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Improving students' critical thinking skills using the STEM learning model for water cycle material in fifth grade elementary school

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ABSTRACT

Education in the 21st century must focus more on student-centered learning, helping students acquire essential skills and guiding them through the learning process. One crucial skill students need to develop is the ability to be active learners. Critical thinking skills enable students to solve problems and address issues by seeking information from various sources. One effective learning model that can enhance students' critical thinking skills is the STEM learning model. This research aims to evaluate the effect of implementing the STEM learning model on improving the critical thinking skills of fifth-grade students with respect to the water cycle material. A mixed-methods approach with an explanatory sequential design was employed for this study. The subjects were 30 fifth-grade students from Giriwangi State Elementary School. The research results revealed that the average pretest score of the students before the implementation of the STEM learning model was 39.00. After applying the STEM learning model to the water cycle material, students showed significant improvement, achieving an average posttest score of 73.66.

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1. INTRODUCTION

This 21st-century education is moving towards learning that is more focused on students, helping them acquire skills, and guiding them in the learning process. Learning is defined as the effort to push And guide students learning (Wijaya, Sudjimat, and Nyoto 2016). Thus, Teachers must have the ability to compile system learning according to the times. Apart from that, teachers must have an understanding strong of choosing model learning in accordance with the development era.

Skills 4C must also be applied to students in Elementary School. According to Brookhart (Widodo and Wardani 2020) teaching 4C skills to elementary school students can teach them

how to communicate in various situations, How to Work The same For reach objectives together, And How to find problem solutions. Skills4C Which must applied in elementary schools are critical thinking skills, critical thinking skills, skills Work And skills communication. According to (Nopiani et al.2023) 21st-century skills that students must have are 4C skills Which among them thinking creatively (CreativityThinking), thinking critically (Critical Thinking), and communication (Communication) work the same (Collaboration). Furthermore (Sugiarto & Wise, 2018) mention that Learning on Century is used For applying skills 4C (Critical thinking, Communication, Creativity, and Collaboration). In harmony with thinking according to Anton & Trisoni (2022) Skills 4C that is skills Work The same (Collaboration), skills critical thinking, creative skills (Creativity), and communication skills (Communication).

Skills 4C This needs to develop century skills to think critically with developed skills This student can solve a problem as well as finish a problem by looking for solutionfrom source information Which found. Skillsthink critical is the ability To help someone decide what to do, according to Ennis (Hafni And Sari 2021).In line with thinking(Princess, Suharno, And English2018) Skills think critically with skills Which use thinking logically To solve problems understanding the problem first, then expressing your opinion, and finally concluding. According to Halimah, Usman, & Maryam (2023), students' ability to think critically To solve problems, formulate problems, make decisions, And make conclusions Which accurate. Critical thinking skills are very important for students according to Erinsyah & Baadilah (2023) Critical thinking skills enable students to find information and solve the problem in the right way. However, according to Syafitri, Armanto, and Rahmadani (2021), the ability of students To critically find and understand the information is very crucial in solving the problems faced. As for characteristics skills thinking critically skills owned by someone To explain a problem, look for information to find solutions, able to conclude problems, and able to act honestly and not easily deceived by others. Critical thinking skills have five indicators according to Ennis in Anisa & Siregar (2024), among others: students can provide simple explanations (Elementary Clarification), develop basic skills (Basic Support), make conclusions (Iffering), provide further explanations (Advance) Clarification) and design strategy and tactics (Strategies and Tactics).

The critical thinking skills of elementary school students are often low due to various factors, as highlighted by past research. According to Rusmita (2022), students exhibit poor critical thinking abilities when the learning environment is predominantly teacher-centered, resulting in limited student engagement. Consequently, many students struggle to grasp the content effectively. Furthermore, the teaching methods employed are frequently not diverse enough, leading to a lack of enthusiasm and increased boredom among students. Typically, learning materials are confined to thematic books. Therefore, it is essential for teachers to select instructional models that actively promote the development of critical thinking skills in their students.

To enhance system learning in alignment with modern developmental timelines, teachers must be capable of understanding the process of selecting learning models that guide students in improving their critical thinking skills. One effective method to achieve this is through the implementation of STEM-based learning models (Kelana et al., 2024). STEM, which integrates four key fields—Science, Technology, Engineering, and Mathematics—enables students to tackle problems within these domains (Yuliana et al., 2023). Utilizing a STEM learning approach can significantly enhance students' critical thinking abilities by encouraging them to engage in activities such as designing, investigating problems, and

finding solutions to real-world challenges (Rusmita, 2022). According to Muttaqiin (2023), STEM education fosters logical thinking, self-organization, creativity in problem-solving, and the exploration of new concepts. By adopting the STEM learning model, students can better comprehend problem concepts, devise effective solutions, and showcase these solutions through product design (Octaviyani et al., 2020). The Engineering Design Process (EDP) model, as outlined by Anne Jolly (Isaac, Israwaty, and Halik, 2021), includes several steps: Define the problem, Research and Imagine, Plan, Create, Test and Evaluate, Redesign, and Communicate.

In a recent study, the application of the STEM learning model was explored to enhance critical thinking skills in science education. Carlina (2023) demonstrated that utilizing the STEM model can significantly improve students' thinking skills in fifth-grade science classes. This improvement was evidenced by the increase in scores from the first cycle, with a 34.79% score in the first meeting and a 44.16% score in the second meeting. In the second cycle, the scores rose further, reaching 51.04% in the first meeting and 71.04% in the second meeting. Additionally, Yasifa's (2023) research indicates that the STEM learning model effectively enhances students' critical thinking skills in science. This was reflected in an N-Gain score of 0.81, indicating a substantial increase in students' critical thinking abilities after implementing the STEM approach compared to their performance before its application in science learning.

Based on the background of the problem, this research aims to address a specific issue and identify solutions by utilizing various information sources and employing technology as a tool. This approach is intended to help students develop critical thinking skills through the application of a STEM learning model focused on the water cycle for fifth-grade elementary students. The study also seeks to evaluate the improvement in critical thinking skills when using the STEM learning model related to the water cycle in fifth-grade classrooms..

2. METHODS

The method used in this research is a quantitative experiment. According to Sugiyono (2019), a quantitative experiment is a type of quantitative study that is implemented through testing. The objective of this study is to understand how the independent variable (treatment) influences the dependent variable (results) under controlled conditions. This research employs a quasi-experimental method, which is one of the most effective types of quantitative research for measuring cause and effect. The research design used in this study is descriptive, specifically a one-group pretest-posttest design. This study design can be depicted as follows:

$$O_1 \quad \times \quad O_2$$

Figure 1. The One Group Pretest Posttest Design

Based on the image, X before 0 represents a pretest assessing critical thinking skills. In Figure 0, the treatment refers to a learning process utilizing the STEM model. Meanwhile, X after 0 indicates a posttest evaluating the critical thinking skills of the students. The subjects of this study consisted of all fifth-grade students, totaling 30, with an equal distribution of 15 male and 15 female students. The study was conducted at Giriwangi State Elementary School 2, located in Cipongkor District, Bandung Regency, West Java. Data collection techniques involved administering tests, including various essay questions. The data was

analyzed using IBM SPSS 25, which included descriptive analysis, normality tests, paired sample t-tests, and N-Gain tests.

3. RESULTS AND DISCUSSION

3.1 Results

Analysis Descriptive

The descriptive analysis in this study aims to identify the largest, smallest, and average scores from the pretest and posttest results. This analysis was conducted using the SPSS 25 software application for statistical analysis. The results are presented in Table 1.

Table 1. Result Analysis Descriptive

Descriptive Statistics					
N	**Result**	**Mark the Smallest**	**Mark the Biggest**	**Average**	**Std. Deviation**
30	Pretest	10	60	39,00	15,960
30	Posttest	50	90	73,66	13,060

The descriptive analysis of the data gathered from the 30 fifth-grade students, who participated in the research, indicates that all students successfully completed both the pretest and posttest assessment sheets. Initially, the average pretest score was quite low, with the lowest score being 10 and the highest score reaching 60, both indicating that the scores did not meet the minimum completeness criteria (KKM). The average pretest score was 39.00, reflecting students' limited critical thinking skills before the learning intervention. This lack of skills can be attributed to their unfamiliarity with the water cycle material, which resulted in logical reasoning difficulties, problem identification, and reliance on their peers' answers.However, after implementing the STEM learning model focused on the water cycle material, students demonstrated significant improvements in their critical thinking abilities. The posttest results revealed a minimum score of 50 and a maximum score of 90, with an average score of 73.66, showcasing a notable enhancement when compared to the pretest scores. This improvement can be linked to students gaining a better understanding of the water cycle content, allowing them to develop their critical thinking skills. The STEM learning model proved effective in encouraging students to engage in problem-solving as they explored new concepts and created innovative solutions through product development.

Test of Normality

Test the normality of the data in this study to determine whether it follows a normal distribution. The Shapiro-Wilk test will be used for this purpose, with a significance level set at $\alpha = 0.05$. If the significance value (sig.) is greater than 0.05, it indicates that the data is normally distributed. Conversely, if sig. is less than 0.05, the data will be considered not normally distributed. This analysis will be conducted using the SPSS 25 application. The results can be found in Table 2.

Table 2. Results Test of Normality

	Shapiro Wilk		
	Statistics	**Df**	**Sig.**
Pretest	.912	30	.017
Posttest	.920	30	.026

To assess the normality of the test results, we examined the significance (sig.) values obtained from the pretest and posttest. The pretest resulted in a sig. value of 0.017, which is greater than 0.05, indicating that the data is normally distributed. Similarly, the posttest yielded a sig. value of 0.026, also greater than 0.05, suggesting that this data is likewise normally distributed. Overall, the findings demonstrate that the significance values for both the pretest and posttest indicate a normal distribution. Thus, we can conclude that the data from both the pretest and posttest utilized by the researcher followed a normal distribution.

Test *Paired Sample T-test*

The paired sample T-test is conducted to examine hypotheses involving pairs of data. Researchers utilize this test to determine whether there is a significant difference in student marks before and after treatment. The criteria for testing the paired sample T-test are as follows: if the significance value (2-tailed) is greater than 0.05, the null hypothesis (H0) is accepted, and the alternative hypothesis (H1) is rejected. Conversely, if the significance value (2-tailed) is less than 0.05, the null hypothesis (H0) is rejected, and the alternative hypothesis (H1) is accepted. This test is performed using the SPSS 25 application, and the results can be found in Table 3.

Table 3. Results Test *Paired Sample T-test*

	Paired Sample T-test		
Pretest – Posttest	T	Df	Sig. (2-tailed)
	-19,767	29	.000

Based on the results of the paired sample T-test, the significance value (2-tailed) is 0.000, which is less than 0.05. This indicates that we reject the null hypothesis (H0) and accept the alternative hypothesis (H1). The results suggest a positive impact from the implementation of the STEM learning model. Additionally, the pretest conducted before the learning activity effectively measured the students' critical thinking skills, and the posttest results demonstrated a significant improvement in these skills among the students.

Test *N-Gain*

The N-Gain test was conducted to assess the improvement and effectiveness of implementing the STEM learning model on the critical thinking skills of fifth-grade elementary

school students. This research was carried out using the SPSS 25 application. The results can be found in Table 4.

Table 4. Results Test *N-Gain*

	N	Minimum	Maximum	Mean	Std. *Deviation*
N-Gain Score	30	.20	80	.5698	.13546
N-Gain Percent	30	20.00	80.00	56.9775	13.54558
Valid N (Listwiss)	30				

In the N-Gain test, the obtained score was 0.5698, placing it within the current category. The resulting N-Gain percentage is 56.97%, which, when rounded up, translates to a score of 57%. This score falls into the category of "sufficiently effective." The N-Gain value reflects an increase in post-test scores, indicating improvements in critical thinking evaluation skills compared to the pre-test scores at the beginning.

3.2 Discussion

The implementation of the STEM learning model during the study has shown to enhance the critical thinking skills of fifth-grade elementary school students. Observations indicate that this application enables students to identify and draw conclusions from real-life problems, allowing them to develop logical methods for problem-solving in their daily lives. This aligns with the viewpoint of Yunita et al. (2019), who assert that critical thinking involves the ability to engage at a higher cognitive level by identifying, analyzing, and concluding, thereby fostering logical thought patterns. Additionally, Saputra (2022) explains that critical thinking skills pertain to cognitive processes that encourage students to resolve problems and support the development of mental activities, such as identifying issues, explaining causes and consequences, and formulating insightful conclusions.

Furthermore, the enhancement of students' critical thinking skills is evident in the pretest and posttest results conducted by the students. In the initial meeting, a pretest was administered to assess the students' baseline critical thinking skills. The pretest results indicated that the students were not yet proficient in critical thinking when solving problems. To address this, we implemented a learning model focused on developing students' critical thinking abilities. The learning model selected was the STEM approach, which encourages project-based learning. Through this method, students engage in real-life problem-solving, working on projects that require them to seek solutions. This aligns with the findings of Idris et al. (2023), who assert that project-based learning is an effective model for enhancing students' critical thinking skills, as it incorporates real-life challenges into the learning process. This approach allows students to practice identifying and solving problems more effectively. Additionally, Setyawan et al. (2019) argue that project-based learning presents challenges that stimulate students' curiosity, leading to positive outcomes. This model is expected to foster a comprehensive understanding of the subject matter—cognitively, affectively, and psychomotorically—thereby optimizing the learning experience.

After the implementation of the learning process, both students were given posttest questions during the meeting. The results from the posttests indicate an improvement

following the application of the STEM learning model aimed at enhancing students' critical thinking skills. This finding aligns with the viewpoint of Yasif et al. (2023), who assert that the STEM learning model can effectively enhance students' critical thinking abilities. This is evident in the ongoing learning process, where students became more engaged and active, demonstrating their capability to solve problems.

5. CONCLUSION

There has been an improvement in critical thinking skills among students in class V at SD Country. Initially, the pretest results indicated a low average score of 39.00 before the implementation of the STEM learning model. However, after applying this model, the posttest results showed an increase, with an average score of 73.66. Additionally, the n-gain acquisition was calculated at 0.5698, which rounds up to 57%. This is categorized as fairly effective. Furthermore, the paired simple t-test revealed a significance level of 0.000, which is less than 0.05, leading to the rejection of the null hypothesis (Ho) and acceptance of the alternative hypothesis (Hi). These findings indicate that the application of the STEM learning model in the context of water cycle learning activities effectively enhances students' critical thinking skills.

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