral Sciences,* vol. 15, pp. 708-711, 2011. https://doi.org/10.1016/j.sbspro.2011.03.169

[10] C. Cigdemoglu and O. Geban, "Context-based lessons with 5E model to promote conceptual understanding of chemical reactions and energy concepts," *Journal of Baltic Science Education,* vol. 14, no. 4, pp. 435-447, 2015. https://doi.org/10.33225/jbse/15.14.435

[11] Z. Parveen, "Educational effectiveness of the 5E model for scientific achievement of students with hearing impairment," *Journal of Baltic Science Education,* vol. 16, no. 5, pp. 723-732, 2017. https://doi.org/10.33225/jbse/17.16.723

[12] Ç. Şahin, Ü. G. Durukan, and E. Arıkurt, "Effect of 5e teaching model on primary school pre-service teachers' learning on some astronomy concepts," *Journal of Baltic Science Education,* vol. 16, no. 2, pp. 148-162, 2017. https://doi.org/10.33225/jbse/17.16.148

[13] S. Nas, M. Calik, and S. Cepni, "Effect of different conceptual change pedagogies embedded within 5E model on grade 6 students' alternative conceptions of'heat transfer'," *Energy Education Science and Technology Part B-Social and Educational Studies,* vol. 4, no. 1, pp. 177–186, 2012.

[14] X. Wei, Y. Chen, P. Zhao, L. Wang, L.-K. Lee, and R. Liu, "Effects of immersive virtual reality on primary students' science performance in classroom settings: A generative AI pedagogical agents-enhanced 5E approach," *Interactive Learning Environments,* pp. 1-20, 2025. https://doi.org/10.1080/10494820.2025.2514101

[15] V. B. Kibici, "Effects of online constructivist 5E instructional model on secondary school music lessons," *International Journal of Technology in Education,* vol. 5, no. 1, pp. 117-131, 2022. https://doi.org/10.46328/ijte.241

[16] J. R. Polanin, M. Austin, J. A. Taylor, R. R. Steingut, M. A. Rodgers, and R. Williams, "Effects of the 5E instructional model: A systematic review and meta-analysis," *AERA Open,* vol. 10, p. 23328584241269866, 2024. https://doi.org/10.1177/23328584241269866

[17] S. Açışlı, S. A. Yalçın, and Ü. Turgut, "Effects of the 5E learning model on students' academic achievements in movement and force issues," *Procedia-Social and Behavioral Sciences,* vol. 15, pp. 2459-2462, 2011. https://doi.org/10.1016/j.sbspro.2011.04.128

[18] E. Bekteshi, "Enhancing the 5E learning model (engage-explore-explain-elaborate-evaluate) among university students in Kosovo," *Folia Linguistica et Litteraria,* vol. 13, no. 40, pp. 335-350, 2022.

[19] K. W. Fouke and C. Kerans, "Evidence for a sea level fall during the last interglacial highstand on West Caicos, Turks and Caicos Islands," *Paleoceanography and Paleoclimatology,* vol. 39, no. 8, p. e2024PA004879, 2024. https://doi.org/10.1029/2024PA004879

[20] C. Sahin, S. Cavus, and S. Gungoren, "Examining usage trends of computer support of the prospective primary school teachers in the science education based on the 5E model," *Procedia-Social and Behavioral Sciences*, vol. 116, pp. 1913-1918, 2014. https://doi.org/10.1016/j.sbspro.2014.01.494

[21] E. Ceylan and Ö. Geban, "Facilitating conceptual change in understanding state of matter and solubility concepts by using 5E learning cycle model," *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi,* vol. 36, no. 36, pp. 41–50, 2009.

[22] D. S. Kaniawati, I. Kaniawati, and I. R. Suwarma, "Implementation of STEM education in learning cycle 5E to improve concept understanding on direct current concept," presented at the International Conference on Mathematics and Science Education, 2017.

[23] J.-L. Lin, M.-F. Cheng, Y.-C. Chang, H.-W. Li, J.-Y. Chang, and D.-M. Lin, "Learning activities that combine science magic activities with the 5E instructional model to influence secondary-school students' attitudes to science," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 10, no. 5, pp. 415-426, 2014. https://doi.org/10.12973/eurasia.2014.1103a

[24] S. D. Kaçan and F. Şahin, "Levels of prospective science teachers' ability to structure 5E model," *SHS Web of Conferences,* vol. 37, p. 01039, 2017. https://doi.org/10.1051/shsconf/20173701039

[25] M. Tezer and M. Cumhur, "Mathematics through the 5E instructional model and mathematical modelling: The geometrical objects," *Eurasia Journal of Mathematics, Science and Technology Education,* vol. 13, no. 8, pp. 4789-4804, 2017. https://doi.org/10.12973/eurasia.2017.00965a