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The Influence of the 5e Learning Cycle Model Based on Project Based Learning on Students' Critical Thinking Skills in Science Learning at Muhammadiyah 1 Elementary School

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ABSTRACT

This study aims to design, implement, and determine the effect of the 5E Learning Cycle model based on Project-Based Learning (PjBL) on students' critical thinking skills in science learning at Muhammadiyah 1 Elementary School. The method used is quantitative with a quasi-experimental non-equivalent control group pretest-post-test design, involving two groups: an experimental group using the 5E Learning Cycle model based on PjBL and a control group using conventional learning methods. The research instruments include a HOTS-based critical thinking ability test, student activity observation sheets, and documentation. The results of data analysis showed that there was a significant difference between students' critical thinking skills in the experimental class and the control class. The experimental class experienced a significant increase based on the results of the Paired Sample t-test ($t = -17.47$, $p < 0.05$) and Welch's t-test ($t = -7.89$, $p < 0.05$). The application of the 5E Learning Cycle model based on PjBL has proven to be more effective in improving students' critical thinking skills than conventional methods. Thus, this learning model can be a strategic alternative in improving the quality of science learning in elementary schools..

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INTRODUCTION

Education in Indonesia, especially at the elementary school level, faces challenges in the implementation of the Independent Curriculum which is not yet optimal. The focus on developing critical thinking skills in various educational units is still uneven, so that the potential of the curriculum to encourage 21st century skills has not been fully realized (Asmaul Husnah et al., 2023; Sanra et al., 2022).

Various studies have shown that the 5E Learning Cycle learning model, which consists of the stages of Engage, Explore, Explain, Elaborate, and Evaluate, is effective in improving conceptual understanding and student engagement (Baptist et al., 2020; Kartikasari et al., 2023). However, its application at the elementary school level, especially in learning Natural and Social Sciences (IPAS), is still limited.

The Project Based Learning (PjBL) approach is also recognized as a strategy that can encourage students to think critically and creatively through completing real projects (Issa & Khataibeh, 2021; Rahman et al., 2023). The combination of the 5E Learning Cycle and PjBL models offers great potential in creating more effective and interesting learning, by providing learning experiences that are relevant to everyday life (Rahmadina, 2024). Critical thinking skills are an important competency in 21st century education, which must be developed to help students face complex life challenges (Pramasdyahsari et al., 2023). However, the low implementation of active learning and the lack of teacher skills in implementing innovative learning

models are major obstacles (Herlina & Abidin, 2024; Ridho et al., 2021). This condition is consistent with the findings of (Rahman, 2024), which indicate that although teachers have access to educational technology, their level of readiness and confidence in implementing innovative learning remains moderate due to limited training and insufficient institutional support.

The 5E Learning Cycle model is a learning approach designed to increase student engagement in the learning process through five integrated stages: Engage, Explore, Explain, Elaborate, and Evaluate. This approach not only encourages students to be active in building their understanding, but also develops critical thinking and problem-solving skills that are very important in 21st-century education.

This model was first developed in 1987 by Rodger Bybee and his team at the Biological Sciences Curriculum Study (BSCS) in the United States. The initial goal of developing this model was to improve the teaching of natural sciences with a more active approach and based on the principles of constructivism. In the development process, Bybee and his team referred to the learning theories of Jean Piaget and Lev Vygotsky, which emphasize the importance of direct experience and social interaction in building knowledge.

The 5E Learning Cycle model provides a clear structure for teachers in designing learning that actively engages students. Although initially focused on science, the model has been expanded to be applied across a range of disciplines, demonstrating its effectiveness in enhancing student understanding and encouraging engagement in learning. As such, the model is an invaluable tool in creating deep and meaningful learning experiences for students.

Through this approach, it is expected that students will not only understand the concept in depth, but also be able to apply the knowledge they gain in a broader context, thus preparing them to face future challenges.

Project-Based Learning (PjBL) is a learning approach that emphasizes real experiences, where students are actively involved in designing, investigating, and producing products that are relevant to everyday life. Through PjBL, students not only learn academic concepts, but also develop important 21st-century skills, such as collaboration, communication, and problem solving. This approach encourages deep learning, increases student engagement, and connects learning to real-world situations, thus creating a more meaningful and applicable learning experience.

Project-Based Learning (PjBL) is a learning approach that emphasizes real experiences, where students are actively involved in designing, investigating, and producing products that are relevant to everyday life. Although currently very popular, PjBL has deep roots in educational theory that began in the days of John Dewey, an American philosopher and educator in the early 20th century. Dewey emphasized the importance of experiential learning, where students actively learn and apply concepts in real life.

In the 1960s and 1970s, some educators began to design approaches that implemented Dewey's ideas more concretely, developing research-based projects and problem-solving that became the forerunner of modern PjBL. In the 1980s, Stanford University popularized PjBL in the context of technology and science, emphasizing student collaboration and problem-solving skills. Over time, PjBL was adopted by schools and educational institutions around the world, especially in the 2000s, as technological developments and the need for 21st-century skills increased. PjBL is now widely accepted as an effective approach to developing students' academic and social skills, as well as providing more meaningful and real-world-relevant learning experiences. PjBL is a learning method that engages students in in-depth exploration of real-world problems, encouraging them to collaborate, think critically, and generate meaningful solutions. According to Thomas (2000), PjBL engages students in constructive learning through exploration and solving relevant problems. Bell (2010) added that PjBL helps students apply knowledge in real-world contexts, while Prince and Felder (2006) emphasized increasing student engagement and motivation. Barrows (1996) explained that PjBL emphasizes the process of solving complex problems, and Larmer, Mergendoller, and Boss (2015) emphasized the importance of projects that are relevant to the real world. From these opinions, it can be concluded that PjBL is an effective method in developing practical skills, such as problem solving, communication, and collaboration.

PjBL is based on several main principles, including: active learning, collaboration, 21st century skills development, problem-based learning, and real-world engagement. In PjBL, students are directly involved in activities that challenge them to think critically and creatively, work together in groups, and relate to real problems, creating a more meaningful learning experience.

Critical thinking is a mental activity that involves the ability to understand, formulate problems, collect relevant information, analyze the information, test hypotheses, and draw conclusions based on existing evidence (Abdullah, 2016). This process includes not only analysis, but also evaluation, investigation, and appropriate decision-making (Saputra, 2020). According to Reichenbach et al. (2019), there are several indicators that can be used to measure critical thinking skills, including the ability to identify arguments, evaluate evidence, and draw logical conclusions. These indicators are important in the context of education, because critical thinking is a skill that is very much needed to face challenges in the real world and in making informed decisions. Thus, the development of critical thinking skills among students is one of the main goals in the learning process.

The subject of Natural and Social Sciences (IPAS) has a significant role in improving students' understanding of the relationship between humans, the environment, and social development. The combination of natural and social studies in IPAS provides students with comprehensive analytical skills to address global challenges, such as climate change, sustainability, and socio-cultural interactions.

According to several experts, IPAS functions as one of the main disciplines that support environmental understanding. For example, according to Supriyadi (2018), IPAS helps students understand the dynamics between humans and the environment, as well as the impact of human activities on ecosystems. In addition, according to Sari (2020), IPAS learning can increase students' awareness of social and environmental issues, so that they are better prepared to contribute to creating sustainable solutions. Thus, IPAS not only focuses on academic knowledge, but also on developing critical skills needed to face today's global challenges.

Science is a subject that combines ideas from natural sciences, such as physics, biology, and chemistry, with social sciences, such as geography, economics, and sociology, to provide students with a comprehensive understanding. The main focus is on studying the interactions between humans, technology, and the environment to address global challenges such as sustainability and climate change. Science lessons have several objectives, including: (1) to connect learning with real-life contexts, so that students can understand the relevance of science in everyday life; (2) to develop students' analytical and critical skills in dealing with complex issues; (3) to encourage students to actively participate in sustainability and environmental conservation efforts; and (4) to equip students with the knowledge needed to contribute to an increasingly complex and interconnected society.

LITERATURE REVIEW

According to research conducted by Shesilya & Aloysius (2023) in the title "Development of E-worksheet of Coordination System in Human Based on Learning Cycle 7E to Improve Critical Thinking Ability and Student Motivation," this study uses the Research and Development (R&D) method with the ADDIE model, which is applied up to the development stage. The product feasibility was assessed by a material expert and a media expert, while the product's practicality was evaluated through field trials. The results of the study showed that the developed e-worksheet has the potential to improve students' critical thinking skills and motivation.

Meanwhile, according to research conducted by Baptist et al. (2020) entitled "Effectiveness of Project-Based Learning and 5E Learning Cycle Instructional Models," the results of the study showed that both the Project-Based Learning (PjBL) model and the 5E Learning Cycle were effective in improving students' abilities in understanding new knowledge about the human immune system. However, the PjBL model proved to be more effective than the 5E Learning Cycle model in achieving these learning outcomes. This study makes an important contribution in demonstrating the superiority of the PjBL model in the context of science learning.

And according to research conducted by Aminah et al. (2024) entitled "The Influence of the Project Based Learning Model using Video on the Creativity Thinking Ability and IPAS Learning Outcomes for Elementary School Students," the results of the study showed significant differences in creative thinking abilities and student learning outcomes between the group using the video-based Project-Based Learning (PjBL) model and the group using conventional learning. In addition, this study also noted a significant increase in the creative thinking skills of students who participated in learning with the video-based PjBL model, showing the effectiveness of this method in improving learning outcomes in Natural and Social Sciences (IPAS) subjects).

From the results of previous studies, there is a gap that can be filled by the research being designed, which focuses on combining the 5E Learning Cycle model with Project-Based Learning (PBL) for learning Natural and Social Sciences (IPAS) at the elementary school level, because many previous studies only focused on students and also the application of Project Based Learning (pjBL) (Shesilya & Aloysius 2023; Asrizal et al 2022; Ramdani et al. 2021; Anggraeni & Suratno 2021; Baptist et at. 2020; Parno et al 2019; Suardana et al 2018; Runisah et al 2017; Rahmadina 2024; Aminal et al 2024). This study distinguishes itself from previous studies that focus more on the application of the Learning Cycle or 7E model in different contexts, such as the use of technology, thematic approaches, integration of local wisdom, or the development of 21st century skills. By integrating these two models, it is hoped that it can improve students' understanding as well as their critical and creative thinking skills in a more relevant and applicable learning context.

METHOD

This study uses a quantitative approach with a quasi-experimental design to test the effect of the 5E Learning Cycle model based on Project-Based Learning (PjBL) on students' critical thinking skills. The design applied is a non-equivalent control group pretest-posttest design, which involves two groups: an experimental group that receives treatment with the 5E Learning Cycle learning model based on PjBL, and a control group that is taught with conventional learning methods.

The research approach used in this study is a quantitative approach, which focuses on collecting and analyzing numerical data to test the relationship between the variables studied. In this context, a quantitative approach is applied to measure the effect of the 5E Learning Cycle model based on Project-Based Learning (PjBL) on students' critical thinking skills. Data were collected through pretest and posttest tests, as well as observations of student activities, which were then analyzed statistically to determine the effectiveness of the learning model applied.

The data used in this study are quantitative data obtained from the results of students' critical thinking ability tests, observation sheets for learning activities, and documentation that supports the research process. The main data sources come from two groups of students: the experimental group taught using the 5E Learning Cycle model based on Project-Based Learning (PjBL) and the control group using conventional learning methods. Critical thinking ability data were obtained through tests carried out before and after treatment, to measure changes in students' critical thinking abilities due to the application of different learning models. Data collection techniques are one of the important series in research to obtain the necessary data. In this study, data collection techniques were carried out through several instruments to obtain comprehensive information related to students' critical thinking abilities taught using the 5E Learning Cycle model based on Project-Based Learning (PjBL) and conventional learning methods. Data collection techniques used include critical thinking ability tests, observation sheets for learning activities, and documentation that supports the research process.

Data analysis in this study was conducted descriptively and inferentially to provide a clear picture of the implementation of learning, student activities, and the influence of learning on students' critical thinking skills. Descriptive analysis includes calculating the average, distribution of scores, and categorizing the implementation of learning and student activities based on predetermined criteria. Meanwhile, inferential analysis was conducted to test the research hypothesis by comparing the results of the pretest and posttest between the experimental and control groups, as well as calculating the influence of learning based on the 5E Learning Cycle model based on Project-Based Learning on students' critical thinking skills.

Data reduction was carried out to filter, simplify, and focus the raw data that had been collected to make it more structured and relevant to the research objectives. This process includes identifying important data from tests, observation sheets, and documentation, as well as eliminating irrelevant data. Data from pretest and posttest results, observations of learning implementation, student activities, and documentation were reduced to facilitate further analysis. The results of this reduction process are then presented in table form for descriptive and inferential analysis.

Descriptive statistical analysis is used to describe the implementation of learning and student activities. Data on the implementation of learning is calculated by adding each aspect and dividing it by the number of aspects assessed. Meanwhile, the analysis of students' critical thinking skills is carried out by calculating the average value, standard deviation, maximum value, and minimum value. For the purposes of the analysis, the Minimum Completion Criteria (KKM) is determined, where a student is said to have completed learning if he has a score of at least 70, and classical completion is achieved if at least 75% of students in the class have achieved that score.

Inferential analysis is carried out to test the research hypothesis, starting with the normality test, homogeneity test, and t-test. The normality test is used to determine whether the data is normally distributed, while the one sample t-test is used to test the hypothesis of the average student learning outcomes and the average normalized gain. In addition, the proportion test is used to test the hypothesis of classical student completion. The testing criteria are determined based on the calculated t and z values obtained from statistical calculations.

In this study, the instruments used consisted of tests, observation sheets, and documentation. The critical thinking ability test was designed to measure students' critical thinking skills before and after the implementation of the learning model. This test instrument consists of questions based on Higher Order Thinking Skills (HOTS), which aims to evaluate the extent to which students can apply, analyze, and evaluate information. In addition, observation sheets are used to record student activities during the learning process, while documentation functions to support data obtained from other instruments.

RESULTS AND DISCUSSION

This study was conducted over 4 meetings, with 3 treatments and 1 Post-test data collection. The data used to measure the effectiveness of the 5E Learning Cycle learning model based on Project-Based Learning (PJBL) on improving students' critical thinking and collaboration skills were collected using 3 research tools, namely learning implementation observation sheets, student activity observation sheets, and critical thinking ability post-test sheets.

Observations of learning implementation were carried out to assess the extent to which the 5E Learning Cycle learning model was applied in the classroom. The main focus of the observation was on the use of the

5E stages, namely engage, explore, explain, elaborate, and evaluate, as well as student involvement in each stage. Observations of student activities were carried out to assess two main aspects, namely critical thinking skills and collaboration skills. Critical thinking skills and collaboration skills were each observed through 3 indicators of student attitudes in learning observed by observers during the learning process.

1. Descriptive Statistical Results of Observation Data on the Implementation of Experimental Class Learning
   The steps observed on the learning implementation observation sheet consist of 5E, namely Engage, Explore, Explain, Elaborate, and Evaluate with each step consisting of 4 components.
2. Descriptive Results of Statistics of Observation Data on Experimental Class Student Activities.
   Observation of student activities includes two ability assessments, namely collaboration ability which is assessed through three observation activities and critical thinking ability which is also assessed through three observation activities.
3. Descriptive Statistics Results of Student Worksheet Data
   The assessment of student worksheets was carried out for three consecutive days by measuring two main aspects, namely presentation scores and project scores. Each group was given the opportunity to present their project results and work on projects based on the topics that had been given. Presentation scores reflect students' ability to convey project results, while project scores measure the quality and understanding of students in working on the project collaboratively.
4. Descriptive Statistical Results of Student Post-Test Data
   Furthermore, to provide a more detailed picture of the distribution of the average post-test scores of students in the Control Class and Experimental Class, Table 4.3 presents the frequency and percentage distribution based on the score category. The categories include very high, high, medium, low, and very low scores, which will provide further understanding of the comparison of learning outcomes between the two groups.

The study used several instruments, namely observation sheets for the implementation of learning, observation sheets for student activities, and post-test sheets for students' critical thinking skills. The instruments that were compiled consisted of several indicators, thus requiring expert validation tests. The validation process in this study was carried out by three validators, each of whom would be given a validation sheet according to the instrument.

In this study, the reliability of each test question was tested using the Pearson correlation coefficient. The results of the reliability test for five descriptive questions showed that all questions had an r-hit greater than the r-table (0.404) at a significance level of $\alpha = 0.05$ and degrees of freedom df = 23, which indicated that all questions were valid and reliable for use in this study.

After assessing the post-test results of the control class and the experimental class, a normality test was then carried out. The results of the normality test using Shapiro-Wilk showed that the data from the Control Class and Experimental Class were normally distributed. In the Control Class, the Shapiro-Wilk test statistic value was 0.9749, with a p value of 0.7329. A p value greater than 0.05 indicates that the Control Class data is normally distributed. In the Experimental Class, the Shapiro-Wilk test statistic value was 0.9317, with a p value of 0.0760. This p value is also greater than 0.05, indicating that the Experimental Class data is normally distributed. So it can be concluded that the normality test carried out with Shapiro-Wilk on both groups shows that both the Control Class and the Experimental Class have a distribution that is close to normal. So that further statistical analysis can be carried out, namely a comparison test between the two groups using the t-test.

Based on observation data from three meetings, the following is a discussion for each learning step:

1. Engage
   In the first meeting, the average score for the Engage step was 3, indicating that the teacher was successful in activating students' interest in the topic being discussed. In the second meeting, the score increased to 3.25, indicating that the teacher was more successful in arousing students' interest. The score for the third meeting was 3.5, indicating that the implementation of this step became more effective over time, with students becoming more interested and active in learning.
2. Explore
   At the first meeting, the average score for the Explore step was 2.75, indicating that students were not fully engaged in exploration. However, at the second meeting, the score increased to 3, and at the third

meeting to 3.25, indicating that students began to be more active in exploring the material through experiments and discussions.

3. Explain
   The Explain step showed consistent scores. In the first and second meetings, the average score for this step was 3, indicating that the teacher's explanation was clear and effective. In the third meeting, the score increased to 3.5, indicating an improvement in the teacher's ability to convey the material more clearly.
4. Elaborate
   In the first meeting, the average score for Elaborate was 2.75, indicating that students were still having difficulty developing their ideas or projects. However, in the second meeting, the score increased to 3, and in the third meeting, the score remained at 3.25, indicating that students were beginning to work more effectively in designing, developing, and completing their projects.
5. Evaluate
   The Evaluate step in the first meeting obtained an average score of 3, indicating that the evaluation of student work was done well. In the second meeting, the score remained at 3.25, indicating consistent evaluation and providing constructive feedback. However, in the third meeting, the score decreased slightly to 3.25, indicating that although the evaluation went well, there was little variation in how teachers provided feedback on student projects.

Based on the results of the analysis conducted, the critical thinking skills between the Control Class and the Experimental Class showed a significant difference. In the Experimental Class which implemented the 5E Learning Cycle model based on Project-Based Learning (PjBL), there was a significant increase in students' critical thinking skills. This can be seen from the results of the Paired Sample t-test, which showed a very significant difference between the pre-test and post-test scores in the Experimental Class, with a t statistic of -17.47 and a very small p value (6.91×10^{-16}), which is smaller than 0.05.

Meanwhile, in the Control Class using conventional learning methods, although there was an increase in critical thinking skills, the difference was not comparable to the increase in the Experimental Class. The results of the Welch's t-test showed that the difference between the Control Class and the Experimental Class was significant, with a t statistic of -7.89 and a p value of 1.24×10^{-9}.

Overall, the data shows that the applied learning model successfully improves students' critical thinking skills, with consistent improvements in each meeting. This is in line with the results of the Paired Sample t-test which showed a significant difference between the pre-test and post-test scores, which also indicates the success of the application of the learning model in improving students' critical thinking skills. Thus, the application of the 5E Learning Cycle model based on Project-Based Learning has a greater influence on improving students' critical thinking skills compared to conventional learning methods applied in the Control Class.

CONCLUSION

Based on the results of the study, it can be concluded that the implementation of the 5E Learning Cycle model based on Project-Based Learning (PjBL) has a significant influence on improving students' critical thinking skills in science learning at SD Muhammadiyah 1. This model successfully encourages students to be active, directly involved in the learning process, and think more deeply about the problems faced.

Statistical analysis shows that students in the experimental class experienced a higher increase in critical thinking skills compared to students in the control class using conventional methods. This proves that the project-based learning approach integrated into the 5E structure is able to create meaningful learning and improve students' cognitive learning outcomes, especially in the aspect of critical thinking. Therefore, the 5E Learning Cycle model based on PjBL is recommended as an effective learning strategy in improving critical thinking skills at the elementary school level.

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