

Implementation of STEM Approach in Improving Elementary School Science Process Skills

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Abstract: Science process skills are one of the important skills that students must have. This is because it can improve students' basic competencies, which include the formation of scientific attitudes, as well as their ability to solve problems. The STEM (Science, Technology, Engineering, Mathematics) approach is considered capable of encouraging students to improve these skills and solve problems in an integrated manner from an early age. This is because STEM is an approach that integrates science, technology, engineering and mathematics into one learning process, so that it will focus students on solving problems related to everyday life. The purpose of this article is to examine how the application of the STEM approach improves students' science process skills. The method used in this article is a systematic literature review. Literature reviews are carried out by analyzing various references related to the research topic. Data collection was carried out by following the PRISMA guidelines sourced from two databases, namely Google Scholar and Scopus, with a time span of 2015–2024 through the assistance of the Publish or Perish 8 (PoP) application. A total of 15 articles were obtained which were used as research data that were analyzed. The results of this study concluded that the application of the STEM approach can improve students' science process skills positively. Furthermore, teachers must be able to improve their skills in applying this STEM approach in teaching and learning activities in the classroom.

Keywords: Elementary School; Science Process Skills; STEM

Introduction

Education is one of the most important things students to go through while in the school environment, especially for elementary school students who have been introduced to technology from the beginning, which is increasingly advanced from time to time. In addition, education in elementary schools has an important role in shaping students' mindsets, attitudes, and skills (Wiratman et al., 2023). In this era of advanced technological and information development, education is one of the important factors in producing a new generation that is knowledgeable and flexible in adapting to changes in the times, especially in the field of science learning in elementary schools.

Science in elementary schools is one of the subjects that plays a very important role in education,

where science can be the main provision for students to face various challenges in this global era. Science learning that students feel will be more meaningful if the subject matter is linked to everyday life. Four elements including attitudes, processes, products and their applications are expected to emerge in the science learning process so that students can feel the learning process and understand natural phenomena through scientific methods, problem-solving activities, and can imitate the way scientists work in finding new facts (Rini & Aldila, 2023). One of the important skills for developing knowledge and problem-solving abilities is science process skills.

Science process skills are one of the important skills that students must have in carrying out scientific activities. According to Carin (in Mulyeni et al., 2019) who stated that these skills can be used in predicting and

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explaining phenomena and can solve problems. Science process skills can help students develop a sense of responsibility in learning and increase the importance of research methods in the learning process (Inayah et al., 2020). In addition, science process skills involve cognitive, intellectual, manual and social skills that are used to solve problems faced in everyday life so that these skills are considered as tools that allow individuals to get the most out of their knowledge (Zorlu & Zorlu, 2017).

Science process skills are very important because they require students to increase active participation and develop a sense of responsibility in learning, as well as being able to develop the ability to think and behave like scientists (Darmaji et al., 2018). Another opinion expressed by Amalia (in Angelia et al., 2022) states that science process skills are needed by students when solving science problems related to real events or during the learning process. In addition, students are given the opportunity to develop critical and creative thinking skills, because students must think analytically and make decisions based on existing evidence (Wiratman et al., 2023).

The use of learning approaches and models that are not varied will have an impact on students' skills and learning outcomes. Often the monotonous models and approaches used by teachers focus on students' science process skills such as expertise in using tools and materials, observation skills, skills to explain, and the ability to collaborate due to learning limitations in schools such as class time in small classes, making it difficult for teachers to use models or examples of learning that aim to improve the value of participants' skills in the science instruction process. Science process skills must be truly utilized by teachers to teach science facts effectively, because science is not just knowledge, but a way of understanding the environment systematically (Suryanti et al., 2020).

Given the lack of science process skills in elementary school students, it is important to implement learning approaches and strategies that can help students improve their science process skills. One approach that can help students improve their science process skills is a learning approach based on Science, Technology, Engineering, and Mathematics or better known as STEM. Priyani & Nawawi (2020) stated that STEM can help elementary school students develop their science process skills. Another opinion was conveyed by Wicaksono (in Firdaus et al., 2023) who stated that the STEM approach can help build students' creative and innovative nature in preparing themselves to face the era of the industrial revolution 4.0.

Indonesia must prepare reliable human resources in the fields of science, technology, engineering, and mechanics (STEM) to face global

competition (Retnowati et al., 2020). STEM education is very important for students to develop 21st century skills such as problem solving, innovation, creativity, communication and collaboration (Sari et al., 2020). STEM learning makes students more creative in finding solutions to problems in running their lives (Atiaturrehmaniah et al., 2022). Because in the implementation of education it is necessary to anticipate the challenges of the times so that they can produce children who can adapt to developments in the times (knowledge and technology) but still prioritize noble moral values in society and in accordance with national education goals (Amelia & Marini, 2022). Given the problems that have been explained, many studies have examined the STEM approach to improving science process skills. Because of the many integration studies that have been conducted, it is also necessary to analyze the results of these studies.

Based on the explanation above, this article aims to discuss the STEM learning approach in improving students' science process skills at the elementary school level by analyzing several predetermined articles. The main question in this article is "How is the application of the Science, Technology, Engineering, and Mathematics (STEM) approach in improving elementary school students' science process skills?".

Method

The method used in writing this article is the Systematic Literature Review (SLR). The SLR method is used to identify, review, evaluate, and interpret all available research with an interesting topic area of phenomena, with specific relevant research questions (Triandini et al., 2019). Literature Review is conducted by reviewing various articles related to the topic to be discussed. This study uses articles sourced from various scientific literature and disciplines. The data collection technique in this study follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, which is a collection of evidence-based items that set minimum standards for reporting in systematic reviews and meta-analyses (Page et al., 2021). The PRISMA guidelines used include the process of identification, screening, eligibility, and inclusion of articles.

The data source for this study is scientific articles obtained from various Google Scholar and Scopus databases through the help of the Publish or Perish (PoP) 8 applications. This study focuses on articles published in the last ten years (2015-2024) that are relevant to the topic of discussion, namely STEM and science process skills. Article searches were identified using the keywords "STEM Approach in Elementary Schools", "Elementary School Students' Science Process

Skills" and "STEM Approach in Improving Science Process Skills". The articles used were publications from 2015 to 2024. A search using keywords found 717 articles, the Scopus Database as many as 422 articles and Google Scholar as many as 295 articles. Continued with filtering and determining articles.

The article selection process involves inclusion and exclusion criteria that serve to determine the subjects or objects that can be part of the research sample. The following Table 1 describes the criteria used in this study.

Table 1. Inclusion Criteria and Exclusion Criteria

No	Inclusion Criteria	Exclusion Criteria
1	Using scientific articles	Using sources from proceedings, books, or papers.
2	Publication of articles published in 2015-2024	Article publication before 2015
4	Research that discusses STEM and Science Process Skills	Does not address STEM and Science process skills
5	Using research methods other than SLR	Using the SLR Method

The selection of articles is limited to articles that include the quality of the research methodology used in the article, presentation and discussion of data, journals that have Open Access, and the suitability of the data for analysis, both current and relevant references. This is done as a limitation study and to ensure credibility and sources relevant to the research context. The exclusion stage is the final stage to refine the process of searching for articles relevant to STEM and Science process skills. From the systematic article

search steps, 15 articles were found that met the criteria. The following are details of the procedure for determining articles described using a Flowchart as shown in Figure 1.

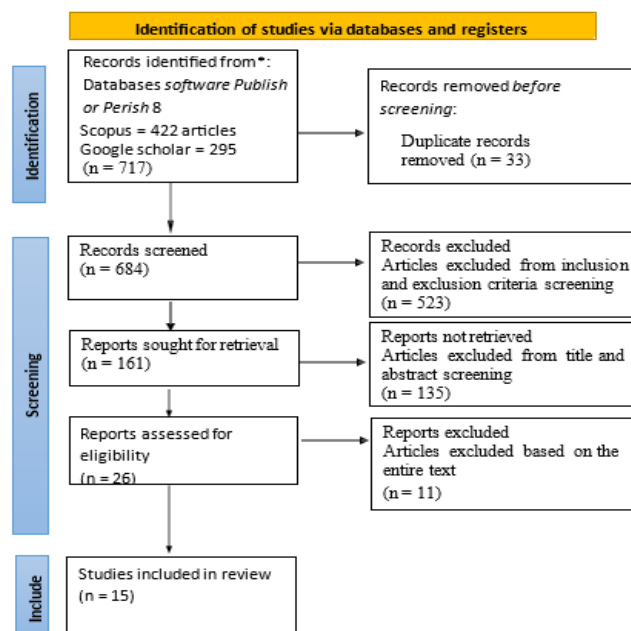


Figure 1. Flowchart of the Search and Filtering Process

Result and Discussion

There are 15 scientific articles used as research data according to the criteria of research needs. The selected articles have gone through a screening process according to the criteria determined by the researcher. The following is a table of article identities included in the criteria for this research literature review.

Table 2. The Scientific Articles Used as Research Data According to The Criteria of Research Needs

Author	Year	Country	Research Methods	Name of Journal	Variable
Gultekin & Altun	2022	Turkey	Quasi-experimental	International Electronic Journal of Elementary Education	Science process skills
Wulandari & Sari	2023	Indonesia	quantitative	Science Incandescent Journal	STEM, Science process skills
Kurnaz & Kutlu	2016	Turkey	Quasi Experiment	Elementary Education Online	Science process skills
Mulyeni et al.,	2019	Indonesia	Mixed method	Journal of Turkish Science Education	Science process skills
Mai et al.,	2023	Vietnamese	Survey	International Journal of Learning, Teaching and Educational Research	STEM
Savaş & Seker,	2022	Türkiye	Quasi-experimental	Journal of Innovative Research in Teaching	STEM, Scientific process skills
Meepat et al.,	2024	Thailand	one-group experimental design	Higher Education Studies	STEAM education, Science process skills

Author	Year	Country	Research Methods	Name of Journal	Variable
Adlaon & Ercillo	2023	Philippines	Quantitative	Journal for Re Attach Therapy and Developmental Diversity	Science Process Skills
Perdana et al.,	2021	Indonesia	Descriptive quantitative	International Journal of Evaluation and Research in Education (IJERE)	STEM
Sias et al.,	2017	United States of America	Qualitative research	The Journal of Educational Research	STEM
Susanti et al.,	2020	Indonesia	Qualitative research	Prima Education Journal	STEM
Lestari et al.,	2018	Indonesia	Quasi Experimental	Journal of Primary Education	STEM, Science Process
Quigley et al.,	2020	Pittsburgh, Pennsylvania, USA.	Qualitative research	Journal of Science Education and Technology	STEM
Mustafa et al.,	2021	Malaysia	Rasch model	International Journal of Evaluation and Research in Education (IJERE)	Science process skills
Sari et al.,	2020	Turkey	Mixed method	Turkish Science Education	STEM Education, Scientific Process Skills

This literature review will compare and analyze empirical data findings in previous studies on the application of STEM in improving science process skills in elementary schools. This section focuses on answering the research question, how is the application of the Science, Technology, Engineering, and Mathematics (STEM) learning approach in improving students' science process skills.

Based on Table 2, there are specifically 5 articles that discuss the application of STEM in improving students' science process skills (Sari et al., 2020; Lestari et al., 2018; Wulandari & Sari, 2023; Meepat et al., 2024; Savaş & Şeker, 2022). The results of the analysis of the 5 articles, STEM is effective in improving students' science process skills. Because this model is interactive, creative, and integrated, it is very suitable for elementary science education. The results of the analysis found that the application of STEM in improving science process skills can be done with project-based learning or problem solving. Through this approach, students become more active and creative in dealing with real problems and are able to link learning concepts with everyday life applications.

Based on the table, there are 5 articles that discuss the importance of the role of teachers and teacher understanding of STEM and science process skills in supporting learning (Mai et al., 2023; Adlaon & Ercillo, 2023; Quigley et al., 2020; Susanti et al., 2020; Sias et al., 2017). Teacher involvement in implementing STEM and science process skills contributes directly to higher quality learning, because the process requires in-depth planning, reflection, and evaluation. This is in accordance with the results of the analysis of the five

articles that there are still teachers who do not understand how to implement STEM. So comprehensive support is needed from various parties.

The application of the STEM approach in elementary school learning has become an effective strategy to improve students' science process skills. Science process skills, such as observation, classification, asking questions, interpreting data, and concluding, are basic skills that are important to develop early on because they support the formation of scientific mindsets and 21st century skills. The results of research by Meepat et al., (2024) suggest that STEAM-based learning is effective in improving science process skills, understanding of the physical properties of materials, and student learning satisfaction. This learning model is interactive, creative, and integrated, very suitable for elementary science education. The STEM approach can help build students' creative and innovative nature in preparing themselves for the era of the industrial revolution 4.0 (Firdaus et al., 2023). This is supported by research by Savaş & Şeker (2022) conducted in an elementary school in Turkey, the results of which STEM training that was developed positively influenced children's science process skills at an early age so that it could affect cognitive development and readiness to learn in the future. Furthermore, Mulyeni et al., (2019) in their research stated that to improve the basic science process skills of early childhood students, time and structured practice are needed so that students can apply science process skills spontaneously.

Elementary school is the right time for students to

try new things, because elementary school-aged children have many and varied interests. The STEM approach to learning can encourage children to try new activities so that they can improve students' science process skills. This can help students form a foundation for scientific and logical thinking that will be useful throughout their lives. In accordance with the research results of Lestari et al., (2018) which stated that the STEM project-based learning model has been proven effective in improving students' science process skills. Her research also shows that through this approach, students become more active and creative in dealing with real problems and can link learning concepts with everyday life applications. This means that the application of the STEM model not only improves the understanding of science concepts but also develops critical and creative thinking skills that are important for students in the future. This means that project-based learning like this can provide significant advantages and benefits for students. This statement is in accordance with the opinion of Wulandari & Sari (2023) in their research which shows that the application of a project-based learning model integrated with STEM significantly improves the science process skills of elementary school students. This model is effective in encouraging students to be more active and directly involved in the learning process, especially in understanding the concept of the material.

The implementation of STEM integrated with project-based learning that improves students' science process skills is evidence that teachers need to innovate learning and try different things to meet the needs of students. Sias et al., (2017) emphasized the same important thing in their study discussing educational innovation in STEM lesson plans produced by teachers for students in grades 3-5 and focused on preparing for 21st century skills. This study analyzed 39 lesson plans and identified nine educational innovations, with a strong emphasis on project-based and student-centered learning methods. In addition to the use of projects or experiments carried out in the implementation of STEM, there needs to be a special program that supports the improvement of science process skills through the STEM approach. Based on the results of the study by Kurnaz & Kutlu (2016), the Science Process Skills Program (BSBP) that was developed can significantly increase the level of use of students' science process skills. The programs provided are effective in helping students develop abilities such as observation, classification, experimental planning, and explanation of results.

Based on the results of the literature review, the STEM approach encourages students to be more actively involved in learning activities that require

them to explore, design, and solve problems creatively and collaboratively. Zengin et al., (2022) in their research stated that STEM is effective in improving the problem-solving skills of elementary school students. Students become more involved, creative, collaborative, and enjoy science activities. This can also be one of the bases that can be believed that the implementation of the STEAM approach in elementary schools can improve students' science process skills. One component of the science process is how to solve a problem. Sevim Gültekin & Altun (2022) stated that activities based on scientific process skills can improve the problem-solving abilities of 4th grade elementary school students.

STEAM-based learning also requires students to be able to use science process skills to find problems or create something to solve problems. Science process skills are certainly not easy for students to have. Mustafa et al., (2021) in their research managed to identify science process skills that are easy and difficult to master for elementary students, with observing and communicating skills as the easiest. While concluding and classifying are difficult skills. In line with that, Sari et al., (2020) in their research on exploring changes in the level of STEM awareness and students' scientific process skills as a result of Inquiry-Based Learning activities, stated that although the majority of students had a positive view of the use of simulations in STEM education, some students had difficulty adapting to the simulation program they had just learned. The results showed a significant increase in scientific process skills and STEM awareness after the activity. Therefore, the need for professional development and further support for teachers to facilitate the implementation of educational innovations, so that students can be better prepared to face challenges in the era of synthesis (Sias et al., 2017).

Teachers' understanding of the cognitive development of elementary school students is key to ensuring that the STEM approach applied is relevant and appropriate to the students' ability level. Teachers who understand the concept of science process skills will be able to design learning activities that stimulate scientific thinking skills without burdening students with concepts that are too abstract. This is in accordance with the research results of Mai et al., (2023) which showed that elementary school teachers need to have a good awareness of teaching integrated with STEM, although teachers' beliefs and confidence in implementing teaching are still low. Teachers need to have high awareness and confidence in teaching integrated with STEM. If necessary, all teachers regardless of their place of work and where they live. Because it is proven from the results of research that has been conducted, teachers who work in urban areas

have a high awareness and confidence in teaching integrated with STEM compared to teachers with lower qualifications who work in other areas. Furthermore Adlaon & Ercillo (2023) presented similar research results showing that elementary teachers in Surigao City had learned basic scientific process skills, but integrated scientific process skills were still not fully mastered. Male teachers were rated higher in controlling variables than female teachers.

Based on the research results (Mai et al., 2023; and Adlaon & Ercillo, 2023), it can be concluded that teacher knowledge of the STEM approach and science process skills play an important role in the successful implementation of STEM-based learning in elementary schools. Teachers are the main facilitators who determine how learning experiences are structured and delivered. Without adequate understanding, teachers tend to teach conventionally and are unable to integrate STEM elements effectively. Therefore, improving teacher competence, both in mastering STEM content and learning strategies based on science process skills, is crucial to achieving optimal learning outcomes. In line with that, Susanti et al., (2020) in their research emphasized the need for better socialization of STEM and adequate training to improve teacher readiness in implementing this approach in the classroom. The same thing was conveyed by Quigley et al., (2020) that it is necessary to emphasize the importance of ongoing support for teachers to overcome challenges in implementing the STEAM curriculum and increase student engagement.

Teachers not only need to understand the STEM approach to improve science process skills, but it is also important to understand students' attitudes in learning. Perdana et al., (2021) in their research concluded that understanding students' attitudes needs to be considered by educators and policy makers before implementing STEM-based learning and 21st century skills, to create more effective and relevant policies in STEM education at the elementary level. Based on the description above, the application of the STEM approach in improving elementary school science process skills can be designed through integrated learning, guidance in Problem Solving, and project-based learning. Through projects, students conduct experiments, observe, process data, draw conclusions, and reflect on the process. This process is very close to science process skills because it involves analytical processes, experiments, and evaluations. Thus, it can be concluded that the application of the STEM approach makes a positive contribution to improving students' science process skills in elementary schools. Learning that integrates science, technology, engineering, and mathematics can create meaningful learning experiences, foster curiosity, and develop scientific

thinking skills from an early age. However, the success of implementing this approach is highly dependent on the readiness and competence of teachers as the spearhead of implementing learning in the classroom. Therefore, there needs to be ongoing support in the form of training, curriculum development, and provision of relevant resources for educators

Conclusion

Based on the results of the literature review, it can be concluded that the application of the STEM approach in learning in elementary schools has proven effective in improving students' science process skills. This approach not only encourages students to actively think critically, creatively, and collaboratively, but also provides contextual learning experiences that combine various disciplines. However, the success of the implementation of the STEM approach is highly dependent on the knowledge and readiness of teachers in designing learning that is in accordance with the characteristics and cognitive development of students. Therefore, improving teacher competence in understanding STEM concepts and science process skills is important to support meaningful and sustainable learning at the elementary school level.

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Conflict of Interest

The author declares no conflict of interest.

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