

THE ROLE OF STEAM EDUCATION IN IMPROVING STUDENT COLLABORATION AND CREATIVITY: A CASE STUDY IN MADRASAH

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Received: May, 2024. Accepted: June, 2024. Published: June, 2024

ABSTRACT

The 21st century is marked by increasing technological progress and productivity. This progress has provided a challenge for the education sector to produce quality young people with adequate skills. This research examines the effectiveness of a learning approach that integrates a multi-subject called STEAM, namely science, technology, engineering, arts and mathematics, to improve 21st-century skills. These skills include collaboration, creativity, critical thinking and communication, known as the 4Cs. As a case study, this STEAM learning was given to students at two State Madrasahs in West Java. To achieve this goal, mixed methods were used. The research combined qualitative and quantitative approaches. A qualitative approach was used to observe phenomena experienced by students, learning design, and implementation. Moreover, a quantitative approach was used to analyze the impact of STEAM learning on student skills. The STEAM learning design was delivered in three learning meetings. Research findings show that the STEAM learning model by using a multi-subject approach could significantly improve students' collaboration skills. However, it did not significantly improve students' critical thinking, creativity and communication skills. Meanwhile, student responses showed positive results on the implementation of this model. Factors that were considered to influence the implementation of this model are: Duration of learning, literacy skills and student learning experiences, as well as teacher competencies.

Keywords: Collaboration, Madrasah, STEAM Learning, 21St-Century Skills

INTRODUCTION

Since the beginning of the 21st century, the world has witnessed the widespread use of information and communication technology in all areas of life, as evidenced by the emergence and ubiquity of high-tech products. Mastery of science and technology has become irreplaceable in this high-tech era, necessitating the involvement of various stakeholders, particularly educators. They are tasked with developing students' capabilities related to technology. In Indonesia, this development has been promoted through the inclusion of technology mastery in the new school curricula, aiming to prepare a new generation that is ready and reliable in facing globalization (Daryanto & Karim, 2017).

In modern workplaces, individuals need competencies such as critical thinking, problem-solving, and collaboration (AlAli, 2024). These competencies, often referred to as 21st-century skills or the 4Cs, are essential and should be nurtured through a directed educational process. Improving the curriculum is essential for preparing graduates for the era of the industrial revolution 4.0 (Trilling & Fadel, 2009). A study by Trilling and Fadel (2009) reveals that high school and university graduates often lack competencies in communication, critical thinking, problem-solving, work ethics, professionalism, collaboration, teamwork, technology, project management, and leadership. Compared to graduates from other countries, especially in Southeast Asia, Indonesian graduates need to strengthen their skills to meet the demands of

new jobs based on the production, analysis, distribution, and consumption of information (Guerra, 2024).

The shift from manufacturing service-based jobs to those based on technology, information, and knowledge has been significant (Luna Scott, 2015). Many traditional jobs have been disrupted, and surviving in the current job market requires technological proficiency, communication skills, collaboration, and networking abilities. Those who thrive are often individuals who possess creativity and can generate job opportunities for themselves and others (Herro & Quigley, 2016).

Information and communication technology has also transformed the way of learning. Students are now expected to master various skills demanded in the 21st-century industrial revolution 4.0 era. Educational institutions face the challenge of producing high-quality graduates, especially since not all educators are equally prepared to meet this challenge. Current learning often emphasizes memorization rather than reasoning, focusing on students' ability to recall content and facts rather than developing analytical and problem-solving skills (Angreni, Sari, & Mursyafiela, 2024). Critical and creative thinking skills, which are part of higher-order thinking, help individuals use learning experiences to solve problems and critically analyze information they receive (Ahmad & Sukiman, 2019).

Effective learning models are needed to enhance the 4Cs: critical thinking, creativity, collaboration, and communication. There is a growing global discussion among researchers and educators on new learning perspectives in response to 21st-century challenges. This has led to the search for new learning models that can address complex global issues, moving beyond traditional methods that focus on memorization to those that engage students in inquiry-based learning to develop higher-order thinking skills (Barron & Darling-Hammond, 2008).

Students have diverse learning styles, and teachers are challenged to find effective ways to help all students learn. Studies show that certain pedagogies are more successful in helping students gain a deeper understanding of 21st-century skills. One such educational breakthrough in Indonesia is STEAM learning, which integrates Science, Technology, Engineering, Arts, and Mathematics (STEAM) to develop a science and technology-based economy (Wijaya et al., 2016; An, 2020). STEAM learning incorporates arts into the STEM fields to enhance creativity, innovation, problem-solving, collaboration, and communication skills (Katz-Buonincontro, 2018; Liao, 2016). The implementation of this STEAM learning model in Islamic schools with a multi-subject approach is likely to capture each student's 21st-century competencies more specifically and measurably. This study investigates whether this learning model improves student skills as needed for 21st-century learning and examines its impact on various student competencies (Bertrand & Namukasa, 2022; Faizah & Supriyanto, 2024).

While previous studies have highlighted the benefits of STEAM education in enhancing student engagement and skills in STEM fields (Daugherty, 2013; Quigley, Herro, & Jamil, 2017), there is limited research on its specific impact on 21st-century skills in the context of Indonesian schools, particularly Islamic junior high schools. Furthermore, the challenges faced by educators in integrating STEAM into existing curricula and the specific competencies that students develop through this approach are not well-documented. Additionally, the short-term impacts of STEAM learning interventions on critical thinking, communication, creativity, and collaboration skills require further exploration (Herro, Quigley, & Cian, 2019).

The present study addresses these gaps by investigating the implementation of the STEAM learning model in two Islamic junior high schools in Indonesia. The specific objectives are to: (1) evaluate the impact of STEAM learning on students' critical thinking, communication, creativity, and collaboration skills, (2) examine the students' and educators' perceptions of STEAM learning and its effectiveness, (3) identify the challenges and facilitators in integrating STEAM into the existing curriculum, (4) provide recommendations for enhancing

the effectiveness of STEAM learning in developing 21st-century skills in Indonesian educational settings.

METHOD

This study employs a mixed-method approach, integrating both qualitative and quantitative methodologies to ensure comprehensive, valid, reliable, and objective results (Creswell & Plano Clark, 2018; Johnson & Onwuegbuzie, 2004; Tashakkori & Teddlie, 2010). The mixed-method approach is essential for addressing the research questions outlined in Chapter 1. The qualitative approach aims to understand the phenomena experienced by research subjects, such as behaviors, perceptions, motivations, and holistic actions, through descriptive language within a natural context (Yin, 2017). The quantitative approach involves quasi-experimental research using a Nonequivalent (i.e., Pretest and Posttest) One Group Design (Shadish, Cook, & Campbell, 2002). The primary objective of this quasi-experimental research is to examine the impact of STEAM learning (the independent variable) on the enhancement of 21st-century skills (the dependent variable). The research design includes a pre-test to assess initial conditions (O1), followed by the experimental treatment (X), and a post-test to evaluate the effects of the treatment (O2). The structure of the quasi-experimental design is presented in Table 1.

Table 1. Quasi-Experimental Research Design

Group	Pre-test	Treatment	Post-test
E	O1	X	O2

E = Experimental group

O1 = Pre-test for the experimental group

O2 = Post-test for the experimental group

X = Treatment involving the implementation of STEAM learning to improve the students' 21st century skills

The implementation of STEAM learning was conducted in three stages during our experiments. Initially, a pre-test was administered before the learning began to establish a baseline. Subsequently, a post-test was given at the end of the third meeting to assess the impact of STEAM learning on 21st-century skills. The effectiveness of the STEAM learning model on students' critical thinking skills was evaluated by comparing the final post-test results with the initial pre-test scores. Additionally, a control class used a conventional learning model, with a pre-test administered before learning and a post-test at the final meeting. This allowed for a comparative analysis between the conventional and STEAM learning models. More details are provided in Table 2.

Table 2. STEAM Research Design

Group	Pre-test	Treatment	Post-test
Experiment	Yes	-	-
	-	Meeting 1 (X1)	-
	-	Meeting 2 (X2)	-
	-	Meeting 3 (X3)	-
	-	Meeting 4 (X4)	Yes

Sample and Population

The population for our experiments consisted of students from two Islamic junior high schools in Indonesia: Madrasah Tsanawiyah Negeri (MTsN) 1 in Garut, a public school, and Madrasah Tsanawiyah (MTs) Muslimin in West Bandung, a private school. These schools were

selected to compare the impact of STEAM learning between public and privately funded institutions. Due to COVID-19 pandemic restrictions, STEAM learning was not feasible for all students, so a random sample of 15 students from each school was chosen to represent the population.

The data collection methods used in this study include observation, tests, questionnaires, interviews, and documentation studies. Direct observation was conducted to evaluate the implementation of STEAM learning in developing the 4Cs (critical thinking, communication, collaboration, and creativity). This involved observing active learning sessions over three meetings to assess student engagement and responses. Tests comprised pre-tests and post-tests to measure the impact of STEAM learning on students' 4Cs skills before and after the intervention. The 4Cs are categorized into ways of thinking (creativity, innovation, critical thinking, problem-solving, decision-making, and proactive learning), ways of working (communication, collaboration, teamwork), living as global and local citizens, and using information technology and digital literacy. Questionnaires were administered at the end of the STEAM learning to gather student feedback on their interest, excitement, and challenges faced during the learning process. Interviews were conducted with school principals, teachers, and a team from both schools to discuss the current learning processes and the design of the STEAM learning model. Finally, a documentation study was performed to collect data on teachers' conditions, student numbers, infrastructure, and the overall environment, facilitating further analysis of the differences between public and private Islamic schools.

STEAM Learning Model Design

STEAM is an educational approach that deeply involves students in exploring and understanding lesson content, with teachers acting as facilitators while students collaborate on assignments (Yakman, 2013). It integrates five subjects: Science, Technology, Engineering, Art, and Mathematics, creating contextual learning experiences (Angreni, Sari, & Mursyafiela, 2024). This approach encourages students to understand phenomena around them and fosters creative thinking, problem-solving, and interaction skills through Project-Based Learning (PjBL) (AlAli, 2024). PjBL was chosen for its alignment with STEAM activities, integrating various subjects: Science for knowledge, Technology for skills, Engineering for techniques, Art for creativity, and Mathematics for logical problem-solving (Bertrand & Namukasa, 2020). The STEAM learning design involves multiple stages, including preliminary study, literature review, competency analysis, unit creation, practicum procedures, worksheet development, and project preparation (Colucci-Gray et al., 2017). This comprehensive approach aims to enhance students' 21st-century skills, such as critical thinking, creativity, collaboration, and communication (An, 2020; Faizah & Supriyanto, 2024).

RESULTS AND DISCUSSION

Procedure of learning

The implementation of STEAM learning in two madrasah observed in this study was carried out over three meetings. In the first meeting, a front loading was carried out, followed by a presentation of the concepts of science, mathematics and Indonesian. At the second meeting, the three subjects had entered practical activities filled with making projects. Meanwhile, the third meeting was dedicated to an exhibition of students' work.

The 1st face-to-face learning process begins with front-loading activities. After that, students take part in core learning activities starting with Mathematics, followed by Natural Sciences, and ending with Indonesian language material. In the second meeting, students carried out science practicum activities in groups, with heat transfer material. For the Indonesian language assignment, students made a procedure text for a Science Cinematic Photo exhibition. In the third meeting, students held an exhibition where students were asked to show their

creativity. They presented their best work based on group collaboration and communication. Students were more enthusiastic when presenting their work to their friends and teachers.

Impacts of STEAM Learning on the 21st-Century Skills

After three meetings, it can be seen how the impact of the implementation of STEAM learning on 21st-century skills. The impact can be seen from the results of the pre-test and post-test, observation, and students' responses to learning. The details of the data analysis are as follows.

MTs Negeri 1 Garut

According to a pre-test given before introducing STEAM learning, most students at MTs Negeri 1 Garut have critical thinking skills at the lowest level. The results show that the critical thinking skills of 74% of students are at the lowest level (Level 1). In addition, about 21% of students are at the second level indicating that their critical thinking skills are still quite low, while only 5% of students are at Level 3. Similarly, in terms of communication skills, around 63% of students are at the lowest level (Level 1), and 26% of students are at Level 2. In Level 3, only 11% of students in which their communication skills at a good level. For students' creativity, most students are at Level 1 with 68% of students, followed by 32% of other students at the next level. For the aspect of collaboration, 74% of students demonstrate their skills at Level 1, while the rest students are at Level 2. No students have shown their collaboration skills at Level 3. These results depict the 4Cs students' skills at MTs Negeri 1 Garut before we introduced STEAM learning.

After the post-test, where students have received three meetings of STEAM learning, students' critical thinking skills have not shown a meaningful improvement. Around 83% of students are still at the low level for such skills. About 11% of students are at Level 2, while only 6% of students exhibited critical thinking skills at a good level. For communication skills, the students have not shown a significant change based on the results of the post-test. Around 83% of students are at the lowest level, followed by 11% of students at Level 2. Meanwhile, only 6% of students are in Level 3. Furthermore, the students' creativity is shown a slight improvement. The number of students at Level 1 reduces from 68% to 61%, while the number of students at Level 2 roughly remains the same. While there are no students at Level 3 of creativity based on the pre-test, after the post-test, there are 6% of students exhibited their creativity at this high level. Collaboration is the aspect with a significant change among the other skills. The number of students at the lowest level (Level 1) dropped significantly by 52% from 68% to only 22% of students. Moreover, the number of students at Level 2 reduced by around half from 26% to 11%. Another notable improvement is shown in the number of students classified in Level 3. STEAM learning ignited 17% of students whose collaboration skills were categorized at Level 3 as shown in figure 1.

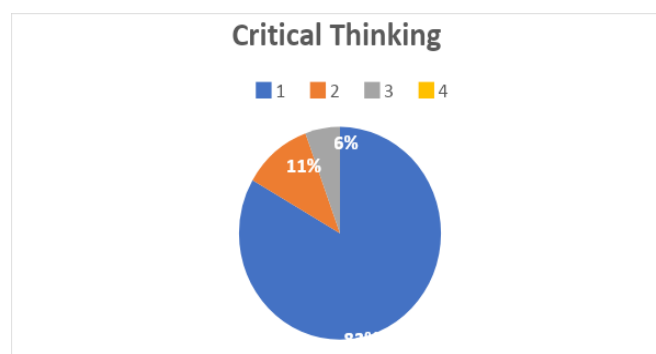


Figure 1. Critical Thinking Competency

This diagram shows that the critical thinking abilities of MTs Negeri 1 Garut students have not changed significantly. It appears that after participating in learning with the STEAM model, students still have not demonstrated their critical thinking skills. It can be explained that as many as 83% of students are still at score 1 for critical thinking skills. As many as 11% of students were at score 2 for critical thinking skills. Meanwhile, only 6% were at grade 3.

Communication

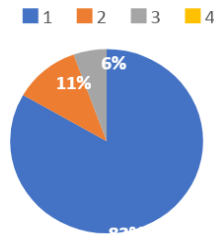


Figure 2. Communication Competency

The communication skills of MTs Negeri 1 Garut students have not shown any significant changes after following the STEAM learning model. Based on the post-test results, it appears that 83% of students are still at score 1 for communication skills. As many as 11% of students were at grade 2. Meanwhile, only 6% of students were at grade 3.

Creativity

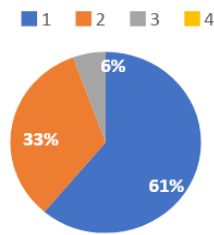


Figure 3. Creativity Competency

In terms of creativity, MTs Negeri 1 Garut students seem to show changes, even though they are not yet significant. Based on the diagram, as many as 61% of students are still at grade 1. As many as 33% of students are at grade 2. Meanwhile, there are 6% of students who are at grade 3.

Collaboration

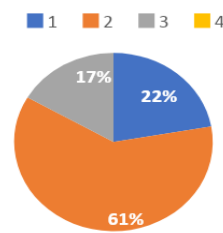


Figure 4. Collaboration Competency

Collaboration competency is the point that shows the highest change among the other 4 21st century skills. It appears that there are still 22% of students who show collaboration abilities at grade 1. As many as 11% of students show collaboration abilities at grade 2. Meanwhile, another 17% have started to show quite high collaboration abilities, namely at grade 3.

Therefore, at MTsN 1 Garut the STEAM learning model is able to improve students' collaboration skills significantly, but has not shown a significant increase in the other three competencies.

MTs Muslimin Citapen Bandug Barat

As in MTs Negeri 1 Garut, students at MTs Muslimin Citapen also carried out a pretest. The results show that students' 21st-century skills were not yet optimal. First, students' critical thinking skills have not been stimulated. Around 93% of students were at the lowest level, while the rest is at Level 2. Second, their communication skills have the same figure as their critical thinking skills. The last two skills, i.e., creativity and collaboration skills, are still not honed. All students scored at Level 1 for both skills. Below is presented data for each competency:

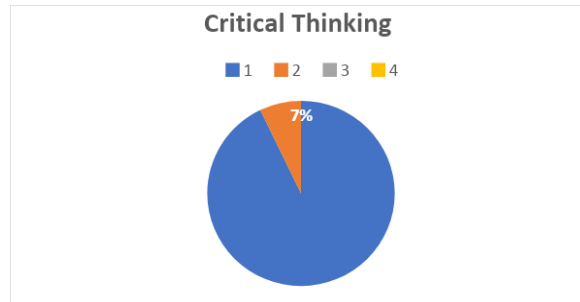


Figure 5. Critical Thinking Competency

The critical thinking skills of MTs Muslimin Citapen students are still in the low category. It appears that 93% of students are still at grade 1 in critical thinking abilities. Meanwhile, 7% of other students were at grade 2.

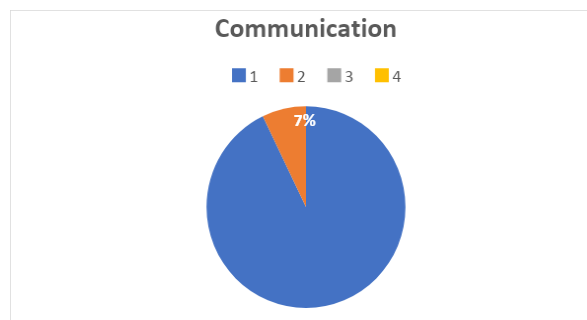


Figure 6. Communication Competency

Figure 6 shows that the communication skills of MTs Muslimin Citapen students are still in the low category. As many as 93% of students showed communication skills at grade 1. Meanwhile, the other 7% were at grade 2.

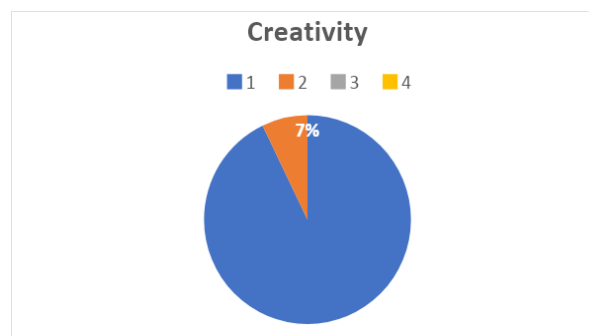


Figure 7. Creativity Competency

Students' creativity abilities are no different from their critical thinking and communication skills. After following the STEAM learning model, there were no significant changes. Only 7% of students showed a score of 2. Meanwhile, the other 93% were still at a score of 1.

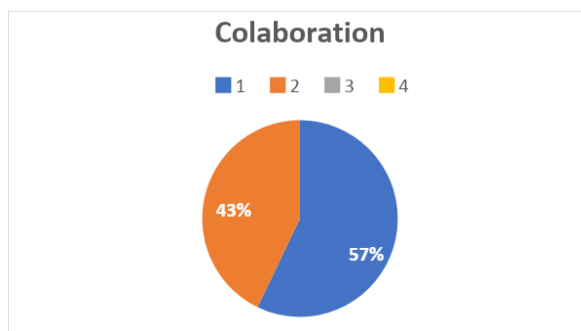


Figure 8. Collaboration Competency

The collaboration ability of MTs Muslimin Citapen students is the point that has developed most significantly. It appears that as many as 57% of students still show collaboration abilities at grade 1. However, another 43% have shown development in collaboration abilities from grade 1 to grade 2.

From the figures above which explain each competency partially from the two schools studied, it can be concluded that: After implementing the STEAM learning model by using multi-subject approach, this model has not had a significant impact on students' skills in critical thinking, creativity, and communication. In collaboration skills, however, students showed significant changes. This is acceptable that STEAM learning is something new for students, in which they require to be actively involved in learning, able to solve problems, and be creative in completing assigned projects. Hence, they need to adapt to this new learning model more times and in regular meetings.

Another possible reason is that STEAM learning is only carried out within three meetings. This is considered inadequate to be able to improve 21st-century skills. Furthermore, this research was carried out during the covid pandemic, when students had been carrying out learning for 1.5 years online, so it takes time for them to adapt to face-to-face learning.

Students' Perception of STEAM Learning

To find out how students respond to the STEAM learning model, they were asked to fill out a questionnaire after the post-test. The number of students filling out this questionnaire was 29 students. In general, students' responses to STEAM learning are good as shown in Figure 1. Most students agreed that they felt improvements in their skills. Most students agreed that their creativity after STEAM learning has improved. For the aspect of problem-solving, students' responses are quite diverse. The proportion of students who disagreed with the impact of STEAM learning on their problem-solving skills is the highest among the other aspects. Furthermore, the most significant impacts of STEAM learning based on the student's perception are in the aspects of collaboration skills and learning motivation.

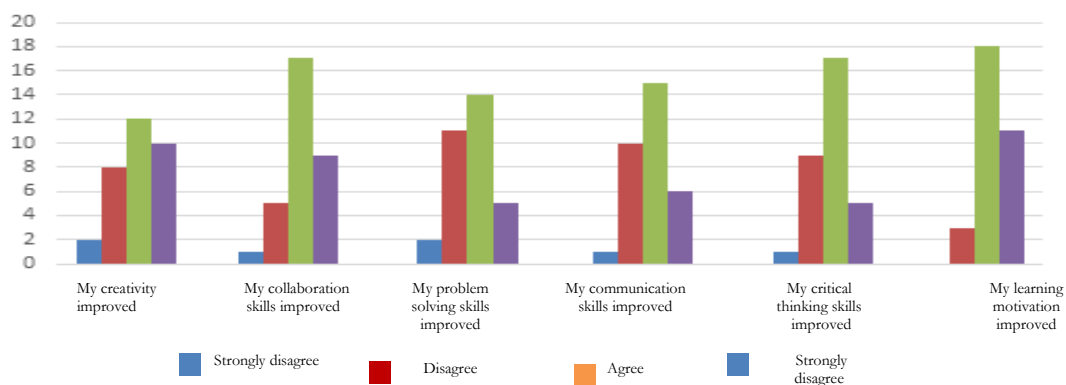


Figure 9. Students' Perception of STEAM Learning

The implementation of STEAM learning in the two Madrasah Tsanawiyah observed in this study was structured over three meetings. Initially, the students were introduced to the core concepts of science, mathematics, and Indonesian through front-loading activities. This was followed by practical activities and project-making in the second meeting, and an exhibition of students' work in the final meeting. This approach aligns with the principles of contextual learning, where students are encouraged to understand and engage with phenomena close to their everyday experiences (Yakman, 2013).

Despite the structured approach, the impact of STEAM learning on 21st-century skills varied. At MTs Negeri 1 Garut, the pre-test results revealed that the majority of students had low levels of critical thinking, communication, creativity, and collaboration skills. Post-test results indicated only a slight improvement in creativity and a significant improvement in collaboration skills. However, critical thinking and communication skills did not show significant progress. This limited improvement might be due to the short duration of the STEAM intervention, as three meetings may not be sufficient to produce substantial changes in these skills (Bertrand & Namukasa, 2022; AlAli, 2024).

Similar trends were observed at MTs Muslimin Citapen. Pre-test results showed that students' 21st-century skills were at the lowest levels, with slight improvements in collaboration after the STEAM learning intervention. This aligns with findings from other studies which suggest that longer and more integrated STEAM programs are necessary to see significant improvements in critical thinking and communication skills (Herro, Quigley, & Cian, 2019; Faizah & Supriyanto, 2024).

One of the key observations from both schools was the substantial improvement in collaboration skills. This supports the notion that STEAM learning, particularly through project-based learning (PjBL), effectively enhances teamwork and collaborative efforts among students (Angreni, Sari, & Mursyafela, 2024; Barron & Darling-Hammond, 2008). The interactive and collaborative nature of STEAM projects likely contributed to this improvement.

However, the lack of significant improvement in critical thinking and communication skills raises important considerations. According to AlAli (2024), and Katz-Buonincontro (2018), effective STEAM education requires not just a multidisciplinary approach but also a sustained and immersive experience that challenges students to apply critical thinking and communication in diverse contexts. The short duration of this study's intervention may have limited its impact, suggesting the need for more extended and continuous STEAM learning experiences.

Students' positive perceptions of STEAM learning, as indicated by the questionnaire results, highlight their engagement and interest in this educational approach. Most students reported improvements in creativity and collaboration, and expressed enthusiasm for the STEAM learning process. This aligns with findings from An (2020), who noted that STEAM

integration positively affects student disposition and engagement. While the STEAM learning model showed promise in enhancing collaboration skills, its short-term implementation did not significantly impact critical thinking, creativity, and communication skills. The findings suggest that a more extended and immersive STEAM learning experience is necessary to foster these essential 21st-century skills effectively. Future research should consider longer intervention periods and explore ways to integrate STEAM learning more deeply into the regular curriculum (Bertrand & Namukasa, 2020; Luna Scott, 2015).

CONCLUSION

This study investigated the implementation of STEAM learning model in two MTsN. The STEAM learning model, using a multi-subject approach, involves stages such as project planning, schedule preparation, monitoring plans, student assessments, and evaluating experiences. Integrated subjects include Science, Technology, Engineering, Art, and Mathematics. Implemented in two MTsN over three meetings, the model begins with preparation, competency analysis, unit integration, practicum preparation, worksheet making, and project planning. The observed impacts show significant improvement in collaboration skills but not in critical thinking, problem-solving, creative thinking, or communication skills, likely due to factors like students' literacy levels, prior learning experiences, and limited time. Students responded positively, finding STEAM learning interesting and skill-enhancing. To improve, more face-to-face sessions, thorough preparation, interdisciplinary discussions, and competent teachers using various methods are essential. Adequate facilities, costs, and principal support are also crucial for success.

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