p-ISSN : 2623-2359
e-ISSN : 2623-2340
Guru Tua : Jurnal Pendidikan dan Pembelajaran
Vol. 8, No. 1, Mei 2025, Hal. 7-13

ANALYSIS OF CRITICAL THINKING SKILLS DEVELOPMENT THROUGH STEAM PROJECT-BASED MATHEMATICS LEARNING IN ELEMENTARY SCHOOL

Sukri [1], Destria Pitaloka Pertiwi[2]

[1]Tadulako University, Palu City, Indonesia
uky.sukri53@gmail.com
[2]State Islamic Senior High School in Tolitoli, Tolitoli, Indonesia
destriapitaloka@gmail.com

ABSTRACT

Learning difficulties in students refer to conditions where they experience obstacles or difficulties in understanding subject matter, following the learning process, or achieving the expected academic goals, even though they have sufficient potential. The aim of this research is to determine the learning difficulties of grade 5 students at SD Impress 1 Tondo. This research is a quantitative descriptive research. A total of twenty fifth graders from SD Inpres 1 Tondo were part of the sample that was selected using a population sampling method. Questionnaires, interviews, and records were the means of data collecting. The results of the questionnaire data analysis on Class V learning issues at Impress 1 Tondo Elementary School indicate that there are two main variables, internal and external, that contribute to these difficulties. contributing element. Yes, I get it. contributing element. With a score of 60 and medium-range criteria, motivation is the internal component that significantly impacts, followed by study habits which is 50%, medium category, interest which is 46.67, and finally attitude 43.33%. The school environment as an external factor has the highest value, namely 50, while the home environment has a value of 46.67, both of which are included in the medium category. In conclusion, the learning difficulties of fifth grade students at SD Impress 1 Tondo are significantly influenced by motivational factors and the school environment.

Keywords: Class V students, Factors, Learning difficulties,

INTRODUCTION

Critical thinking skills are one of the most essential competencies in modern education. Amid the rapid development of science and technology, students need to think critically to evaluate information, solve problems, and make the right decisions. According to Ennis, critical thinking involves thinking logically, analytically, and reflectively in making correct decisions (Ennis, 2011). In an educational context, critical thinking skills help students not only passively receive information but also analyze, evaluate, and apply the information in different situations. Critical thinking skills are relevant in mathematics learning, where students face various problems requiring in-depth analysis and logical thinking to find the right solution (Adrillian & Noriza, 2024).

Effective mathematics learning focuses on understanding basic concepts and developing higher-order thinking skills, such as analyzing, synthesizing, and evaluating information. According to Anderson and Krathwohl, developing higher order thinking skills, including critical thinking, is crucial to effective learning (Anderson & Krathwohl, 2001). Critical thinking skills allow students to connect mathematical concepts with real-world situations so they can see the relevance and

practical application of what they are learning. According to Fedi et al., problem-based learning strategies can improve students' critical thinking skills (Fedi et al., 2019). Therefore, developing critical thinking skills through mathematics learning is very important to prepare students to face future challenges.

In primary schools today, there are several significant challenges related to developing critical thinking skills in students. One of the main problems is that learning approaches still tend to be conventional and focus on memorization and application of routine procedures (Çeviker Ay & Orhan, 2020). In mathematics learning, students are often taught to follow specific steps mechanically without understanding the underlying concepts or being invited to explore various possible solutions. This results in students needing to be more trained in developing analysis, evaluation, and problem-solving skills, which are the core of critical thinking skills. Research by Hiebert and Grouws shows that learning approaches emphasizing routine procedures can inhibit students' ability to think critically and explore various alternative solutions to solving mathematical problems (Hiebert & Grouws, 2007).

In addition, a crowded curriculum and assessments that focus more on results, such as test scores, also contributes to the need for more opportunities for students to engage in more in-depth and reflective learning activities. Brookhart found that outcome-oriented assessment can hinder the development of critical thinking skills and reduce students' motivation to learn deeply (Brookhart, 2015). Students are rarely allowed to think independently, ask critical questions, or engage in discussions that can inhibit higher-order thinking skills. Black and Wiliam found that an assessment system that emphasizes results often makes students focus on grades rather than the learning process, resulting in shallow knowledge mastery and limitations in applying concepts to real situations (Black & Wiliam, 2018).

Given these issues, a more holistic and interdisciplinary learning approach, such as STEAM, is essential, as it can encourage students to think critically and creatively. Integrating STEAM into primary education, particularly in mathematics lessons, offers a relevant solution to address these challenges. Research by Yakman and Lee shows that the STEAM approach can improve students' critical and creative thinking skills by integrating various disciplines in project-based learning (Yakman & Lee, 2012). Students are invited to understand mathematical concepts more deeply and apply them in an accurate and relevant context using a project-based method combining science, technology, engineering, art, and mathematics. This approach encourages students to think critically, explore various solutions, and develop the ability to work collaboratively, all crucial in equipping them to face future challenges (Hsiao & Su, 2021).

The STEAM (Science, Technology, Engineering, Art, and Mathematics) approach in primary education comprehensively supports mathematics learning. By integrating various disciplines, STEAM encourages students to see mathematics not as an isolated subject but as part of an interrelated whole of science. This approach also emphasizes developing creative and innovative thinking skills, essential components of critical thinking.

One of the effective methods in the STEAM approach is project-based learning. This method allows students to engage in practical and applicable activities, where they can apply mathematical concepts in real projects relevant to everyday life. According to research by Holmlund et al., project-based learning helps students connect theory with practice, thus improving their understanding and making learning more meaningful (Holmlund et al., 2018). For example, in a project to design a simple building, students must apply their knowledge of geometry, measurement and estimation. Through this process, they understand mathematical concepts and develop critical thinking skills, such as analyzing problems, formulating solutions, and evaluating results (Chu et al., 2021).

Project-based learning in the STEAM approach also provides space for students to work collaboratively, develop communication skills, and hone other social

skills essential in work and community life. Thus, the STEAM approach improves mathematical understanding and prepares students to become critical-thinking, creative and innovative individuals in the future. Several previous studies have explored the application of the STEAM approach in education with various positive results. For example, research by Beers showed that STEAM integration in the secondary school curriculum could increase student engagement and develop 21st-century skills, such as critical thinking and creativity (Beers, 2011). Another study by Yakman and Lee found that the STEAM approach can help students understand complex concepts better through interdisciplinary learning that connects math with science and technology (Yakman & Lee, 2012). At the primary education level, research by Herro, Quigley and Cian revealed that STEAM project-based learning could increase students' motivation and deepen their understanding of the subject matter, especially in real-world problems (Herro et al., 2019).

While many studies have examined the development of critical thinking skills in the context of mathematics education, there still needs to be a more in-depth understanding of how a project-based STEAM approach can specifically facilitate the development of these skills at the primary school level. Most existing research focuses on applying STEAM at higher education levels, such as secondary schools and colleges. In contrast, its application in primary schools needs to be explored. In addition, most studies that discuss project-based learning in the context of STEAM tend to focus on the science and technology aspects, with little attention to how the mathematics component can be effectively integrated to develop students' critical thinking skills. Therefore, this study aims to fill the gap by analyzing how project-based mathematics learning within a STEAM framework can significantly contribute to developing students' critical thinking skills in primary schools.

The main objective of this review-based study is to analyze the effect of STEAM project-based learning on the development of student's critical thinking skills in mathematics and identify best practices and challenges in implementing this method in primary schools. The main research questions are: How can STEAM project-based learning improve students' critical thinking skills in mathematics? What challenges do teachers face in implementing STEAM project-based learning in elementary schools?

METHOD

The research method used was a qualitative approach focusing on case studies. The research was conducted by collecting data from one specific case, an elementary school in Palu City. The subjects of this study consisted of 28 students and several teachers involved in the STEAM project-based mathematics learning process. The selection of these subjects was based on their active participation in the STEAM program and their potential to provide rich insights into the development of critical thinking skills through this educational approach. This purposive sampling allowed for a focused examination of how such an integrated learning model impacts student outcomes, particularly in terms of critical thinking abilities.

The case was selected, meaning that the school was chosen based on specific considerations relevant to the research objectives. The selection of this school enabled the researcher to obtain comprehensive data regarding the learning process and its influence on the development of student's critical thinking skills.

This research involves classroom observation to understand the dynamics of learning, where the researcher is present during STEAM project-based mathematics learning. During the observation, the researcher recorded various aspects, such as the teaching methods used, the interaction between teachers and students, and how students solved problems and applied concepts in the project. This observation focuses on identifying signs of students' critical thinking skills development, such as the ability to analyze, evaluate, and synthesize information.

In addition, this study also involved structured or semi-structured interviews with teachers who taught STEAM project-based mathematics and students who participated in the lesson. The interview questions were designed to explore teachers' understanding of the strategies they use to develop students' critical thinking skills. Students will be asked about their experiences during the project, their challenges, and how the project helped them think more critically. Then, the researcher also conducted a document analysis of the projects made by students as part of the learning. The researcher collected and analyzed the STEAM-based mathematics projects done by the students. This analysis aims to evaluate the project's results, seeing how students' critical thinking skills develop, for example, by formulating problems, finding creative solutions, and presenting results with structured logic. These documents provide insight into the effectiveness of project-based learning in developing critical thinking skills.

Through a combination of these techniques, researchers hope to gain a deep understanding of how STEAM project-based learning in mathematics contributes to the development of critical thinking skills in elementary school students and identify challenges and opportunities in its application.

RESULT AND DISCUSSION

This study explores how the STEAM project-based learning approach can influence the development of student's critical thinking skills in primary schools, particularly in mathematics learning. The STEAM method, which integrates science, technology, engineering, art and mathematics in one learning framework, is believed to significantly impact students' ability to critically analyze, evaluate and apply concepts. In addition, this study also focuses on the challenges teachers face in implementing the STEAM method and students' perceptions of the effectiveness of this approach. To gather complete data, the researchers involved classroom observations, interviews with teachers and students, and an analysis of the projects created by students throughout the learning process. This section will discuss the results obtained from this research, including comparing students' critical thinking skills before and after the application of STEAM, the main themes from the interviews, and the evaluation of students' projects based on specific criteria. These findings are explained in detail to provide a clearer picture of the contribution of the STEAM method to the development of critical thinking skills and the challenges faced in its implementation.

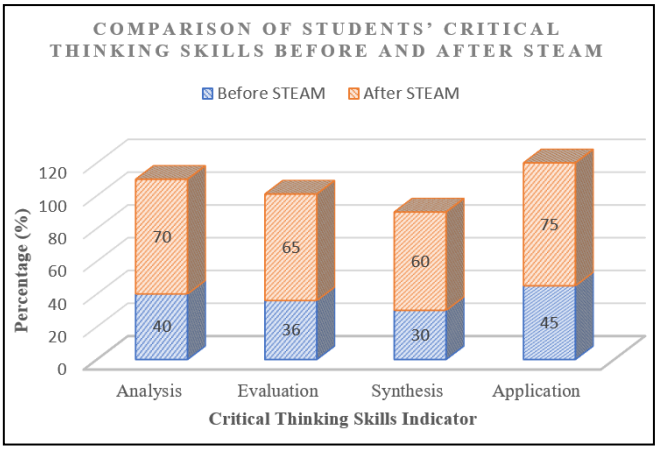

Fig. 1. Comparison Chart of Students' Critical Thinking Skills

The results of this study indicate a significant increase in students' critical thinking skills after applying the STEAM project-based learning method. Figure 1 shows that before the application of STEAM, the percentage of students who had

critical thinking skills in the aspects of analysis, evaluation, synthesis, and application was below 50%. However, after the application of STEAM, there was a drastic increase in the percentage of students who could think critically, increasing to above 60% in all indicators. This improvement demonstrates that the STEAM approach integrates various disciplines in project-based learning and can stimulate students to think more critically. They not only learn to understand concepts profoundly but also apply them in different situations, analyze problems, and critically evaluate solutions. This improvement also reflects the effectiveness of STEAM in encouraging students to not only passively receive information but actively engage in the learning process, which is crucial in the development of critical thinking skills in the 21st century.

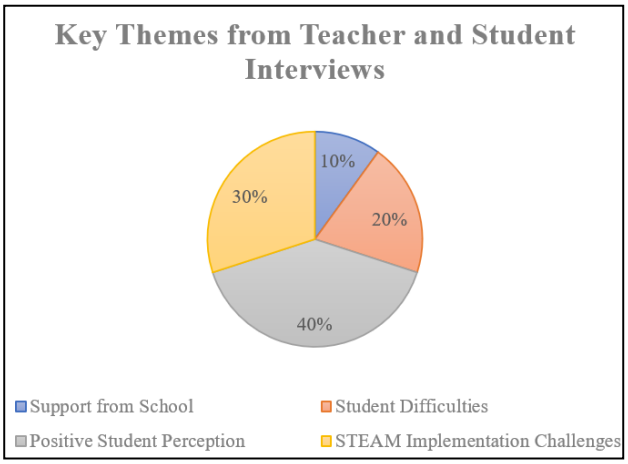

Fig. 2. Key Interview Themes

Interviews with teachers and students revealed some key themes related to the implementation of STEAM in mathematics learning, as seen in Figure 2. One of the most prominent themes that emerged was students' positive perception of the method, where they felt more motivated and challenged to think critically. Students also appreciate how project-based learning allows them to engage in activities that are real and relevant to everyday life. However, teachers also face challenges in implementing this method, especially related to time constraints and support from the school. Some teachers expressed difficulty in integrating all STEAM aspects into an already packed curriculum. In addition, support from the school, such as adequate facilities and resources, is also one factor that affects the success of the implementation. Nevertheless, teachers also recognized that the STEAM method can encourage students to work collaboratively and develop their social skills, which are essential aspects of holistic education.

Table 1. Evaluation of Student Projects Based on Criteria

No.	Criteria	Satisfies the Criteria (%)	Fails to Satisfy the Criteria (%)
1	Creativity	80	20
2	Analysis Skills	70	30
3	Collaboration Skills	65	35

Table 1 shows mixed results in evaluating the projects produced by students based on the criteria of creativity, analytical skills, and collaboration ability. Most of the projects met the creativity criteria, with a percentage reaching 80%, indicating that students could

think out of the box and develop innovative solutions for their projects. Analytical skills were also quite good, with 70% of projects meeting this criterion. This high percentage shows that students can analyze problems well and find logical solutions. However, students' collaboration skills still need to be improved, with 35% of projects not meeting this criterion. This issue may be due to students' lack of experience working in teams or challenges in dividing tasks fairly among group members. This evaluation shows that while the STEAM method has successfully encouraged creativity and analytical skills, there is still room for improvement in developing collaboration ability, which is crucial in future work and social life.

Overall, this study confirmed that the STEAM project-based learning approach has great potential to develop elementary school students' critical thinking skills. After implementing this method, the results showed a significant improvement in the ability to analyze, evaluate, and apply concepts. In addition, although there are challenges in its implementation, both in terms of school support and time constraints, the positive perceptions of students and the resulting projects show that this method can positively impact learning. However, further adjustments and development are needed to optimize better results in the future, especially in student collaboration. More significant support from schools and flexible curriculum adjustments could be the key to success in effective STEAM implementation. These findings align with previous studies that have highlighted the importance of collaborative learning environments and adaptive curricula in enhancing educational outcomes. Prior research has demonstrated that integrating STEAM approaches not only fosters critical thinking but also encourages creativity and problem-solving skills among students (Mariana & Kristanto, 2023; Putri et al., 2023). Thus, the results of this study not only provide new insights into the teaching of mathematics in primary schools but also provide a foothold for the development of a more innovative and relevant curriculum in the era of 21st-century education. By building on these earlier studies, this research underscores the necessity for educational systems to evolve continuously by incorporating interdisciplinary methods like STEAM to meet modern educational demands effectively.

CONCLUSION

Based on the results of the research conducted, it can be concluded that the STEAM (Science, Technology, Engineering, Art, and Mathematics) project-based learning approach significantly improves students' critical thinking skills at the elementary school level. This research answers the problem of how the STEAM method can improve students' critical thinking skills in mathematics and the challenges faced by teachers in its implementation. Results showed that after the implementation of this method, there was a clear improvement in students' analysis and evaluation skills of mathematical concepts. Although there were challenges, such as time constraints and support from the school, the positive perceptions of the students, as well as the results of their projects, showed the positive impact of this method. Development prospects from the results of this study include the need for more significant support from the school through training for teachers as well as the provision of adequate facilities to support STEAM learning. In addition, adjusting the curriculum to allow STEAM integration without sacrificing learning time for other subjects is also very important.

Recommendations based on the study results include the need for schools to provide more significant support to teachers through training related to the STEAM approach, as well as the development of learning methods to encourage collaboration between students by providing more opportunities for them to work in teams. By following these recommendations, it is expected that the implementation of STEAM project-based learning can be carried out more effectively so that it has a positive impact on the development of student's critical thinking skills significantly in the future.

REFERENCES

Adrillian, H., & Noriza, D. (2024). Pengaruh Model Pembelajaran Problem Based

Learning dengan Pendekatan Kontruktivisme Terhadap Kemampuan Berpikir Kritis Matematis Peserta Didik. *Pengaruh Model Pembelajaran Problem Based Learning Dengan Pendekatan Kontruktivisme Terhadap Kemampuan Berpikir Kritis Matematis Peserta Didik*, 57–65. https://proceeding.unnes.ac.id/prisma

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives: complete edition*. Addison Wesley Longman, Inc.

Beers, S. (2011). *21st century skills: Preparing students for their future*.

Black, P., & Wiliam, D. (2018). Classroom assessment and pedagogy. *Assessment in Education: Principles, Policy and Practice*, *25*(6), 551–575. https://doi.org/10.1080/0969594X.2018.1441807

Brookhart, S. M. (2015). *How to make decisions with different kinds of student assessment data*. ASCD.

ÇEVİKER AY, Ş., & ORHAN, A. (2020). Farklı Eleştirel Düşünme Öğretim Yaklaşımlarının Eleştirel Düşünme Becerisine Etkisi: Bir Meta Analiz Çalışması. *Pamukkale University Journal of Education*, *49*, 88–111. https://doi.org/10.9779/pauefd.561742

Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2021). *21st century skills development through inquiry-based learning from theory to practice*. Springer.

Ennis, R. H. (2011). The nature of critical thinking: An outline of critical thinking dispositions and abilities. *University of Illinois*, *2*(4), 1–8.

Fedi, S., Gunsi, A. S., Ramda, A. H., & Gunur, B. (2019). Pengaruh model pembelajaran berbasis masalah terhadap kemampuan berpikir kritis siswa. *JKPM (Jurnal Kajian Pendidikan Matematika)*, *4*(1), 11–20.

Herro, D., Quigley, C., & Cian, H. (2019). The challenges of STEAM instruction: Lessons from the field. *Action in Teacher Education*, *41*(2), 172–190.

Hiebert, J., & Grouws, D. A. (2007). The Effects of Classroom Mathematics Teaching on Students' Learning. *Second Handbook of Research on Mathematics Teaching and Learning*, 371–404.

Holmlund, T. D., Lesseig, K., & Slavit, D. (2018). S40594-018-0127-2.Pdf. *International Journal of STEM Education*, *5*(32), 1–18.

Hsiao, P. W., & Su, C. H. (2021). A study on the impact of steam education for sustainable development courses and its effects on student motivation and learning. *Sustainability (Switzerland)*, *13*(7), 1–24. https://doi.org/10.3390/su13073772

Mariana, E. P., & Kristanto, Y. D. (2023). Integrating STEAM Education and Computational Thinking: Analysis of Students' Critical and Creative Thinking Skills in an Innovative Teaching and Learning. *Southeast Asian Mathematics Education Journal*, *13*(1), 1–18.

Putri, A. S., Prasetyo, Z. K., Purwastuti, L. A., Prodjosantoso, A. K., & Putranta, H. (2023). Effectiveness of STEAM-based blended learning on students' critical and creative thinking skills. *Int J Eval & Res Educ ISSN*, *2252*(8822), 8822.

Yakman, G., & Lee, H. (2012). Exploring the exemplary STEAM education in the US as a practical educational framework for Korea. *Journal of the Korean Association for Science Education*, *32*(6), 1072–1086.