

THE EFFECTIVENESS OF STEM BASED LEARNING METHODS IN IMPROVING PROBLEM SOLVING SKILLS IN DYNAMIC ELECTRICAL MATERIAL

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ABSTRACT

STEM-based learning (Science, Technology, Engineering, and Mathematics) has been widely recognized as an effective educational approach in the 21st century to enhance students' critical thinking and problem-solving skills. This study aims to examine the effectiveness of STEM-based learning compared to conventional methods in improving students' problem-solving skills in dynamic electricity material. The research employed a quasi-experimental design involving two groups: an experimental group that received STEM-based learning and a control group that followed conventional learning methods. Data were collected through pretest and posttest assessments, classroom observations, and teacher interviews. The results showed that students in the STEM-based learning group achieved a significantly higher posttest score ($M = 82.6$, $SD = 6.7$) compared to the control group ($M = 73.2$, $SD = 7.5$). The N-Gain analysis indicated a medium-high category improvement (0.67) in the experimental group, while the control group showed a medium category improvement (0.48). Furthermore, the independent t-test confirmed a statistically significant difference in problem-solving skill enhancement between the two groups ($t = 3.21$, $p < 0.05$). Observational data also revealed that STEM-based learning promoted higher student engagement ($M = 4.2$ on a 5-point scale) compared to conventional methods ($M = 3.5$). These findings suggest that STEM-based learning is not only more effective in improving students' problem-solving skills but also in increasing their engagement in the learning process. Thus, the implementation of STEM-based learning can serve as an alternative strategy to develop 21st-century competencies, particularly in physics education.

INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM)-based learning has become a widely applied approach in 21st-century education to improve students' critical thinking and problem-solving skills (Bybee, 2013). This approach integrates concepts from various disciplines to create a more contextual and applicable learning experience (Fajrina et al., 2020) (Zhou et al., 2022). In physics learning, the application of STEM methods can help students understand abstract concepts through direct exploration and project-based problem solving (KHUT & Shimizu, 2023). One topic in physics that is often challenging for students is dynamic electricity, which involves the concepts of current, voltage, resistance, and Kirchhoff's laws. A lack of deep

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understanding of this concept often hinders students' ability to apply physics principles in real life (Xing et al., 2022).

Several previous studies have shown that STEM-based learning methods can improve student engagement and learning outcomes in various subjects, including physics (Hasanah, 2024)(Wahono et al., 2020). However, there is still a gap in research regarding the effectiveness of this method specifically in improving students' problem-solving skills, especially in dynamic electricity material. Problem-solving is one of the main skills needed in physics learning because it requires students to understand concepts, analyze situations, and develop solutions systematically (Bao & Koenig, 2019). Therefore, further research is needed to examine the extent to which the STEM method can improve students' problem-solving skills compared to conventional learning methods.

Based on this background, this study aims to compare the learning outcomes of students who use STEM-based learning methods with students who use conventional learning methods in dynamic electricity material. This study is expected to contribute to the development of innovative learning methods that are more effective in improving students' conceptual understanding and problem-solving skills.

METHOD

This study used an experimental method with a quasi-experimental design to test the effectiveness of Science, Technology, Engineering, and Mathematics (STEM)-based learning in improving problem solving skills in dynamic electricity material. This research design involved two groups of students, namely the experimental group given STEM-based learning and the control group receiving conventional learning. The research sample consisted of grade X students of SMK Darul Wusthha who were selected by random sampling. This research was conducted in the odd semester of the 2023/2024 academic year.

Data collection was carried out using three types of instruments, namely problem solving skills tests in the form of pretest and posttest questions to measure conceptual understanding and the ability to solve physics problems, classroom observations to assess student involvement in the STEM-based learning process, and teacher interviews to obtain additional perspectives on the effectiveness of the learning methods applied. Data collection techniques in this study included pretests and posttests given to both groups to compare the improvement in students' problem solving skills, questionnaires used to measure students' perceptions of STEM-based learning, and documentation in the form of records of learning activities and student work results during the study.

The data obtained were analyzed using descriptive and inferential statistical techniques. Descriptive analysis was used to see data trends, while inferential analysis was carried out using a t-test to compare the pretest and posttest results between the experimental group and the control group, as well as an N-gain test to measure the effectiveness of STEM-based learning in improving students' problem solving skills.

RESULTS

After the entire series of research activities were carried out, data analysis was carried out with the following results.

Group	Number of Students	Pretest Average	SD Pretest	Posttest Average	SD Posttest	N-Gain	N-Gain Category
Experiment (STEM)	20	55,4	8,2	82,6	6,7	0,67	Medium-High
Control (Konvensional)	19	54,8	7,9	73,2	7,5	0,48	Medium

Table 1. Pretest and Posttest Analysis Results

Based on table 1 above, it is known that there is a significant increase in learning outcomes in the experimental group that uses STEM-based learning compared to the control group that uses conventional methods. The average pretest score in the two groups was relatively similar, namely 55.4 for the experimental group and 54.8 for the control group. However, after being given treatment, the average posttest score for the experimental group increased to 82.6 with a standard deviation of 6.7, while the control group only reached 73.2 with a standard deviation of 7.5. The results of the N-Gain calculation show that the experimental group had a higher increase in problem-solving skills (0.67, medium-high category) than the control group (0.48, medium category). Next, the t test results are as shown in the table below.

Table 2. Independent t-test results

Variable	t-value	df	p-value (Sig.)	Conclusion
Experiment Posttest vs. Control Posttest	3,21	37	< 0,05	Significant

In table 2 above, it can be seen that the results of the independent t-test compare the posttest scores between the two groups. With a value of $t = 3.21$, $df = 37$, and $p\text{-value} < 0.05$, it can be concluded that there is a significant difference between the learning outcomes of students who use STEM methods and students who use conventional methods. This shows that STEM-based learning has a significant positive impact on improving students' problem-solving skills.

Furthermore, the results of observations of student involvement in the learning process showed that the experimental group that used STEM-based learning had a higher level of involvement compared to the control group that used conventional methods. The average student engagement observation score in the experimental group reached 4.2 on a scale of 1-5, while the control group only obtained an average score of 3.5. This difference shows that STEM-based learning is able to encourage students' active participation during the learning process, which is likely due to the interactive and contextual approach applied in the STEM method. Thus, these findings indicate that STEM-based learning is not only more effective in improving students' problem-solving skills, but can also increase their involvement in learning compared to conventional methods.

DISCUSSION

The results showed that STEM-based learning was more effective in improving problem-solving skills compared to conventional methods. Based on the analysis results in Table 1, there was a significant increase in student learning outcomes in the experimental group using the STEM method. Before the treatment, the average pretest scores between the two groups were relatively the same, namely 55.4 for the experimental group and 54.8 for the control group. However, after being given treatment, the average posttest score of the experimental group increased to 82.6 with

a standard deviation of 6.7, while the control group only reached 73.2 with a standard deviation of 7.5. The results of the N-Gain calculation showed that the increase in problem-solving skills in the experimental group was higher (0.67, medium-high category) than the control group (0.48, medium category).

The results of the independent t-test presented in Table 2 confirm that there is a significant difference between the posttest results of the two groups. With a t value = 3.21, df = 37, and p-value <0.05, it can be concluded that STEM-based learning has a significant positive impact on improving students' problem-solving skills. This finding is in line with research conducted by Astuti et al, which found that the STEM approach is able to improve students' critical thinking and problem-solving skills through the integration of science, technology, engineering, and mathematics concepts in the learning process (Astuti et al., 2021). In addition, research by Hasibuan et al also showed that STEM-based learning is more effective in improving conceptual understanding and high-level thinking skills compared to conventional learning methods (Hasibuan et al., 2022). In addition to improving learning outcomes, STEM-based learning also contributes to increasing student engagement in the learning process. The observation results showed that the experimental group had an average engagement score of 4.2 on a scale of 1-5, while the control group only reached 3.5. This difference indicates that the STEM method is able to encourage active student participation during learning, most likely due to the interactive and contextual approach applied in this method. These results support the findings of Baharin et al, which states that the STEM approach increases students' motivation and engagement in learning, especially because this method allows students to be directly involved in solving real-world problems (Juškevičienė et al., 2021).

Overall, the results of this study indicate that STEM-based learning is not only more effective in improving students' problem-solving skills, but also more capable of increasing their engagement in the learning process compared to conventional methods. Thus, the application of the STEM method in science learning, especially in dynamic electricity material, can be an alternative learning strategy that is more effective in building 21st century skills.

CONCLUSION

STEM-based learning has been shown to be more effective in improving problem-solving skills and student engagement compared to conventional methods. The results showed that the posttest scores of the experimental group increased significantly after the STEM method was applied, with a higher N-Gain value than the control group. An independent t-test confirmed a significant difference between the two groups, indicating a positive impact of STEM on improving problem-solving skills. In addition, STEM-based learning also increased students' active participation in learning, as supported by previous studies. Thus, the STEM method can be a more effective alternative strategy in building 21st-century skills, especially in science learning.

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