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An Extensive Analysis of the 5E Learning Cycle Model and Its Impact on Student Character Development, Higher-Order Thinking, and Learning Outcomes

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Abstract: This study aims to comprehensively review the application and impact of the 5E Learning Cycle model on various aspects of learning in primary and secondary education. This research uses SLR (Systematic Literature Review). twenty research articles published between 2017 and 2025, focusing on improving learning outcomes, science process skills, science literacy, critical and higher-order thinking skills, problem-solving skills, and character development of students. The results of the study show that the 5E Learning Cycle model, which consists of the stages of Engagement, Exploration, Explanation, Elaboration, and Evaluation, able to produce active, constructive, and meaningful learning. The consistent application of this model improves cognitive, affective, and psychomotor learning outcomes, as well as strengthening students' motivation, learning engagement, and scientific attitudes. The integration of the 5E model with various learning strategies such as mind mapping, three-dimensional thinking-based worksheets, the STEM approach, Quizwhizzer, and educational videos and games further use in building conceptual understanding and science literacy. The improvement in learning outcomes and scientific skills obtained ranged from moderate to high, with an average N-Gain score of 0.37–0.69. In addition to improving critical thinking and concept representation skills, the 5E model also contributes to the formation of social character traits such as responsibility and cooperation The 5E Learning Cycle model is a relevant and adaptive constructivist method to tackle 21st-century learning difficulties because it encourages active student participation.
Keywords*:* 5E learning cycle, higher order thinking skills, learning outcomes, science literacy, science process skills.

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Introduction

The 21st century workplace is very different from earlier ones since it requires critical thinking abilities to tackle ever-more-complex issues (Augustine & Pichayapha, 2022). High school students' critical thinking skills are still very low; less than 55% of them pass Higher-Order Thinking Skills (HOTS) tests (Sholikhah et al., 2025; Quraisyah Basimin et al., 2025; Ibrahim et al., 2020). Consequently, it should come as no surprise that a lack of critical thinking abilities is a significant issue in education, primarily due to instructors' failure to prioritize critical thinking in their lessons (Purwanto, 2022). In the context of 21st century education which is characterized by increasing dynamics and complexity, the development of critical thinking skills becomes a long-term process that requires planned and sustainable learning strategies. A significant responsibility falls on the education sector to address these challenges. This concept aligns with the characteristics of 21st Century Skills published by the 21st Century Skills Partnership (Kawedhar et al., 2020).

Furthermore, teachers have an important role in education (Murati, 2015). To allow students to explore and expand knowledge without feeling pressured, teachers must help create a welcoming and safe environment. In order to reduce issues and create successful learning, this situation necessitates that educators innovate in a number of areas, including the learning media, the learning technique, and the development of information technology (Fauziddin et al., 2021). The process of teaching and learning can be accomplished if the instructor can implement the strategy and create the most effective learning model to meet learning goals. Teachers are supposed to be proficient in a variety of teaching strategies and use them in the classroom. According to Jaya and Indrayani (2021), if the teacher's learning paradigm does not permit pupils to engage in the learning process, they become passive listeners. Therefore, a teacher's aptitude and accuracy in selecting and implementing learning models is the primary factor that determines how well children learn.

The 5E learning cycle model is one of the learning models that encourages students to actively participate in the learning process and incorporates various cognitive processes to stimulate students' intellectual development (Sani et al., 2020). The learning cycle was divided into three phases, or the 3E learning cycle, which stood for exploration, explanation, and elaboration. But in the subsequent process, the three phases evolved into five stages, which are referred to as the 5E learning cycle: engagement, exploration, explanation, elaboration, and evaluation. According to (Rodriguez et al., 2019), the 5E learning cycle model is a constructivist approach that has five stages: engagement, exploration, explanation, elaboration. Before delving deeper into constructivism, it would be better to first understand constructivism itself. Constructivism means "constructive." In the context of educational philosophy, constructivism is an effort to build a modern, culturally structured way of life. Constructivism is a theory that is constructive in nature, building on abilities and understanding in the learning process. By having a constructive nature, it is hoped that students' activeness will increase their intelligence.. In the stages of the 5E learning model, students can actively, meaningfully learn content by working and thinking independently or in groups, allowing them to master the skills that must be acquired in learning (Sani et al., 2020). The 5E learning cycle model also has the advantage of motivating students to reflect on prior knowledge in order to connect it to the content being studied and to verbally communicate concepts (Nur & Noviardila, 2021). Previous research findings indicate that the implementation of learning activities in the 5E Learning Cycle model is able to facilitate students in actively building knowledge, developing critical thinking skills, and improving learning outcomes. 5E learning cycle model that helps students improve learning outcomes is that students who learn using the 5E model get better learning outcomes compared to conventional learning, the application of the 5E Learning Cycle is able to improve learning outcomes and students who learn using the 5E model assisted by LKPD have higher learning outcomes compared to the lecture method. Student learning activities also contribute greatly to improving learning outcomes. The research gap in the 5E learning cycle model lies in the limited number of studies that specifically examine the effectiveness of structured learning exercises at each 5E stage in improving critical thinking skills, activeness, and overall student learning outcomes.

This study aims to systematically examine the available empirical evidence regarding the effectiveness of structured learning activities in the 5E Learning Cycle model in improving student activity, critical thinking skills, and learning outcomes.

Method

The purpose of this systematic literature review (SLR) is to synthesize the effect of implementing structured learning exercises in the 5E learning cycle model on increasing student activity, critical thinking skills, and learning outcomes. of empirical research pertaining to the implementation of the 5E Learning Cycle model at different educational levels. To get a thorough picture of the patterns in the use, efficacy, and contribution of the 5E model to learning outcomes, higher-order thinking abilities, science process skills, science literacy, and student character development, the analysis was carried out.

Research Type and Design

This study uses a systematic literature review (SLR) approach with a descriptive-thematic analysis design. This approach was chosen to enable critical analysis of various published research results, covering variations in context, design, and innovation in the application of the 5E Learning Cycle model.

Data Sources and Collection Techniques

The prism diagram of learning in the 5E learning cycle model can be seen in Figure 1.

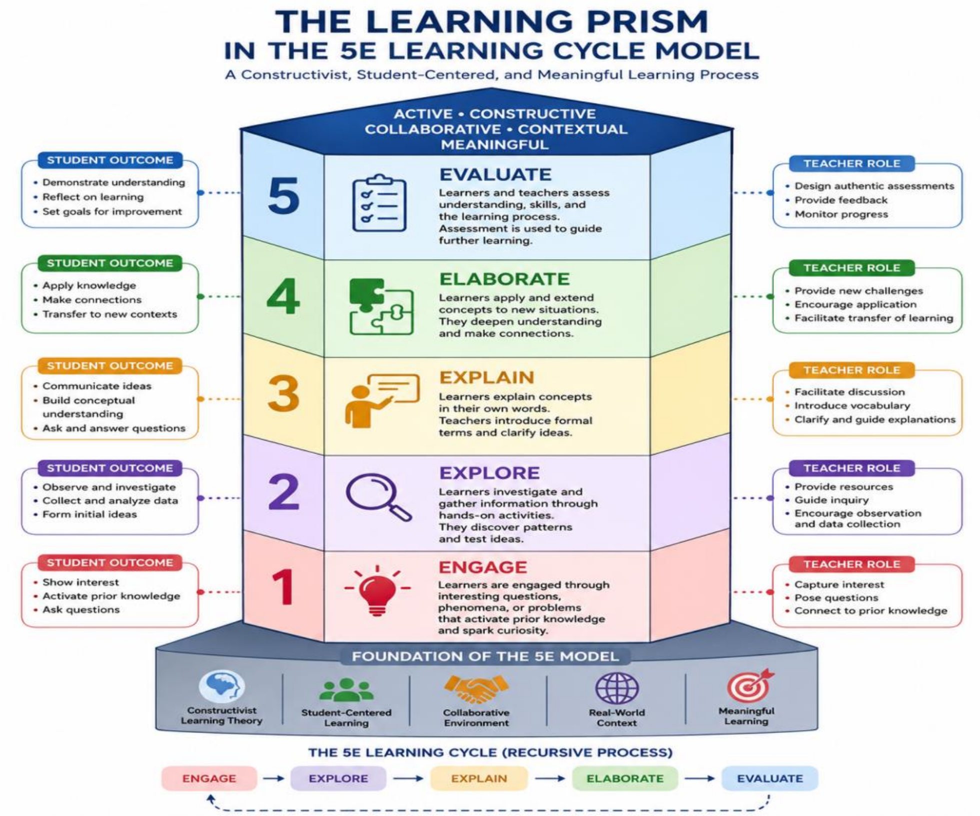

Figure 1. Learning prism diagram in the 5E learning cycle model

Peer-reviewed national and international journal articles pertinent to the research topic served as the data sources. Search terms including Learning Cycle 5E. 5E learning model, learning outcomes, science literacy, HOTS, and science process skills were used to gather articles from Google Scholar, Scopus, DOAJ, and the SINTA portal.

The inclusion criteria used in the article selection process are as follows:

a) The article explicitly discusses the application of the 5E Learning Cycle model.

b) The research uses an experimental, descriptive, qualitative or classroom action approach.

c) The research results describe the effect of the model on learning outcomes.

d) The articles were published between 2017 and 2025 and are available in full.

e) Articles that are not peer-reviewed, such as proceedings, books and conceptual research without empirical application, were excluded.

The quality of an article about learning in the 5E learning cycle model can be evaluated as shown in Figure 2.

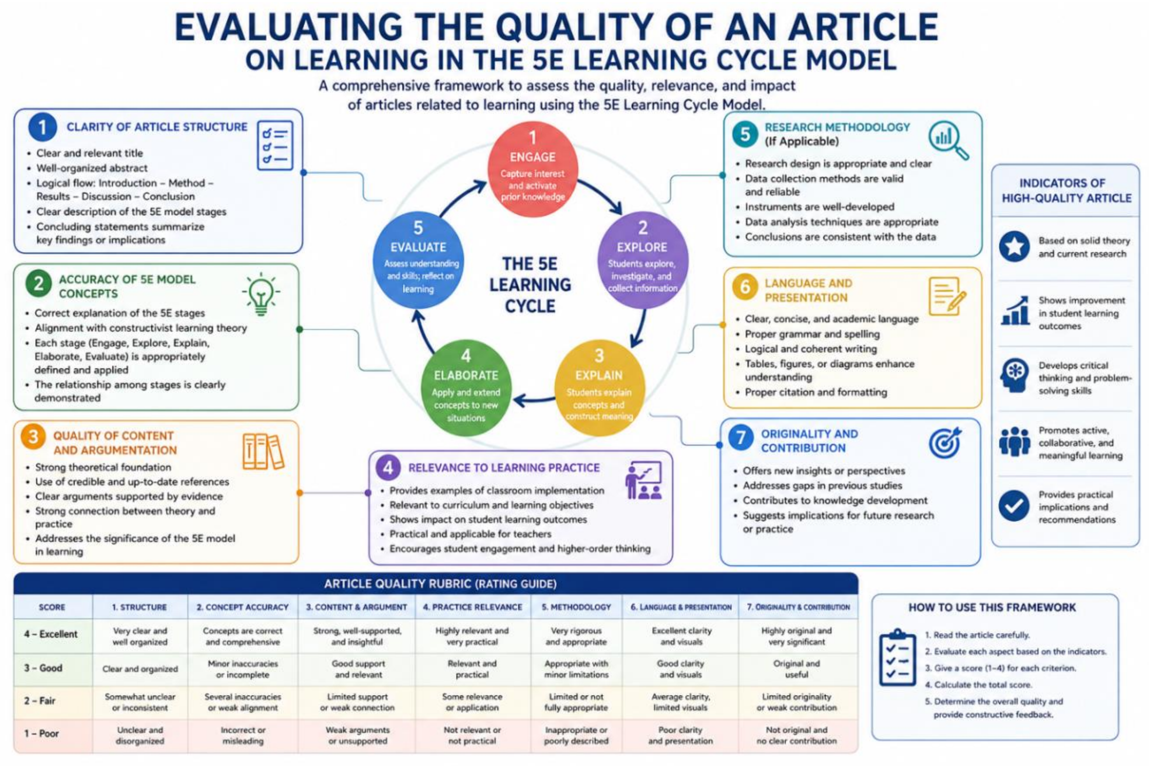

Figure 2. The quality of an article about learning in the 5E learning cycle model

Data Collection and Analysis Procedures

The research procedure was carried out in several systematic stages:

a) Initial identification and selection: searching for articles based on keywords and year of publication.
b) Feasibility evaluation – reviewing article content to ensure suitability for the research focus.
c) Data extraction: collecting important information from each article, including research objectives, design, sample, variables, supporting media, and results and conclusions.
d) Thematic synthesis – analyzing and grouping results based on similarities in themes, patterns, and differences in context between studies.

Thematic coding of Analyzing and grouping results based on similarities in themes, patterns, and differences in context between studies can be seen in Table 1.

Table 1. Thematic Coding Table

Study Findings / Excerpts	Initial Codes	Subthemes	Main Themes
Students became more active during 5E-based discussions	Student participation	Active engagement	Student engagement
Learners showed increased curiosity during inquiry activities	Learning motivation	Curiosity development	Student engagement
Teachers experienced difficulty managing time in each 5E phase	Time management issues	Implementation challenges	Implementation barriers
Schools with laboratory facilities achieved better outcomes	Learning facilities	Learning environment	Contextual factors

Study Findings / Excerpts	Initial Codes	Subthemes	Main Themes
The 5E model improved students' critical thinking skills	Critical thinking	Higher-order thinking	Learning outcomes
Different results appeared between urban and rural schools	Educational context	Contextual variation	Contextual factors

The analysis was conducted descriptively and interpretively, grouping the research findings into three main domains. The domains of Cognitive Psychology (knowledge and thinking), affective domain (attitudes and values), and psychomotor domain (physical skills) are interrelated in educational theories such as behaviorism, cognitivism, constructivism, and humanism because all three together explain the process of student development intellectually, emotionally, and in terms of practical skills in learning.

a) Cognitive domain: improvement in learning outcomes, conceptual understanding, and critical thinking skill
b) Affective domain: motivation, scientific attitudes, and learning engagement.
c) Psychomotor domain: science process skills, conceptual representation, and problem-solving skills.

Results and Discussion

The Effect of the 5E Learning Cycle Model on Learning Outcomes (Cognitive Domain)

Based on the synthesis of twenty articles reviewed between 2020 and 2025, the majority of studies show that the application of the 5E Learning Cycle model has a significant effect on improving student learning outcomes in the cognitive domain. The synthesis of the reviewed studies revealed that these improvements were consistently observed across various fields of study such as science, physics, biology, and economics at various levels of education (elementary school to university). analisis statistik deskriptif show that the average value of N-Gain is in the range of 0.37–0.69, which is included in the moderate to high category, so it can be interpreted that the learning model or strategy used is quite effective in improving student learning outcomes. $0.37 \leq$ N-Gain ≤ 0.69, indicating consistent improvement. (Dianningrum et al., 2025; Salma et al., 2022).

This effectiveness is explained by the characteristics of 5E, which emphasizes constructivist learning through five sequential stages Engage, Explore, Explain, Elaborate, and Evaluate that help students build understanding from direct experience. The Engage and Explore phases encourage the activation of prior knowledge and curiosity, while Explain and Elaborate reinforce concept formation. The findings from various studies indicated that students who learned through this approach demonstrated improvements in learning engagement, critical thinking skills, and learning outcomes. not only achieve higher scores but also demonstrate improved analytical skills and long-term concept retention.

The consistent improvement in cognitive achievement across multiple studies indicates that the 5E Learning Cycle promotes a deep conceptual understanding rather than surface memorization. This occurs because each stage of the model systematically scaffolds learning, transitioning students from curiosity to mastery. The 'Engage' phase builds emotional readiness and contextual relevance, ensuring students can connect new content with their prior experiences. During Explore, learners interact with concrete materials and phenomena, which stimulates inquiry and hypothesis generation. These early phases prepare a strong foundation for the Explain stage, where students construct meaning through dialogue and evidence-based reasoning.

Furthermore, the Elaborate and Evaluate stages provide opportunities to transfer knowledge to new contexts, thereby reinforcing conceptual stability and encouraging metacognitive reflection. Such cyclical reinforcement aligns with constructivist principles proposed by Piaget and Vygotsky, which emphasize that understanding develops through iterative interaction and reflection. The evidence of high N-Gain values (ranging from 0.37 to 0.69) across diverse subject areas demonstrates that the model's framework transcends disciplinary boundaries and is effective at multiple educational levels. (Nugroho, 2018; Salong & Lasaiba, 2024; Sani et al., 2020; Sari & Rahmi, 2024; Wahyuningsih et al., 2023).

In addition, the combination of 5E with innovative instructional tools such as digital worksheets, mind maps, and inquiry-based laboratories enhances the model's capacity to support both high-order thinking and long-term retention. Students become active participants in the creation of meaning, fostering self-regulated learning and analytical reasoning. Overall, the results suggest that the 5E Learning Cycle is not merely a pedagogical structure but a dynamic learning ecosystem that cultivates deeper, more durable cognitive growth. (Desyana et al., 2024; Sari & Rahmi, 2024).

The combination of the 5E learning cycle model (Engage, Explore, Explain, Elaborate, and Evaluate) with innovative constructivism-based learning is able to optimally develop students' cognitive domains through exploratory, collaborative, and problem-solving activities that encourage increased thinking skills from low levels to Higher Order Thinking Skills (HOTS) such as analysis, evaluation, and creativity.

An overview of 20 studies on the Learning Cycle Model and Its Influence on Learning Outcomes, Higher-Order Thinking, and Student Character Development is presented in Table 2.

This review research uses a systematic literature study approach to comprehensively analyze various research results on the effectiveness of the 5E learning cycle model on student character development, higher order thinking skills (HOTS), and improving learning outcomes.

Table 2. Synthesis of the Main Findings from 20 Articles on the Implementation of the 5E Learning Cycle Model

No	Journal Identity	Context / Level	Research Focus	Approach / Supporting Media	Main Findings	Implications
1	(Rosanti et al., 2023)	Senior High – Physics	Mastery of Concepts & Science Process Skills	5E Learning Cycle + Link Map	Students with Link Map showed higher concept mastery and science skills	5E with visual mapping strengthens conceptual understanding
2	(Ristia et al. 2023)	Junior High – Science	Scientific Reasoning	5E Learning Cycle + LKPD (3D Thinking Graph)	Moderate improvement (N-gain = 0.51) in scientific reasoning	3D graph-based LKPD effectively enhances analytical reasoning
3	(Salong & Lasaiba, 2024)	Senior High – Economics	Learning Outcomes	5E Learning Cycle (Classroom Action Research)	Improved mastery from 72.5% to 85%; increased engagement	5E cycle promotes holistic learning and active participation
4	(Sani et al., 2020)	Junior High – Science	Higher Order Thinking Skills (HOTS)	–	Significant improvement across cycles (62% → 87%)	5E proven effective for developing HOTS
5	(Salma et al., 2022)	Senior High – Biology	Scientific Literacy & Learning Outcomes	5E Learning Cycle integrated with STEM	Significant improvement in literacy and achievement	STEM-based 5E strengthens scientific understanding and literacy
6	Budianti et	Elementary	Science	Systematic	5E consistently	5E suitable for

No	Journal Identity	Context / Level	Research Focus	Approach / Supporting Media	Main Findings	Implications
	al. (2023)	– Science	Learning Outcomes	Literature Review (2012–2022)	improved students' learning results	building active, inquiry-based scientific learning
7	(Dewi et al., 2025)	Elementary – Social Studies	Cooperative Character (Gotong Royong)	5E Learning Cycle + Snakes & Ladders Game	High improvement (89.8% vs 69.1%) in cooperation character	Game-based 5E fosters social values and collaborative learning
8	(Sari & Rahmi, 2024)	Elementary – IPAS	Learning Outcomes	5E Learning Cycle + Video Media	Post-test significantly higher in experimental class (84.21 > 77.25)	Video-assisted 5E increases engagement and comprehension
9	(Nida et al., 2017)	Junior High – Science	Science Process Skills	5E Learning Cycle + Mind Mapping	Effective in improving process and inquiry skills	Mind mapping in 5E enhances conceptual retention and activity
10	(Wulandari et al., 2024)	Junior High – Science	Scientific Reasoning	5E Learning Cycle + LKPD (Multidimensional Thinking Diagram)	Significant positive effect on reasoning ability	Diagram-based 5E model develops logical and critical thinking
11	(Hayat et al., 2025)	Junior High School – Science	Critical Thinking Skills on Vibration Material	Learning Cycle 5E Model	Students' critical thinking improved from mean 34 to 59.43 with N-gain 0.372 (moderate)	The 5E model positively impacts critical thinking and can be applied to other materials for deeper cognitive understanding.
12	(Muliana et al., 2024)	Senior High School – Biology	Scientific Literacy	Learning Cycle 5E	5E model significantly improved students' scientific literacy ($p < 0.05$, 0.024)	5E model is effective for enhancing scientific literacy and fostering scientific reasoning among students.
13	(Agustiana et al., 2025)	All Levels – Science	Development of Learning Materials	Systematic Literature Review (PRISMA)	Majority of studies focus on product validation rather than cognitive or affective outcomes.	Future research should explore cognitive and noncognitive impacts of 5E-based teaching materials.
14	(Aprilia et al., 2023)	Senior High School – Physics	Critical Thinking Skills in Mechanical Waves	Practicum-based Learning Cycle 5E	Significant improvement in students' critical thinking (tcount 7.31 > ttable 2.65)	Practicum-based 5E model effectively develops critical thinking through active engagement and

No	Journal Identity	Context / Level	Research Focus	Approach / Supporting Media	Main Findings	Implications
						inquiry.
15	Nugraha, S., & Rahman, T. (2024)	Junior High School – Physics	Conceptual Understanding in Thermodynamics	Learning Cycle 5E Model	Improvement in conceptual understanding and motivation among students.	The 5E model supports meaningful learning and concept retention.
16	Rahmawati, D., & Yusuf, M. (2024)	Elementary – Science	Problem Solving in Environmental Education	5E with Contextual Approach	Students' problem-solving skills improved significantly post-intervention.	Integrating 5E with contextual learning fosters critical environmental awareness.
17	(Sari & Rahmi, 2024)	Elementary – Science	Learning Outcomes in Sound and Its Properties	Learning Cycle 5E	Positive effect on students' science learning outcomes (Paired t-test significant)	5E enhances active participation and understanding of scientific phenomena.
18	Pratiwi, A., & Fadillah, R. (2024)	Senior High School – Chemistry	Learning Motivation and Achievement	Learning Cycle 5E with Project-Based Learning	Increased motivation and achievement compared to conventional methods.	5E integrated with PjBL increases engagement and achievement simultaneously.
19	(Wulandari et al., 2024)	University Level – Physics Education	Metacognitive Skills	Learning Cycle 5E with Reflective Journal	Improvement in metacognitive awareness and learning autonomy.	Reflective-based 5E model enhances self-regulated learning and reflection skills.
20	(Dianningrum & Sufian, 2025)	Senior High School – Physics (Kinematics)	Conceptual Understanding and Representational Fluency	Learning Cycle 5E with Multi-Representational Approach	Students' understanding (N-gain = 0.693) and fluency (N-gain = 0.654) improved significantly.	The 5E model with multiple representations effectively builds deep conceptual and representational understanding.

A Systematic Literature Review (SLR) typically includes a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) diagram to illustrate the systematic process of identifying, screening, appraising, and selecting research articles for review. The PRISMA flowchart helps ensure transparency and methodological rigor by showing the number of records identified from the database, duplicates removed, articles screened, full-text studies assessed for eligibility, and the final studies included in the review. This diagram allows the reader to clearly understand how the literature selection process was conducted and why certain studies were included or excluded from the analysis as seen in Figure 3.

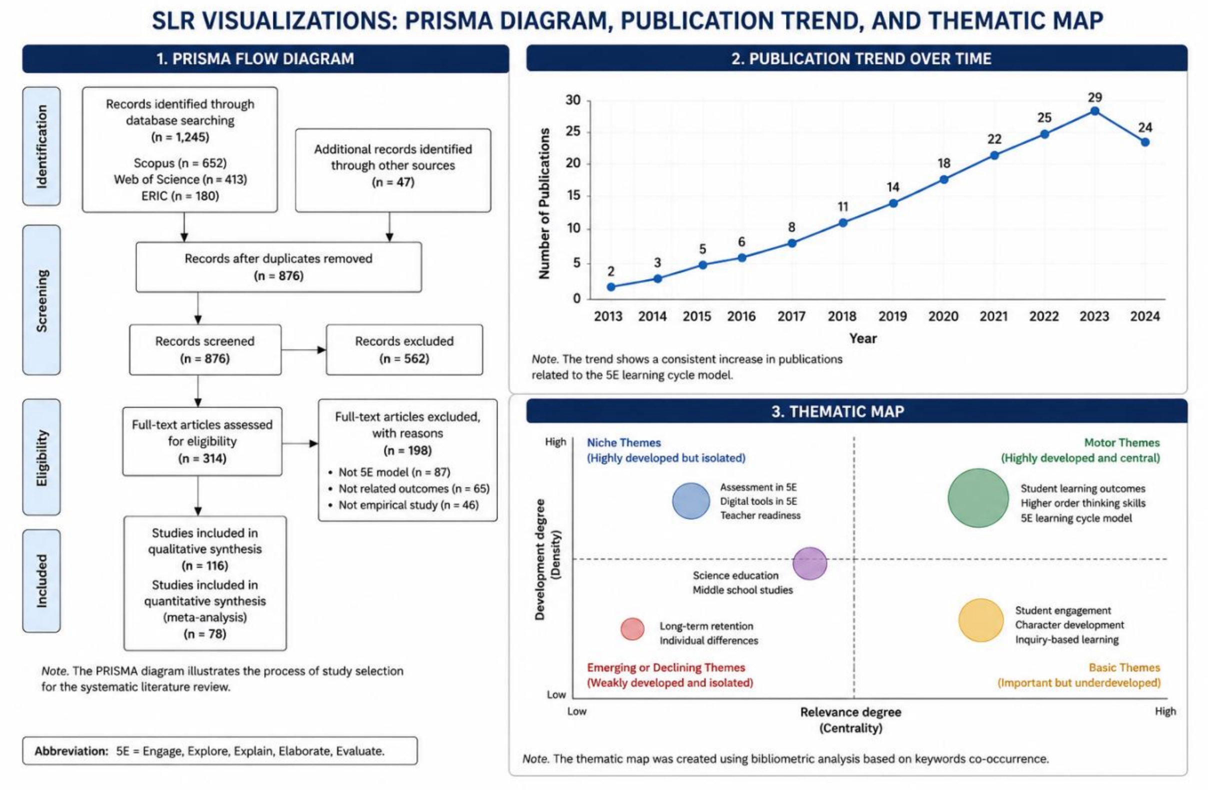

Figure 3. PRISMA diagrams, trend charts and thematic maps

Improvement in Science Process Skills and Scientific Reasoning

Several quasi-experimental studies (Nida et al., 2017; Putri et al., 2022; Rosanti et al., 2023) show that the 5E Learning Cycle model can improve students' science process skills (SPS) and scientific reasoning at a moderate to high level. The Explore and Elaborate phases allow students to experience scientific processes such as observation, data collection, evidence analysis, and reflection on conclusions. The use of 3D thinking worksheets, mind mapping, and exploratory practicums strengthens these skills by guiding students to think systematically and reason based on empirical data.

This positive effect is also due to the 5E design, which places students at the center of learning. Teachers act as facilitators who help students build scientific arguments through reflective dialogue. These results show that the 5E Learning Cycle not only impacts declarative knowledge but also improves students' procedural and metacognitive abilities.

The enhancement of science process skills (SPS) and scientific reasoning under the 5E framework reflects its strong alignment with inquiry-based pedagogy. In the Explore phase, students are encouraged to design simple experiments, record data, and analyze relationships between variables activities that mirror authentic scientific investigation. This active engagement fosters critical habits such as accurate observation, hypothesis testing and inferential reasoning. In the Elaborate phase, learners apply previously formed concepts to new or extended situations, thereby reinforcing procedural fluency and logical consistency.

Empirical findings consistently reveal that when students participate in 5E-based learning, their reasoning patterns become more evidence-driven. They demonstrate a greater ability to justify conclusions, distinguish between correlation and causation, and critique the validity of experimental results. These improvements are particularly evident in subjects such as physics and biology, where conceptual understanding relies heavily on empirical verification.

Moreover, the integration of cognitive scaffolds such as 3D-thinking worksheets and mind-mapping tools provides visual structure that helps learners organize data and track causal relationships.

These tools support cognitive development and promote metacognitive awareness as students reflect on how they constructed their conclusions. The role of the teacher as a facilitator further reinforces this dynamic, shifting learning from teacher-centered transmission to student-centered inquiry. Collectively, these findings affirm that the 5E Learning Cycle effectively bridges declarative, procedural, and metacognitive domains, fostering comprehensive scientific literacy and reasoning competence. (Aprilia et al., 2023; Hayat et al., 2025; Nida et al., 2017; Ramdani et al., 2021).

Impact on Affective Domain, Motivation, and Social Character

In addition to the cognitive domain, many studies report that the application of the 5E model contributes to increased learning motivation, emotional engagement, and the formation of students' social character. A study by (Dewi et al., 2025; Nugroho, 2018.; Ketut Risa Intania et al., 2025) shows an increase in mutual cooperation and collaboration through the application of 5E-based educational games. Noted that the integration of visual and digital media, such as mind mapping and Quizwhizzer, can increase students' interest and active participation during the learning process (Nida et al., 2017).

This affective involvement arises because the Engage and Elaborate phases provide space for students to express themselves, discuss, and collaborate. Learning is not only results-oriented, but also develops a positive attitude towards science. Thus, 5E plays an important role in supporting character education and social-emotional learning in the classroom.

The affective outcomes observed in 5E-based learning environments demonstrate that this model nurtures not only intellectual growth but also emotional and social development. During the 'Engage' phase, students are drawn into the learning process emotionally by being presented with thought-provoking questions, real-world problems or contextual phenomena that stimulate curiosity and personal relevance.

As students progress to the Elaborate phase, cooperative learning structures become central to the experience. Group discussions, peer collaboration and shared reflections promote empathy, mutual respect and teamwork. Studies such as (Dewi et al., 2025) highlight that activities like 5E-based educational games not only improve comprehension but also encourage interpersonal communication and collective problem-solving key components of social-emotional learning (SEL).

Furthermore, the integration of digital media tools such as Quizwhizzer and mind mapping enhances participation by transforming learning into an interactive, student-driven process. These platforms appeal to students’ creativity and competitive spirit, which in turn boosts engagement and motivation. More importantly, they provide immediate feedback that builds confidence and self-efficacy.

Overall, the 5E model contributes to a holistic form of learning that blends cognitive and affective development. It transforms classrooms into communities of inquiry where collaboration, curiosity, and emotional engagement coexist conditions essential for cultivating lifelong learners with both academic competence and social character. (Salma et al., 2022; Muliana et al., 2024; Sani et al., 2020).

Moderating Factors Context, Material, and Technology Integration

Comparative analysis shows that the effectiveness of the 5E Learning Cycle model is influenced by the context of application, type of material, and media support. At the elementary school level, the greatest impact was observed in the improvement of students' practical skills and learning motivation. while at the high school and college levels, this model is more effective in deepening abstract concepts.

The integration of technology and other approaches, such as STEM, instructional videos, and multi-representation, proved to strengthen the exploration and concept explanation stages (Dianningrum & Sufian, 2025; Salma et al., 2022).

The variability of results across studies highlights that the impact of the 5E Learning Cycle is not uniform but mediated by several contextual and pedagogical factors. The educational level, subject complexity, and technological resources available in classrooms all play crucial roles in determining the degree of success. At the elementary level, learners often respond more strongly to tangible, hands-on exploration activities such as simple experiments and guided observations because these experiences align with their developmental stage of concrete operational thinking. Consequently, the 5E model fosters curiosity, engagement and confidence through active participation.

In contrast, at higher levels of education (secondary and tertiary), the 5E framework supports a deeper conceptual understanding of abstract and theoretical content. The Explain and Elaborate stages are particularly critical here, allowing students to apply principles to new phenomena and construct mental models that bridge theory and practice. For example, in topics such as Newtonian mechanics or wave propagation, the integration of simulations, multi-representational tasks, and digital visualizations helps students grasp relationships between mathematical formulas and observable phenomena.

Furthermore, the use of complementary pedagogical strategies like STEM integration, video-based learning, and interactive learning management systems enhances the adaptability of the 5E model. These tools expand the range of sensory input, promote multimodal learning and make abstract content more accessible. Technology integration also increases learner autonomy, enabling self-paced exploration and collaborative digital discussion that extend learning beyond the classroom.

Taken together, these findings indicate that the 5E Learning Cycle functions effectively as a flexible pedagogical framework rather than a fixed formula. Its adaptability across contexts demonstrates that when properly aligned with learner characteristics, curriculum content, and available resources, the 5E model can amplify both cognitive and affective learning outcomes. (Agustiana et al., 2025; Dewi et al., 2025; Sari & Rahmi, 2024; Wahyuningsih et al., 2023; (Wulandari et al., 2024).

Methodological Strengths and Research Limitations

Most of the reviewed studies employed quasi-experimental or classroom action research (CAR) designs with single-class samples; the statistical analyses commonly used included t-tests, N-gain, and non-parametric tests. Critical discussion shows several limitations: many studies have relatively small sample sizes, short intervention durations, or insufficient reporting of instrument validity and randomization procedures, so generalizations must be made carefully. In addition, few studies have conducted long-term follow-ups to observe concept retention and skill sustainability. Therefore, although the initial findings are promising, replication studies with stronger designs, cluster randomized trials, longitudinal measurements) are needed to strengthen claims of effectiveness.

The methodological review across the twenty studies reveals both commendable rigor and notable gaps in empirical design. The dominant use of quasi-experimental methods and classroom action research (CAR) indicates a practical orientation to the research, with greater emphasis on applicability and feasibility of implementation in the classroom environment than on strict experimental control. This design choice is appropriate for educational contexts, yet it limits the ability to generalize findings beyond specific settings. Small sample sizes and non-randomized groups make it difficult to isolate the independent effects of the 5E model from confounding factors such as teacher expertise, classroom culture, and student readiness. (Agustiana et al., 2025; Rosanti et al., 2023; Wahyuningsih et al., 2023)

Furthermore, short intervention periods (often spanning one or two learning cycles) may not adequately capture long-term conceptual change or retention. Learning models like 5E, which emphasize iterative engagement and reflection, require sustained implementation to achieve their full potential. The limited duration of many studies therefore underrepresents the deeper cognitive and affective transformations that might occur over time.

Another issue lies in the inconsistent validation of research instruments. While several studies report reliability coefficients or expert validation, others omit these details, weakening the transparency and replicability of results. Similarly, few studies incorporate mixed-method approaches that combine quantitative outcomes with qualitative insights such as student perceptions, reflective journals, or classroom observations which could enrich the interpretation of the model's impact.

Despite these limitations, the reviewed literature collectively demonstrates methodological progress. The increasing use of N-Gain analysis and pretest–posttest comparisons provides measurable evidence of learning improvement. Going forward, future research should adopt more robust designs such as cluster randomization, longitudinal tracking, and cross-disciplinary replication to ensure stronger validity and broader generalization. These methodological enhancements will not only substantiate the 5E model's effectiveness but also guide its optimization for diverse educational contexts. Future research on the 5E Learning Cycle Model should focus on technology integration, longitudinal character development, higher-order thinking assessment, cross-disciplinary implementation, contextual influences, and comparative studies with other innovative learning models to better understand its comprehensive impact on student learning and 21st-century competencies. ((Hayat et al., 2025; Nida et al., 2017; Ramdani et al., 2021).

Conclusion

Based on the synthesis of twenty research articles analyzed, it can be concluded that the 5E Learning Cycle model is an effective, adaptive, and relevant approach to be applied in various science learning contexts from elementary to higher education. The consistent application of this model has been shown to improve student learning outcomes in the cognitive, affective, and psychomotor domains. Through the stages of Engagement, Exploration, Explanation, Elaboration, and Evaluation, students are encouraged to actively construct knowledge, develop curiosity, and relate their learning experiences to meaningful scientific concepts. This process encourages constructive, reflective, and student-centered learning, in line with the principles of student-centered learning in the Merdeka Curriculum. The study implies that the 5E Learning Cycle Model can practically enhance student character, higher-order thinking skills, and learning outcomes through active and student-centered learning; however, limitations such as limited sample scope, short intervention duration, and contextual differences suggest the need for future longitudinal, technology-integrated, and cross-disciplinary research in diverse educational settings.

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