

## The Implementation of STEM Approach (Science, Technology, Engineering, and Mathematics) on Science Learning at Elementary School

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### ABSTRACT

STEM is an approach that integrates science, technology, engineering, and mathematics in learning. The purpose of this study is to find out how much the STEM approach is implemented in science learning and to analyze the effective learning process while implementing the STEM approach. The research method used is literature review through Scopus and Google Scholar in 2017-2022. The results of a study of 15 articles that match the topic show: 1) the STEM approach is suitable to be implemented in science learning in elementary schools, 2) the learning process with the STEM approach can run effectively if the topic of the issues raised focuses on real problems in students' daily lives, the teacher understands the learning model used in integrating with STEM, enabling student-centered learning by conducting investigations to solve problems. Elementary teachers still need training and guidance in applying the STEM approach during the learning process. Elementary teachers still need training and guidance in applying the STEM approach during the learning process.

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### 1. INTRODUCTION

Educational trends in the 20th century have changed a lot so that the paradigm of the learning process must also change according to the times. Students must be equipped according to the demands of the very rapid development of science and technology, so the educational paradigm must adapt to the development of science, technology and the demands of the times. Many countries have implemented the STEM approach as integrating curriculum with learning processes such as Taiwan Vietnam, Finland, Malaysia, Australia, China, and the Philippines [1][2][3].

The concept of the STEM (Science, Technology, Engineering, and Mathematics) approach is needed by students in facing the industrial revolution 4.0 which is able to equip students with competencies according to the era. States that the application of STEM can help students develop knowledge, help answer questions based on investigations, create new knowledge. Students are encouraged to design, develop, utilize technology, hone cognitive, affective, and psychomotor abilities and be able to apply knowledge to produce a product that is useful for life[ ]. Learning with the STEM approach can train students to communicate, think critically, foster creativity and innovation so that students can face global challenges[5].

In learning science, it is agreed that argumentation is an important component because science is the result of construction of a theory that contains explanations and supporting evidence that explanation. Argumentation is central to education, especially in science education, namely to make meaning and have an

important effect on learning [6]. This is based on several opinions which state that students' involvement in scientific argumentation can improve conceptual, epistemological, and methodological understanding of science[7] as well as support students for enculturation into science practices[ ]. Related to this, improving the quality of learning by implementing STEM education as a preventive approach is expected to be able to help students integrate aspects of science, technology, engineering and mathematics so that it has an impact on improving argumentation skills.

The STEM approach shows students how the concepts, principles, techniques of science, technology, engineering and mathematics (STEM) are used in an integrated manner to develop products, processes and systems that benefit human life. STEM education means providing practical strengthening of education in STEM fields separately, as well as developing an educational approach that integrates science, technology, engineering, and mathematics by focusing the educational process on solving real problems in everyday life or professional life<sup>[9]</sup>. STEM is an integrated learning approach that connects real-world applications with classroom learning covering four disciplines, namely natural sciences, technology, engineering results, and mathematics. Therefore, it is necessary to study the STEM approach as a form of science learning that can be applied in elementary schools or not and how the potential for STEM learning is used in science learning in elementary schools.

## 2. RESEARCH METHODS

The method used in this study was a literature review with a data source of 15 articles on the topic of the STEM approach in the science learning. The search for data sources was carried out through scopus (<http://scopus.com>) and google scholar (<http://scholar.google.co.id>). The keywords used in this search process are 'STEM', 'science learning' or 'pembelajaran IPA', 'sekolah dasar' or 'elementary school'. Articles other than journal article or proceeding paper and published earlier than 2017 are eliminated. The collection of journals that was carried out reduced the sources from 25 articles to 15 articles that were appropriate to the topic of discussion. Data analysis was carried out by means of descriptive analysis. The data that has been collected is analyzed and then a conclusion is drawn which is used to answer questions in the research.

## 3. RESULT AND DISCUSSION

STEM is an approach that integrates science, technology, engineering, and mathematics in learning. The goal is that students can develop skills in reasoning, analyzing, solving, creating, and using various technological products in learning [10]. STEM approach means providing practical reinforcement of education in STEM fields separately, as well as developing an educational approach that integrates science, technology, engineering, and mathematics by focusing the educational process on solving real problems in everyday life or professional life [11]. STEM is an integrated learning approach that connects real-world applications with classroom learning covering four disciplines, namely natural sciences, technology, engineering results, and mathematics.

### STEM Approach in Elementary School Science Learning

STEM approach can be implemented at the formal education level/inside the classroom and the non formal unit level/outside the classroom [12].

Table 1. STEM Approach in Elementary School

No.	Author	Title	Focus of Study
1	Falentina, Lidinillah & Mulyana, (2018) <sup>[1]</sup>	Wind Powered Car: STEM Based Media for Class IV Elementary School Students	STEM-based Teaching & Learning Media
2	Oktavia, (2019) <sup>[2]</sup>	Teaching Materials Based on Science, Technology, Engineering, Mathematics to Support Integrated Science Learning	
3	Lidinillah, et,al (2019) <sup>[3]</sup>	Integration of STEM Learning into the Elementary Curriculum In Indonesia: An Analysis and Exploration.	

<sup>1</sup> Falentina, C. T., Lidinillah, D. A., & Mulyana, E. H. (2018). Mobil Bertenaga Angin : Media Berbasis STEM untuk Siswa kelas IV Sekolah Dasar. *Pedidaktika: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar*, 5(3), 152-162.

<sup>2</sup> Oktavia, R. (2019). Bahan Ajar Berbasis Science, Technology, Engineering, Mathematics Untuk Mendukung Pembelajaran IPA Terpadu. *Semesta: Journal of Science Education and Teaching*, 2(1), 32-36.

<sup>3</sup> Madyani, Yamtimah, & Utomo. (2019).

No.	Author	Title	Focus of Study
4	Fatimah, Hamdu & Nugraha, (2019) [4]	Development of Student Worksheets on Outdoor Learning STEM-Based in Primary Schools	
5	Erviana & Asmara (2019) [5]	STEM Integrated Encyclopedia as The Enrichment for Elementary School Students	
6	Setiawaty, Imanda, Fitriani, & Sari (2020) [6]	Development of STEM-Based Science Worksheets for Elementary School Students	
7	Maula & Fatmawati (2020) [7]	Development of Learning Media for Kayaku (Kayanya Alam Negeriku) STEM- Based in 4th Grade of Elementary Schools	
8	Nurazizah, Suwarma & Jauhari (2018) [8]	Implementation of STEM Learning: Assessment of Students' Learning Outcomes Achievement	STEM impact on learning achievement in general
9	Artobatama, (2018) [9]	Outbound Traditional Game Based STEM Learning	
10	Sukmana (2018) [10]	Science, Technology, Engineering, and Mathematics (STEM) Approach as an alternative in Developing the Learning Interest of Elementary School Students	STEM impact on critical thinking skill
11	Dywan & Airlanda (2020) [11]	The Effectiveness of Project Based Learning Learning Model Based on STEM and Not Based on STEM on Students' Critical Thinking Skills	
12	Rohmah, Ansori & Nahdi (2019) [12]	STEM Learning Approach in Improving Science Literacy Ability of Elementary School Students	STEM impact on scientific literacy
13	Mufidah, Badarudin &	Application of Learning Based on Science, Technology, Engineering,	STEM impact on questioning skill

<sup>4</sup> Fatimah, S., Hamdu, G., & Nugraha, A. (2019). Pengembangan Lembar Kerja Siswa pada Pembelajaran Outdoor Berbasis STEM di Sekolah Dasar. *Pedagogika Jurnal Ilmiah Mahasiswa Pendidikan Sekolah Dasar*, 6(1), 101-107.

<sup>5</sup> Erviana, V. Y., & Asmara, A. P. (2019). STEM Integrated Encyclopaedia as The Enrichment for Elementary School Students. *Jurnal Inovasi Pendidikan Dasar*, 5(1), 31-44

<sup>6</sup> Setiawaty, S., Imanda, R., & Fitriani, H. (2020). Pengembangan LKS Sains Berbasis STEM Untuk Siswa Sekolah Dasar. *Prosiding Seminar Nasional Peningkatan Mutu Pendidikan*, 485-490. Langsa: Fakultas Keguruan dan Ilmu Pendidikan Universitas Samudra.

<sup>7</sup> Maula, N. R., & Fatmawati, L. (2020). Pengembangan Media Pembelajaran Kayaku (Kayanya Alam Negeriku) Berbasis STEM Kelas IV Sekolah Dasar. *Jurnal Ilmiah Sekolah Dasar*, 4(1), 97-105

<sup>8</sup> Nurazizah, Suwarma, I. R., & Jauhari, A. (2018). Implementasi Pembelajaran Stem: Kajian Terhadap Pencapaian Hasil Belajar Siswa. *Prosiding Seminar Nasional Fisika (SiNaFi) 2018*. Bandung: Departemen Pendidikan Fisika, FPMIPA UPI.

<sup>9</sup> Artobatama, I. (2018). Pembelajaran STEM Berbasis Outbound Permainan Tradisional. *Indonesian Journal of Primary Education*, 2(2), 40-47.

<sup>10</sup> Sukmana, R. W. (2018). Pendekatan Science, Technology, Engineering And Mathematics (STEM) Sebagai Alternatif dalam Mengembangkan Minat Belajar Peserta Didik Sekolah Dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 2(2), 189-197.

<sup>11</sup> Dywan, A. A., & Airlanda, G. S. (2020). Efektivitas Pembelajaran Model Project Based Learning Berbasis STEM Terhadap Keterampilan Berpikir Kritis. *Jurnal Basicedu*, 4(2), 344-354.

<sup>12</sup> Rohmah, U. N., Ansori, Y. Z., & Nahdi, D. S. (2019). Pendekatan Pembelajaran STEM dalam Meningkatkan Kemampuan Literasi Sains Siswa Sekolah Dasar. *Seminar Nasional Pendidikan*, 471-478.

No.	Author	Title	Focus of Study
	Yuwono (2019) [13]	and Mathematics (STEM) to Improve Basic Questioning Skills and Learning Achievement of Elementary School Students	
14	Hughes, et al (2022) [14]	<u>RAISE: Robotics &amp; AI to improve STEM and social skills for elementary school students</u>	STEM impact on social skills
15	Adiwiguna, Dantes, & Gunamantha (2019) [15]	The Effect of STEM-Oriented Model Based Learning (PBL) on Critical Thinking Ability and Science Literacy of Class V Elementary School Students in Gugus I Gusti Ketut Pudja	STEM impact on critical thinking skill and scientific literacy

Based on Table 1, it shows that the STEM approach has been applied to learning science in elementary schools with different goals. In general, the purpose of the STEM approach in science learning are to impact on learning achievement in general, critical thinking skill, scientific literacy, questioning skill, social skills, critical thinking skill and scientific literacy.

Learning using STEM approach can seek to bring out skills in students, for example the ability to solve problems and the ability to carry out investigations. These skills are important to help improve human resources. Proponents of a more integrated approach to STEM education also argue that teaching STEM in a more connected way, especially in the context of real-world issues, can make STEM subjects more relevant to both students and teachers. This in turn can increase motivation to learn and increase student interest, achievement, and persistence. It is believed STEM that integrates the four disciplines will also increase the number of students considering careers in STEM-related fields [28]. The use of the STEM approach in the field of education has the aim of preparing students to be competitive and ready to work according to the field they are engaged in. Research shows that the main goal of STEM Education is sebuah usaha untuk menunjukkan pengetahuan yang bersifat holistik antara subjek STEM[29].

The four STEM disciplines are Science, Technology, Engineering, and Mathematics and can be summarized as follows [30].

1. Science to develop interest in and understanding of the living, material, and physical worlds and develop skills of collaboration, research, critical inquiry, and experimentation.
2. Technology covers a wide range of fields that involve the application of knowledge, skills, and computational thinking to expand human capabilities and help meet human needs and wants.
3. Engineering as the skills and knowledge to design and construct machines or equipment and processes that are useful for solving real-world problems.
4. Mathematics equips the skills necessary to interpret and analyze information, simplify and solve problems, assess risks, make informed decisions and further understand the world around us through modeling abstract and concrete problems [31].

STEM approach is an alternative solution in 21st century learning. This is because STEM is able to increase the leverage and leverage of students' potential. In addition, STEM is also able to present ways of solving problems in real life. For example, students can develop useful products, processes, and systems through the interplay of science, technology, engineering, and mathematics. That way, it is hoped that students will have the provision of life skills to compete with the demands of the 21st century.

STEM is a bridge that connects educational institutions (schools) to the real world. A world in the future that is dependent on advanced technology such as: drones, robotics, industrial automation, smartphones, IoT (Internet of Things), and so on. STEM is an integrated learning approach that connects application in the real world with learning in the classroom that covers the four disciplines science, namely natural science (science), technology, engineering results, and mathematics.

<sup>13</sup> Mufidah, I. A., Badarudin, & Yuwono, P. H. (2019). Penerapan Pembelajaran Berbasis Science, Technology, Engineering, and Mathematics (STEM) untuk Meningkatkan Keterampilan Bertanya Dasar dan Prestasi Belajar Peserta Didik Sekolah Dasar. *Al- Ishlah Jurnal Pendidikan*, 11(2), 210-222.

<sup>14</sup> Hughes CE, Dieker LA, Glavey EM, Hines RA, Wilkins I, Ingraham K, Bukaty CA, Ali K, Shah S, Murphy J and Taylor MS (2022) RAISE: Robotics & AI to improve STEM and social skills for elementary school students. *Front Virtual Real.*

<sup>15</sup> Adiwiguna, S., Dantes, N., & Gunamantha, M. (2019). Pengaruh Model Problem Based Learning Terintegrasi STEM Terhadap Kemampuan Literasi Sains dan Berpikir Kritis Siswa Kelas V SD di Gugus I Gusti Ketut Pudja. *Jurnal Pendidikan Dasar Indonesia*, 3(2), 94-103

In the context of primary and secondary education, STEM education aims to develop students who are STEM literate [32], with the following details.

1. Have the knowledge, attitudes, and skills to identify questions and problems in their life situations, explain natural phenomena, design, and draw evidence-based conclusions about STEM-related issues.
2. Understand the special characteristics of STEM disciplines as human-initiated forms of knowledge, inquiry, and design;
3. Have an awareness of how STEM disciplines shape the material, intellectual and cultural environment,
4. Have a desire to be involved in studying STEM-related issues (eg energy efficiency, environmental quality, limited natural resources) as constructive, caring, and reflective citizens by using the ideas of science, technology, engineering, and mathematics

### An Effective Learning Process for Implementing The STEM Approach

If you look in the mirror from education in Indonesia, the trend regarding STEM in Indonesia very interesting but very minimal at all in its implementation. Science learning using the STEM approach for elementary school students is one of the efforts to improve learning in the scientific literacy skills of elementary school students. What is very important to note is that elementary school teachers must correctly understand the main points related to this STEM approach. First, learning must focus on real issues or problems. Second, activities must be inquiry, hands-on and open-ended. Third, learning must be developed through an engineering design process so that students will be creative and make the latest breakthroughs. Fourth, apply science and mathematics creatively, effectively and contextually. Fifth, it must allow for multiple answers from students and correct any failures from learning (trial and error). Finally, facilitating students to build the ability to cooperate between students and other students. To understand the implementation of the STEM approach in learning science is as follows.

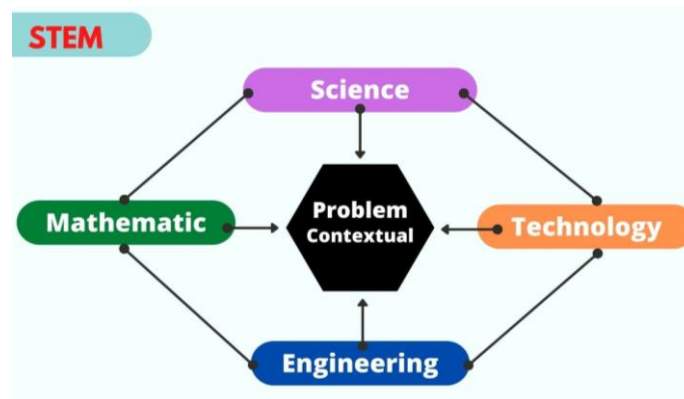


Figure 1. STEM design

1. Contextual Problem: regarding the sound produced by vibrating objects, for example by using a guitar and explaining various points of view about musical instruments.
2. Science: the teacher explores students' knowledge of how the guitar is rhythmic, why musical instruments can sound
3. Technology: Students are asked to make a simple guitar by paying attention to the tools and materials needed.
4. Engineering: Students are asked to adjust the strings or rubber on the guitar to produce different sounds.
5. Mathematics: students will measure the length and width before making a guitar and calculate the price of the materials needed when making a guitar.

Therefore, the teacher in designing the STEM approach in learning is centered on real issues or problems that are contextual, learning must be inquiry, hands-on and open-ended, there must be design activities that produce products so that students can apply science, technology, engineering, and mathematics creatively and effectively. This is necessary because the STEM approach must be able to integrate the four interdisciplinary fields simultaneously.

Teachers have high confidence in STEM learning to help students' abilities to solve problems in everyday life. They usually use basic mathematics and techniques to explain scientific problems[ ]. They ask students to create or design a model and free them to adopt math-based thinking, and use technology to support problem solving and model design. The application of STEM in learning can encourage students to design, develop and utilize technology, hone cognitive, affective, and apply knowledge. STEM-based learning can train students in applying their knowledge to create designs as a form of solving problems related to the environment by utilizing technology.



STEM learning combines science, technology, engineering, and mathematics to produce works so that elementary school students are taught from an early age about technological developments. With STEM learning, students can carry out investigations to solve problems in elementary schools as well as a more complete understanding of material concepts. In addition, STEM learning is very suitable to be applied in elementary schools because it is in accordance with the 2013 curriculum through the integration of several subjects and applied in real life [34][35]

#### 4. CONCLUSIONS

STEM learning is suitable for implementing science learning in elementary schools which must focus on real problems in everyday life. Before implementing the STEM approach in science learning, the teacher must determine problem topics that focus on real problems in students' daily lives, understand the learning models used to integrate with STEM, and activate student-centered learning by conducting investigations to solve problems.

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