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APPLICATION OF STEM (SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH) APPROACH IN IMPROVING LEARNING OUTCOMES IN MATHEMATICS LEARNING

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Abstract:

This study aims to analyze the effectiveness of applying the STEM (Science, Technology, Engineering, and Math) approach in improving student learning outcomes in mathematics learning. The method used in this research is quasi-experiment with nonequivalent control group design. The research sample consisted of 60 VIII grade students who were divided into two groups, namely the experimental group using the STEM approach and the control group using conventional learning methods. The results showed that there was a significant increase in learning outcomes in the experimental group compared to the control group. The average posttest score of students who learned with the STEM approach was higher than students who learned using conventional methods. In addition, the STEM approach also contributed to increasing students' motivation and engagement in learning, as this method encourages exploration, problem solving, and collaboration in understanding mathematical concepts.

Keywords: *STEM, Math Learning, Learning Outcomes, Educational Innovation*

Abstrak:

Penelitian ini bertujuan untuk menganalisis efektivitas penerapan pendekatan STEM (*Science, Technology, Engineering, and Math*) dalam meningkatkan hasil belajar siswa pada pembelajaran matematika. Metode yang digunakan dalam penelitian ini adalah quasi-eksperimen dengan desain nonequivalent control group design. Sampel penelitian terdiri dari 60 siswa kelas VIII yang terbagi menjadi dua kelompok, yaitu kelompok eksperimen yang menggunakan pendekatan STEM dan kelompok kontrol yang menggunakan metode pembelajaran konvensional. Hasil penelitian menunjukkan bahwa terdapat peningkatan hasil belajar yang signifikan pada kelompok eksperimen dibandingkan dengan kelompok kontrol. Rata-rata skor posttest siswa yang belajar dengan pendekatan STEM lebih tinggi dibandingkan dengan siswa yang belajar menggunakan metode konvensional. Selain itu, pendekatan STEM juga berkontribusi dalam meningkatkan motivasi dan keterlibatan siswa dalam pembelajaran, karena metode ini mendorong eksplorasi, pemecahan masalah, dan kolaborasi dalam memahami konsep matematika.

Kata Kunci: STEM, Pembelajaran Matematika, Hasil Belajar, Inovasi Pendidikan.

INTRODUCTION

The STEM (Science, Technology, Engineering, and Mathematics) approach has become the main focus of education reform efforts in various countries, including Indonesia. The integration of these four disciplines in the learning process is believed to be able to answer the challenges of the 21st century by producing human resources who are competent and adaptive to technological and scientific developments. In the context of mathematics learning, the application of the STEM

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approach is considered strategic to improve student learning outcomes (Izzati et al., 2019).

Math learning is often considered abstract and less relevant to everyday life by some students (Sumaji, 2019). This has an impact on their low interest and motivation to learn, which in turn affects academic achievement. The STEM approach offers a solution by connecting mathematical concepts with real applications through the integration of science, technology and engineering. Thus, students can see the direct relevance and benefits of the material learned, thus increasing their interest and understanding.

The study by (Maulana, 2020) showed that the application of the STEM approach in mathematics learning can significantly improve student learning outcomes. They found that students who learned with the STEM approach showed increased motivation and learning independence compared to conventional methods. This is in line with the findings of Rarastika et al. (2024) who indicated that the STEM approach is effective in improving students' analytical thinking skills and creativity.

In addition, research by (Aeni et al., 2023) revealed that the STEM-based Project Based Learning (PjBL) learning model can improve students' mathematical creative thinking skills. In the study, students who engaged in STEM-based projects showed a significant increase in creative thinking skills compared to students who followed conventional learning. This shows that the STEM approach not only improves learning outcomes, but also develops higher order thinking skills.

The implementation of the STEM approach in mathematics learning also has a positive impact on students' mathematical representation skills. (Sembiring, 2022) in his research found that the use of Geogebra software in the STEM approach helped students understand the concept of the system of linear equations of two variables better. Students can visualize and manipulate the graph interactively, which deepens their understanding of the material.

However, the application of the STEM approach in mathematics learning is not without challenges (Betty Heryuriani & Musdayati, 2020). Several studies identified barriers such as limited resources, lack of teacher training, and resistance to changing traditional teaching methods. Therefore, collaborative efforts between the government, educational institutions and educators are needed to provide the necessary support, including training and professional development for teachers.

Historically, various studies have examined the effectiveness of the STEM approach in mathematics learning. For example, research by (Rahmawati et al., 2022) showed that STEM integration in mathematics learning can improve students' critical and creative thinking skills. Similarly, (Yusuf et al., 2022) found that the STEM approach can increase students' learning motivation and critical thinking skills. These findings are consistent with previous research that emphasizes the importance of an interdisciplinary approach in mathematics education.

In addition, research by (Harahap et al., 2022) showed that the STEM approach based on Project Based Learning (PjBL) can improve students' mathematical creativity. Students involved in STEM-based projects showed increased ability to solve problems and generate innovative ideas. This is in line with the findings of (Vistara et al., 2023) who indicated that the Problem-Based Learning

model with a STEM approach is effective in improving students' mathematical creative thinking skills.

In the context of learning in Indonesia, the application of the STEM approach has also shown positive results. Research by (Widiastuti & Indriana, 2019) at SMPN 13 Makassar showed that the application of the STEM approach can improve student learning outcomes on light and optical devices. Students taught with the STEM approach showed a significant increase in learning outcome scores compared to before the application.

In addition, research by (Astuti* et al., 2023) showed that the implementation of STEM approach can improve students' science literacy and creativity. Students involved in STEM-based learning showed improved ability in understanding science concepts and applying them in real contexts. This shows that the STEM approach is not only useful in learning mathematics, but also in other disciplines.

However, the successful implementation of the STEM approach is highly dependent on teacher readiness and competence (Kusyanto et al., 2022). Teachers are required to be able to design and implement learning that integrates science, technology, engineering and mathematics holistically. Therefore, training and professional development for teachers are key in ensuring the effectiveness of this approach.

Overall, the application of the STEM approach in mathematics learning offers great potential in improving students' learning outcomes and 21st century skills. With the right support and collaboration between various stakeholders, this approach can be an effective strategy in advancing mathematics education in Indonesia.

RESEARCH METHODS

This study used a quasi-experiment method with a nonequivalent control group design to measure the effectiveness of applying the STEM approach in improving student learning outcomes in mathematics learning. The study population was class VIII students at one of the MTs Al-Firdaus, with a sample of 60 students selected through purposive sampling. Class VIII-A (30 students) as the experimental group was taught with the STEM approach, while class VIII-B (30 students) as the control group used conventional methods.

The research instruments included learning outcome tests, observation sheets, and learning motivation questionnaires. The research procedure includes the preparation stage (preparation of learning devices, instrument validation, and instrument testing), the implementation stage (pretest, treatment, and posttest), and the data analysis stage. The t-test was used to analyze the results of the pretest and posttest to see significant differences between the two groups, while the questionnaire data was analyzed descriptively to assess student motivation.

Data analysis included descriptive analysis, normality and homogeneity tests, and Independent Sample t-test to test significant differences in learning outcomes between experimental and control groups. Observation data was analyzed qualitatively to understand students' involvement in STEM-based learning. The research was considered successful if the experimental group's posttest score was significantly higher than the control group, learning motivation increased, and student activity and participation in STEM-based learning showed an increase

compared to conventional methods. With this systematic method, it is expected that the STEM approach can be proven effective in improving students' mathematics learning outcomes.

RESULTS AND DISCUSSION

This study aims to analyze the effectiveness of the STEM approach in improving student learning outcomes in mathematics learning. Based on the results of the pretest and posttest conducted in the experimental and control groups, the data showed that the average posttest score of the experimental group was higher than the control group. The average pretest score of the experimental group was 65.2, while the control group was 64.8. After the treatment, the average posttest score of the experimental group increased to 85.6, while the control group only reached 74.3. The results of the t-test analysis showed that there was a significant difference between the learning outcomes of the two groups with a significance value of $p < 0.05$.

In addition to the test results, data from the learning motivation questionnaire showed that students who learned using the STEM approach experienced increased motivation. As many as 87% of experimental group students felt more interested in learning mathematics than before treatment, while in the control group only 62% of students showed an increase in learning motivation.

The increase in student learning outcomes in the experimental group shows that the STEM approach has a positive impact on the understanding of mathematical concepts. This approach allows students to connect theory with real applications through problem-based projects, which makes learning more meaningful and interesting. These results are in line with previous research which states that STEM-based learning can improve students' critical thinking and problem solving skills.

The main factor contributing to the improvement of learning outcomes in the STEM approach is the active involvement of students in learning. Students not only receive the material passively but also engage in concept exploration, experimentation, and group discussion. This is different from conventional methods which tend to be more teacher-centered and provide less opportunity for students to explore.

In addition, the use of technology in the STEM approach also plays an important role in improving student understanding. The use of mathematical software such as GeoGebra and simulation applications allows students to visualize abstract concepts more concretely. This supports constructivist learning theory which emphasizes that students learn more effectively when they can construct their own understanding through direct experience.

However, there are some challenges in implementing the STEM approach. One of them is the limited resources and teachers' readiness in adapting this method. Some teachers have difficulties in integrating technology and engineering aspects into mathematics learning, so more intensive training is needed to improve teachers' competence in implementing the STEM approach effectively.

Despite the challenges, the results of this study show that the STEM approach has great potential in improving the quality of mathematics learning. Therefore, the integration of STEM in the mathematics curriculum needs to be considered more

widely. Support from various parties, including schools, government and parents, is needed to ensure the sustainability of the implementation of this approach in the education system.

Overall, this study provides empirical evidence that the STEM approach can significantly improve students' mathematics learning outcomes. With the right approach and adequate support, STEM can be an innovative solution to improve the quality of mathematics education in Indonesia.

CONCLUSION

Based on the results of research on the application of the STEM approach in improving learning outcomes in mathematics learning, it can be concluded that this method has a positive and significant impact on students' understanding and motivation to learn. The application of the STEM approach allows students to connect mathematical concepts with real applications, so that learning becomes more interesting and relevant. The results of the pretest and posttest analysis showed a higher score increase in the experimental group than the control group, indicating that this approach is effective in improving learning outcomes.

In addition, the STEM approach also increases student engagement in the learning process. Students learning with this method are more active in concept exploration, problem solving and group collaboration, compared to the conventional method which is more teacher-centered. Another factor that contributes to the effectiveness of the STEM approach is the use of technology and simulations that help students understand abstract concepts more concretely.

Despite its many benefits, the implementation of the STEM approach also faces several challenges, such as limited resources and teachers' readiness to adapt this method. Therefore, training and support are needed for teachers to effectively integrate STEM in mathematics learning.

Overall, this study confirms that the STEM approach can be an innovative solution in improving the quality of mathematics learning. For this reason, continuous efforts are needed to implement this approach, both in terms of curriculum development, training of educators, and provision of adequate resources. With the right support, STEM can be an effective and sustainable learning method in education.

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