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# Implementation of Science, Technology, Engineering, and Mathematics (STEM) Models to Improve Student's Critical Thinking Abilities in Science Learning in Primary Schools

**Zahidah Nurul Kamilah*, Fitri Nuraeni, Afridha Laily Alindra**
PGSD Universitas Pendidikan Indonesia Kampus Purwakarta

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*Corresponding Author:
zahidahnurulkamilah@upi.edu

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**ABSTRACT**

Critical thinking ability is one of the abilities that every student in Indonesia needs to have, especially when learning science. Based on the researcher's initial data, the results of daily tests in science subjects obtained an average of ≥ 75 of 64 with a percentage of completion of classical results of 22.22%. Apart from that, there is data from interviews with teachers that class VD has not implemented innovative learning models in science learning in class VD. It can be concluded that class 5D at SDN 1 Tegalmunjul still requires actions that can innovate classroom learning and improve students' critical thinking abilities in science learning. Therefore, the STEM learning model is applied to determine the process of student learning activities and increase students' critical thinking abilities in science learning after implementing the STEM learning model. This research uses classroom action research (PTK) with a Kemmis and Taggart research design. The subjects of this research were 27 class VD students at an elementary school in Purwakarta Regency. This research instrument uses critical thinking ability tests, written description tests, and student and teacher activity observation sheets. The percentage of students' critical thinking ability test results in one class in cycle 1 was 33.3%, rising to 88.8% in cycle 2. So, applying the STEM learning model can improve students' critical thinking abilities in science learning in elementary schools.

## INTRODUCTION

Education plays an important role in the survival of every society in Indonesia, especially in the process of forming the personality and mindset of each child who will become the nation's intelligent and superior next generation. Basic education will create a good change, namely that they will continue to learn and develop according to the conditions of their surrounding environment. Science is a subject that is the first step for children to gain various knowledge, such as the role of the natural and artificial environment which is associated with everyday life, skills in the process of acquiring new knowledge, broad insight, and how to develop various abilities in dealing with problems. Science can be a process that contains scientific activities in perfecting new knowledge, become a product in the form of a result of the process in the form of new information that can be shared, and become a procedure in implementing scientific methods to find out about research. Teachers become facilitators for students in developing various knowledge. Therefore, it is hoped that teachers can design innovative learning so that it can be applied in everyday life (Sakila et al., 2023).

In the changing era of industrial globalization 4.0, the education system in Indonesia continues to develop according to the times. Of course, in designing learning, teachers adapt to changes in the curriculum. 21st-century education focuses on abilities that must be developed in an educational institution, namely 4C (creativity; Creative Thinking, critical thinking and problem-solving; Critical Thinking and problem-solving, communication; Communication, collaboration;

Collaboration). This is in line with the US-based Partnership for 21st Century Skills (P21) explaining that the competencies that must be honed and developed by human resources, especially elementary school students in the 21st century, are: critical thinking skills (Critical Thinking Skills), creative thinking skills/ creativity (Creative Thinking Skills), communication skills (Communication Skills), and collaboration skills (Collaboration Skills). Science is a subject content at the education level, especially basic education, which can be a combination in developing 4C abilities in schools (Jannah & Atmojo, 2022).

Educational institutions in Indonesia have of course designed various efforts so that students can continue to develop the 4C competency abilities, such as switching to an independent curriculum that focuses on developing soft skills and character. One of the abilities that students must develop, especially during the learning process at school, is the ability to think critically. According to Johnson (in Fadli, 2019), critical thinking is a directed and clear process used in mental activities such as solving problems, making decisions, persuading, analyzing opinions or assumptions, and conducting scientific research. This of course cannot be separated from various problems faced in the world of education, namely the lack of mastery of students' critical thinking skills when faced with a problem or a phenomenon in the surrounding environment. Based on the results of research observations during initial observations in class VD SDN 1 Tegalmunjul, during science learning, the teacher provoked discussion regarding changes in the shape of objects in the surrounding environment. However, only around 10 out of 27 students were able to identify, explain causes and effects, state solutions, and conclude the discussion of the problem. These aspects are indicators of critical thinking abilities. Then, based on the student's initial data, the daily test results in the science and science subjects obtained an average score of 64 with a percentage of classical results completion of 22.22%. Meanwhile, the KKM score in the science and science subjects in class VD is ≥ 75. It is known that 6 students who achieved a score ≥ 75 were categorized as complete and 21 students who did not reach 75 were categorized as incomplete. Apart from that, the researcher also conducted interviews with the 5D class teacher at SDN 1 Tegalmunjul, where the researcher asked questions regarding the suitability of indicators and the level of critical thinking skills as well as the application of the STEM learning model in the classroom. However, based on the results of the interview, the teacher has not implemented innovative learning models in science and science learning in class VD. It can be concluded that class 5D at SDN 1 Tegalmunjul still requires efforts and actions that can innovate classroom learning and improve students' critical thinking skills in science learning. As educators, it is necessary to evaluate learning model strategies in schools, so that the 4C competency abilities, especially the critical thinking abilities of students in Indonesia, can always develop. The STEM (Science, Technology, Engineering, and Mathematics) approach aims to direct students to be able to learn independently, form logical thinking in various knowledge domains, and hone critical thinking skills (Wahyunita & Subroto, 2021).

STEM is an innovative learning model that can be applied in schools to learn science, technology, engineering, and mathematics, which can stimulate students to think critically. The STEM learning model focuses on concrete learning activities related to the surrounding environment. Mutakinati (Ritonga & Zulkarnain, 2021) explained that STEM is a learning model that can improve critical thinking, because students are encouraged to identify problems related to environmental pollution, by focusing on existing facts. They are trained to focus carefully on existing environmental problems. STEM learning aims to develop analytical and problem-solving skills in real-life contexts. By providing problems, students are encouraged to think deeply to find solutions to current problems. STEM also helps students organize and explain the reasons behind the conclusions they draw. When concluding, they can make appropriate and relevant conclusions. At the situation stage, students can use all relevant information well. Then this STEM model focuses on how teachers teach and organize or process students' learning

experiences, such as problem-based, case-based learning projects, experiments or trials, and various other activities that are still related to STEM units (Muttaqiin, 2023).

Research on improving critical thinking skills through the STEM learning model has been carried out by several researchers, such as Davidi et al, (2021) who found that there were significant differences in critical thinking skills between before and after learning with the STEM approach in elementary schools. Meanwhile, research conducted by Hadi (2021) with the results of data analysis and research shows that the use of the STEM-integrated PBL model is more effective in improving the critical thinking skills of fifth-grade elementary school students. Thus, these two studies show good results, namely an increase in students' critical thinking abilities when they have implemented a STEM approach in classroom learning.

Through several problems that have been explained, researchers will then conduct research with the title "Implementation of the Science, Technology, Engineering, and Mathematics (STEM) Model to Improve Student's Critical Thinking Ability in Science Learning in Elementary Schools".

**LITERATURE REVIEW**

STEM is an abbreviation of learning methods that include Science, Technology, Engineering, and Mathematics. The term STEM was introduced by the United States NSF (National Science Foundation), precisely in the 1990s. According to Kapilla and Iskandar (dalam Riyanto et al., 2021) overall, the use of STEM in a teaching or learning context has the potential to inspire students to design, develop, and use technology, improve their cognitive, manipulative, and affective abilities, as well as apply the knowledge gained. they have. The STEM approach integrates learning through four main components: science, technology, engineering, and mathematics. Teachers usually provide a problem, and students can search for information and solve the problem in the classroom or outside the school.

Each aspect of STEM has unique characteristics that differentiate it from one another. These four characteristics are based on the definition outlined by Torlakson (in Pambayun & Shofiyah, 2023). First, science includes knowledge of the principles and concepts that apply in nature. Second, technology refers to the skills or systems used in organizing society, organizations, and knowledge, as well as designing and using artificial tools to make work easier. Third, engineering or engineering involves knowledge to operate or design a procedure to solve a problem. Finally, mathematics is the science that connects quantities, numbers, and space using logical arguments, either with or without the support of empirical evidence. Integration of all these aspects in the learning process can increase the meaning of the knowledge gained.

According to Bybee (in Syarah et al., 2021) the aim of the STEM model is a primary and secondary education context that develops students' abilities in STEM. Therefore, students have the knowledge, attitudes, and skills to find out or discover questions and problems in everyday life. Apart from that, students can draw conclusions related to various STEM problems or issues, understand the characteristics of STEM disciplines as a form of knowledge, explain natural phenomena, create and organize human ideas, and understand the influence of STEM on the material, intellectual, and cultural environment. Therefore, it is hoped that this model can obtain an impact that is by these objectives.

In general, the aims and benefits of the STEM learning model are expected to be able to train critical, creative, logical, and innovative thinking skills, instill a spirit of responsibility and cooperation in solving problems, prepare for future work, utilize technological infrastructure to innovate in learning, and the existence of media to develop the search for information or problems and be able to solve them critically (Suriti, 2021). It can be concluded that the benefits of the STEM learning model for teachers and students can develop various skills to familiarize and improve learning in the 21st century.

According to Nuraeni (in Firdaus et al., 2023), simple steps for STEM learning consist of,

1. Ask, usually the teacher presents a problem that occurs in the everyday environment. Then students identify the problem and observe the limitations of the problem.
2. Imagine, students cooperatively seek and imagine solutions to the problem.
3. Planning, students in groups create and design solutions and make a list of tools and materials needed to solve the problem.
4. Create, students create a new idea for a product based on the plan that has been prepared.
5. Improve (Improve), then students observe the weaknesses of the product being made so that students can revise the product to ensure the quality and function have been tested well.

According to Khasanah & Ayu (dalam Diva & Purwaningrum, 2023), critical thinking ability is a person's ability to review and solve problems thoroughly. After that, the individual can interpret, analyze, and examine the existing information. The information is then checked for correctness using the knowledge the individual has. As a result, individuals can conclude the information provided with logical reasons and explanations, which are then used as a basis for acting in solving problems.

According to Rositawati (2019), the following are the characteristics of critical thinking:

1. Curiosity is related to various problems
2. Interest in improving yourself
3. Be alert to opportunities to use critical thinking
4. Confidence in the search or investigation process
5. Believe in your abilities
6. Openness to different world perspectives
7. Flexibility in considering alternatives and points of view
8. Understanding of other people's points of view
9. Be careful in delaying, making, or changing judgments
10. Readiness to reconsider and revise views
11. Honesty in the face of prejudice, stereotypes, or egocentric tendencies.
12. Be careful in delaying, making, or changing judgments
13. Willingness to reconsider and revise views based on reflection.

Critical thinking skills according to Ennis (Amalia et al., 2021) consist of five main indicators:

**Tabel 1.** Critical Thinking Skills

| No | Aspects of Critical Thinking Ability | Indicators |
|---|---|---|
| 1. | Provide a simple explanation *(elementary clarification)* | 1. Can formulate questions<br>2. Can analyze arguments<br>3. Classify by asking questions |
| 2. | Build basic skills *(basic support)* | 4. Consider the credibility of the source<br>5. Make observations and assess |
| 3. | Concluding *(inference)* | 6. Making deductions and considering the results of the deduction<br>7. Make an induction and consider the results of the induction<br>8. Make and determine your considerations |
| 4. | Make further explanations *(advanced clarification)* | 9. Can identify terms and consider a definition<br>10. Can identify various assumptions |
| 5. | Strategy and tactics *(strategy and tactics)* | 11. Considering reasons / Determining actions<br>12. Combining information and integrating it in making decisions |

According to Trianto (in Ariyawati et al., 2017) Natural Science is considered a branch of science that develops through the process of observation, problem identification, hypothesis formation, hypothesis testing through experiments, deduction of conclusions, and formulation of theories and concepts. In general, science is understood as a science that grows and develops through a series of steps, starting from observation, problem identification, hypothesis formulation, hypothesis testing through experiments, deduction of conclusions, to the discovery of theories and concepts.

According to the Ministry of Education, Culture, Research, and Technology (in Agustina et al., 2022), science learning in the independent curriculum aims to arouse interest and curiosity, encourage active participation, develop inquiry skills, understand oneself and the environment, and expand knowledge and understanding of science concepts. Additionally, science learning also aims to develop scientific literacy and strengthen students' understanding of more complex natural sciences. In environmental learning, students are introduced to interrelated natural and social phenomena, and they are encouraged to observe, research, and engage in activities that strengthen inquiry skills, which are an important foundation before continuing their education to a higher level.

The teaching material that the researcher will take is a discussion from the book Independent Curriculum for Natural and Social Sciences for Class 5, Chapter 5 (How We Live and Grow), Topic A (How Does Breathing Help Me Do My Daily Activities?). This activity is carried out using the STEM model.

**Table 2.** STEM Model

| Science | Technology | Engineering | Mathematics |
|---|---|---|---|
| Human Respiratory System | Use of tools and materials to make SIPERSIA teaching aids | Create designs and simulate how SIPERSIA props work. | Take measurements of each tool and material that is required for its size. |

## METHOD

The type of research that will be used by researchers is Classroom Action Research (PTK). This research applies the research design from Kemmis & Mc. Taggart divides it into four components, namely planning, action, observation, and reflection (Widayati, 2008). The place where the research will be carried out is at SDN 1 Tegalmunjul, located on Jalan Ipik Gandamanah No. 46, Purwakarta District, Purwakarta Regency, West Java Province. Established in 1952 with NPSN 20229547. The research subjects in class V of SDN 1 Tegalmunjul were 27 students, consisting of 16 boys and 11 girls. The research subject that will be applied is the STEM model in science learning, Class 5 Natural and Social Sciences Independent Curriculum, Chapter 5 (How We Live and Grow), Topic A (How Does Breathing Help Me Do My Daily Activities?).

## RESULT AND DISCUSSION

Research in the VD class at SDN 1 Tegalmunjul was carried out in 2 cycles, with 2 meetings in each cycle. Initial data for the VD class of SDN 1 Tegalmunjul in science subjects is categorized as low, namely getting an average of 64 with a percentage of completeness of classical student learning outcomes of 22.2%. Apart from that, there is data from interviews with the VD class teacher, that this class still applies the conventional model and rarely links indicators of critical thinking skills at each stage of learning. Therefore, this class still requires action so that the quality of the learning stages and students' critical thinking abilities increase.

After carrying out various learning stages and actions adapted to the syntax of the STEM learning model and critical thinking ability indicators for 2 cycles, there were quite improved

results. Based on data from observations of student activities at the 1st meeting of cycle 1, the average was 2.588 with a percentage of 64.7%, at the 1st meeting of cycle 2 it increased with an average of 3.259 and a percentage of 88.2%. There was a difference in the results of the 1st meeting activities from cycle 1 to cycle 2, with an increase in the total score of 16 points and a percentage increase of 23.5%. The data from observations of student activities at the 2nd meeting of cycle 1 obtained an average of 3,091 with a percentage of 77.2%, then at the 2nd meeting of cycle 2, there was an average increase of 3,818 and a percentage increase of 95.4%. There was a difference in the results of the 2nd meeting activities from cycle 1 to cycle 2, with an increase in the total score of 16 points and a percentage increase of 18.2%.

Apart from that, an increase occurred in the students' critical thinking ability test results, where there was quite a significant difference between the test results in cycle 1 and cycle 2. In cycle 1, the average student's critical thinking ability test result was 66 points with a classical completion percentage. amounting to 33.3%. However, during cycle 2, students' critical thinking ability test results had an average increase of 86 points with a classical completion percentage of 88.8%. This increase in critical thinking ability test results can increase because, in every act of student learning activity, activities are included that train them to learn to think critically according to the indicators used. Adjusting the stages to the syntax of the STEM learning model is one of the efforts to make learning successful.

## CONCLUSION

Based on research carried out from May to June 2024 at SDN 1 Tegalmunjul, by implementing the STEM learning model to improve students' critical thinking skills in science learning in elementary schools, the following conclusions were obtained:

1. Student activity in science learning with the application of the STEM model increases every cycle. In cycle 1, the first meeting obtained an average of 2,588 with a percentage of 64.7% in the less active category, and the second meeting obtained an average of 3,091 with a percentage of 77.2% in the quite active category. In cycle 2, the first meeting obtained an average of 3,529 with a percentage of 88.2% in the very active category, and the second meeting obtained an average of 3,818 with a percentage of 95.4% in the very active category. PTK in this research was carried out in 2 cycles of 4 meetings, which had a positive impact on the learning process in the classroom.
2. Students' critical thinking abilities in science learning after implementing the STEM model, there is an increase in each cycle to reach KKM. In cycle 1 the percentage of classical completeness was 33.3% and in cycle 2 it was 88.8%. The target percentage of classical completeness in this research is ≥ 85% and the KKM that has been set by SDN 1 Tegalmunjul is ≥ 75. This research concludes that applying the STEM model in improving students' critical thinking skills in science learning in elementary school, is declared successful.

The two points explained above conclude that applying the STEM model in improving students' critical thinking skills in science learning in elementary school has a positive impact on the learning process. This is evident from the increasing ability of teachers in teaching and student activities which improve students' critical thinking abilities in each cycle.

Based on the findings of the classroom action research, the researcher conveys the following recommendations:

1. Can be used as input for teachers to choose the right learning model in the learning process, because the application of this STEM model has increased student activity and students' critical thinking abilities.
2. Based on the results of this research, there are still indicators that have not reached ≥ 85%, namely indicator 3 Clarifying by conducting questions and answers (elementary clarification). Future researchers can improve these indicators by better mastering the material presented

and assisted by digital media that can facilitate students' understanding and always link learning to their learning experiences.

3. Applying the STEM model requires paying attention to every existing aspect to provide a positive impact from the advantages of using this learning model during the learning process. Then the researchers developed a STEM model to improve students' critical thinking skills in science learning in elementary school by analyzing every aspect of skills and attitudes so that this research could show other advantages of the STEM learning model.

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