THE EFFECTIVENESS OF APPLYING STEAM-BASED LEARNING TO IMPROVE 4C SKILLS IN MATHEMATICS LEARNING

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ABSTRAK

Penelitian ini membahas tentang pentingnya kemampuan 4C (berpikir kritis, berkomunikasi efektif, berkolaborasi, dan kreatif) dalam pembelajaran matematika, serta bagaimana pendekatan STEAM (*Science, Technology, Engineering, Arts, Mathematics*) dapat digunakan untuk mengembangkan kemampuan 4C tersebut. Pendekatan STEAM memberikan siswa konteks pembelajaran yang lebih realistis dan relevan dengan mengintegrasikan unsur sains, teknologi, teknik, seni, dan matematika. Tujuan dari penelitian ini adalah untuk mengeksplorasi efektivitas pendekatan STEAM dalam meningkatkan kemampuan 4C pada pembelajaran matematika dan untuk mengidentifikasi langkah-langkah yang dapat diambil guna mengoptimalkan penerapan pendekatan ini. Penelitian ini menggunakan metode kepustakaan (*library research)* untuk mengumpulkan dan menganalisis data dari berbagai sumber, termasuk buku, jurnal, ebook, dan artikel ilmiah lainnya. Hasil penelitian menunjukkan bahwa pendekatan STEAM dapat menjadi strategi yang efektif dalam mengembangkan kemampuan 4C pada siswa.
Kata kunci: *STEAM, Kemampuan 4C, Efektif*

ABSTRACT

This research discusses the importance of the 4C abilities (critical thinking, effective communication, collaboration, and creativity) in mathematics learning, as well as how the STEAM (Science, Technology, Engineering, Arts, Mathematics) approach can be used to develop these 4C abilities. The STEAM approach provides students with a more realistic and relevant learning context by integrating elements of science, technology, engineering, arts, and mathematics. The aim of this research is to explore the effectiveness of the STEAM approach in improving 4C abilities in mathematics learning and to identify steps that can be taken to optimize the application of this approach. This research uses library research methods to collect and analyze data from various sources, including books, journals, ebooks and other scientific articles. The research results show that the STEAM approach can be an effective strategy in developing 4C abilities in students.
Keywords: STEAM, 4C *Capabilities*, Effective

INTRODUCTION

In this fast-paced era of globalization, the ability to think critically, communicate effectively, collaborate, and be creative (4C) is an essential skill that every individual must possess. This is especially important in educational contexts, where students are expected not only to acquire knowledge but also to be able to apply it in real situations. One of the disciplines that requires this 4C ability is mathematics, where understanding concepts and solving problems are essential.

Suharna (2012: 378) asserts that the learning process involves thinking activities, which take place continuously in each individual. This process produces not only knowledge, but also the skills and attitudes necessary to achieve a wide variety of competencies. Meanwhile, Suharna (2015: 282) added that thinking is a way to achieve learning targets and bring up new learning approaches that can increase the effectiveness of the learning process. The 4C's contribute significantly to mathematics learning, helping students to think critically, communicate, collaborate, and be creative in solving math problems. Education that emphasizes the development of 4C is expected to produce superior and competitive human resources.

In 4C abilities have a very large influence in the teaching and learning process, especially in improving understanding in mathematics. In 4C itself there are several abilities including: Critical thinking is the ability to think at a higher level that not only memorizes but uses and manipulates the material that has been learned according to the situation needed. Communication *is social* interaction between people who convey their ideas or ideas owned by someone. Collaboration *is a* form of cooperation to achieve the desired goals as a group. Creativity is the ability to create something new, either ideas or works (Suharna, 2015).

The STEAM (Science, Technology, Engineering, Arts, Mathematics) approach is one solution to encourage the development of 4C capabilities. The STEAM approach is a meta-discipline that integrates science, technology, engineering, art and mathematics into an integrated approach that can be implemented in learning in schools (Sari, 2020). This approach offers an integrated learning approach and

provides students with a more realistic learning context. Through the STEAM approach, students can develop critical thinking skills, problem-solving skills, and collaboration skills, which will help them in the world of work and everyday life.

However, in practice, the implementation of STEAM-based learning is not always in line with expectations. Many challenges must be overcome to achieve effectiveness in implementing STEAM to develop 4C skills in mathematics learning. Therefore, the purpose of this study is to determine the effect of STEAM learning to improve students' 4C abilities in mathematics learning.

The method used in this research is based on a library research method or approach. The research method is a literature review or literature study which contains theories related to the problem the researcher wants to raise. Sources of information include books, magazines, e-books and other scientific articles. The writing steps taken are:

a) collecting data regarding STEAM and how effective STEAM-based learning methods are in improving students' 4C abilities,

b) analyze the data obtained based on the author's thoughts, and

c) conclude the results of the literature review analysis.

DISCUSSION

STEAM

STEAM which stands for *Science, Technology, Engineering, Arts and Mathematics* is an advancement in the world of education that integrates various elements of science into an integrated learning approach. STEAM was born and played a role after the concept of STEM (*Science, Technology, Engineering and Mathematics*) was established. STEAM was born and emerged from the addition of art disciplines integrated into STEM. Buinicontro (2017) defines STEAM as the integration of arts disciplines into the curriculum and learning of science, technology, engineering and mathematics (STEM). But according to Brown et al (2011), STEM is a meta-discipline at the school level, where teachers of science, technology, engineering, and mathematics learn an integrated approach, and the material for each subject is not compartmentalized and dynamic and treated as a unit. Therefore, STEAM can be said to be a metadiscipline that can be introduced

into school learning with an integrated approach between science, technology, engineering, art, and mathematics. Although STEAM and STEAM were born and developed in parallel, there is a fundamental need that most defines STEAM. Because, the results of STEM education are expected to reveal the value of art that has not existed in STEM education. Integration with STEAM provides new opportunities for students to directly carry out the design learning process and produce products with high creativity and problem-solving skills (Buinicontro, 2017).

The definition of STEAM varies from expert to expert. But all these definitions show that STEAM is a meta-discipline that integrates science, technology, engineering, art and mathematics in an integrated approach that can be applied to learning in schools. Buinicontro (2017) defines STEAM as the integration of arts disciplines into the curriculum and learning of science, technology, engineering and mathematics (STEM). With the integration of art elements into STEM as a foundation for other needs to be better and more interesting, the results and products created from STEAM-based learning will undoubtedly have a positive impact on those who appreciate it. The integration of art elements in STEAM provides opportunities for students to be creative and innovative by integrating artistic creativity into learning outcomes.

STEAM products not only cover cognitive aspects, but also various other aspects such as emotional and motor aspects that are generally used by students in the era of the Industrial Revolution 4.0 can be developed. The complexity of today's 21st century requires skills from multiple disciplines, and STEAM-based learning prepares and trains to meet all these challenges (Wijaya et al., 2015). Therefore, it is necessary to improve cognitive abilities and creativity as well as the acquisition of necessary skills through various methods, such as STEAM learning that integrates design, creativity, and innovation from the fields of science, technology, engineering, and mathematics. To fight globalization and the development of science and technology.

4C Capability

4C capabilities consist of *Communication, Collaboration, Critical Thinking*, and *Creativity* In the face of globalization 4C capabilities (*Communication, Collaboration, Critical Thinking*, and *Creativity*) are suitable especially in the 21st Century, a century where the world develops very quickly and dynamically. 4C ability is a type of *soft skill* whose daily implementation is more useful than having mastery of *hard skills*. The explanation of the 4C capabilities is as follows.

a. *Communication* (communication) is an activity of interaction or conveying information orally or in writing. However, not everyone is able to communicate well. Sometimes there are people who are able to communicate orally but not in writing, and vice versa (Ashim et al, 2019). Indicators of students' mathematical communication skills according to NCTM (in Fachrurazi: 2011) are (1) and the ability to express and reduce mathematical ideas orally and in writing. (2) Ability to understand, interpret and evaluate ideas in other oral, written or visual formats (3) ability to express ideas through concepts, mathematical notation and explained structures (Rahma et al, 2022).

b. *Collaborative* is the ability to work together, synergize with each other, and adapt through different roles and responsibilities (Ashim et al, 2019). Indicators of cooperative ability are: (a) Demonstrate the ability to work effectively in a group. (b) accept responsibility and contribute to the performance of group duties; and (c) provide suggestions and reciprocal responses to other friends (Rahma et al, 2022).

c. *Critical thinking* is the ability to understand complex problems, relate information to one another to produce various perspectives, and find solutions to problems. Critical thinking also means the ability to reason, understand and make complex decisions. Understand relationships between systems, represent, analyze, and solve problems (Ashim et al, 2019). Indicators of critical thinking skills developed by P21 (*21st Century Learning Partnership*) include: (a) Use of inductive and deductive reasoning. (b) analyze the interrelation of parts of a whole to achieve comprehensive results in complex

systems; (c) analyze and evaluate facts; (d) draw conclusions based on the results of the analysis; (e) Solving unusual problems using traditional or innovative methods (Rahma et al, 2022).

d. *Creativity* is the ability to develop, implement, and communicate new ideas to others. Be open and receptive to new and different perspectives. Creativity is also defined as a person's ability to create new combinations. In fact, creativity depends on one's creative thinking, that is, the process of one's mind that generates new ideas. Creativity that can produce new discoveries (and often economic value) is often referred to as innovation (Ashim et al, 2019). Indicators of the ability to think creatively include: (a) Development of new ideas. (b) expand basic ideas to enhance and maximize creative efforts; and (c) the application of creative ideas as practical contributions in life (Rahma et al, 2022).

The effect of STEAM to improve 4C skills in Mathematics learning

a. The effect of STEAM to improve students' mathematical communication skills.

Many studies have been conducted to evaluate the impact of STEAM in mathematics learning, and the results consistently show improved mathematical communication skills in students involved in this approach. The integration of art in mathematics learning can help students express their understanding of mathematical concepts through visual mediums. For example, students can use art to illustrate geometric or statistical concepts, allowing them to clarify their mathematical ideas to others more clearly.

A study by Ashkin et al. (2021) stated that the results of the effectiveness test of STEM nuanced educational materials were 88.54%. The readability test of STEM-nuanced material has a score of 63.65%. STEM-based materials improve mathematical communication skills in the medium category. Based on these results, STEM-based materials are effective, easy to understand, and effective in improving students' mathematical communication skills. Meanwhile, research by Siregar et al (2020) found that the D-Geometry module had a positive impact on students' mathematical thinking, communication, and confidence. Another study conducted by

Setiyani et al. (2020) found that digital modules are very effective, with an overall validation rate of 95.1% by experts, placing them in the "excellent" category. Student response to the digital module was very positive with an overall response standard of 89.8%. Research by Wahyuni et al. (2020), obtained an average score of 4.28 in the Very Good category. Based on media expert verification, the average rating for the "Very Attractive" category is 4.01. On a small scale, student response to the module was 4.4, a very interesting measure. In general the student's response to this module was 4.69, a very interesting standard. The results of the validity test produce an N value of 0.688 which indicates mathematical communication skills.

The STEAM approach encourages students to collaborate on projects involving solving math problems. In this process, students not only learn how to apply mathematical concepts in real-world contexts, but also learn to communicate and cooperate with others in solving complex tasks. This helps improve their ability to convey mathematical ideas verbally as well as in writing. STEAM often involves the use of technology in math learning. By using software and applications specifically designed to visualize mathematical concepts, students can develop their abilities in explaining mathematical ideas with the help of digital tools. This can help students become more skilled in using appropriate and clear mathematical language in their communication.

b. The effect of STEAM to improve students' mathematical collaboration skills.

STEAM is a holistic approach, not just a grouping and fusion of disciplines (Zubaidah, 2019). Students who engage with STEAM don't just learn one area, but they become lifelong learners who are better able to adapt. Learning with the STEAM approach also helps students to better understand others, understand perspectives and cultures so that they can communicate and work together while maintaining their identity (Yakman &; Lee, 2012). One of the real-world contexts that can be integrated with STEAM is the cultural context. Learning that integrates local culture has the potential to help students construct their knowledge through contextual problems, so that learning is more meaningful. With this context, students are motivated to

engage in learning. The use of culture as a learning resource not only provides opportunities for students to develop their thinking skills, but also to introduce and preserve their culture (Bahrodin, Istiqomah, &; Abdullah, 2019; Martyanti &; Suhartini, 2018).

In Nur Qomaria &; Ana Yuniasti's research, Retno Wulandari (2022) learning with the ethnoSTEAM approach through pesapean projects can be an alternative learning approach to develop collaborative skills. This is supported by the results of the implementation of learning, namely that most students have high collaborative skills. Through this learning, an average of six aspects out of eleven collaborative aspects measured also reached the high category. The results of FGD with grade VII science and mathematics teachers showed that students were better able to manage work, able to deal with differences of opinion, and most students were more actively involved in learning. Collaborative skills must continue to be developed not only with one or two activities, but rather carried out on an ongoing basis through good learning resources, approaches, and learning media.

c. The effect of STEAM to improve students' mathematical critical thinking skills.

The results of the analysis of critical thinking skills show that training and teaching this ability is very important, because critical thinking skills are closely related to higher-order thinking skills. Mathematics learning must be adapted to the right technology and learning models so as to encourage learning efficiency and be able to train and deepen students' critical thinking skills. A study by Sung, Lee and Chun (2023) examined the impact of STEAM programs on numeracy, vocabulary, arithmetic, self-regulation and social behavior in children and outcomes of children in the group receiving STEAM curriculum investigations. The use of robotics activities has been shown to significantly improve computational thinking and expressive vocabulary. This is also in line with the research of Bertrand, M &; Namukasa, I (2022). The study says learning with STEAM stimulates curiosity, makes students think about math, and encourages reflection and sharing of mathematical concepts.

A study by Alkhabra, Y et al (2023) revealed that students' learning and critical thinking skills increased after the use of augmented reality (AR) technology in education with the STEAM approach. Skills The use of critical thinking models (PBL) was developed by Evendi, E et al. (2022) using mathematical problem-based e-learning models (e-PBL) to assess students' critical thinking skills and found that e-PBL is effective in improving students' critical thinking skills. In line with this, Sari, S et al (2022) stated that the PBL-STEAM model provides a series of problem-solving activities in a real-world context combined with science, technology, engineering, art, and mathematics so that students will be helped in carrying out a more creative thinking process to face every challenge. With PBL-STEAM, students also get an engaging, broad, and meaningful learning experience.

d. The effect of STEAM to improve students' mathematical creative abilities.

The National Council of Teachers of Mathematics (NCTM) provides standards that in order to prepare for the 21st century, students today must equip themselves with problem-solving skills, communication skills, and with mathematical thinking skills and mathematical propensity. It also states that students should be given challenging problems that can stimulate students to develop diverse ways and think creatively. The ability to think creatively is an ability related to creativity which can be interpreted as a way of thinking to change or develop a problem, see situations or problems from different sides, be open to various ideas and ideas, even uncommon ones (Meika &; Sujana, 2017).

In research conducted by Aguilera &; Ortiz-Revilla (2021), it was obtained that STEAM has a positive effect on student creativity. According to N. D. Sari & Setiawan (2020) with STEAM, students feel more motivated and more effective in learning. The integration of STEAM in learning provides new opportunities for students to develop good creativity and problem-solving abilities In supporting its application, STEAM requires a learning model (S. N. Sari et al., 2022). One learning model that familiarizes students with practicing in solving problems is *Challenge Based Learning* (CBL). A literature review conducted by Ardiansyah et al. in 2022 provided results that

Challenge Based Learning can develop 4C skills (*creativity, critical thinking, communication, collaboration)* which shows that the *Challenge Based Learning* model can be integrated with STEAM learning because these models and approaches can lead students to develop critical thinking skills, problem solving skills, and collaborate. This is in line with STEAM which can train and improve students' talents in solving problems in the 21st century (Wijaya et al., 2015).

Integrating the STEAM (*Science, Technology, Engineering, Art, and Mathematics*) approach in the *Challenge Based Learning* model into a learning innovation called the STEAM *integrated Challenge Based Learning* Model (CBL-STEAM). CBL-STEAM is a learning model that exposes students to problem-solving activities in the context of science, technology, engineering, art, and mathematics. This model provides opportunities for students to explore topics in more depth where the material in learning is designed to be problem-based material with STEAM nuances.

CONCLUSION

The STEAM (*Science, Technology, Engineering, Art, and Mathematics)* approach has proven to have a positive impact in developing 4C skills, namely communication, collaboration, critical thinking, and creativity, in the context of mathematics learning. STEAM allows students to communicate more effectively by integrating art and technology in math learning. Through art, students can express mathematical ideas in a more visual and creative way. The STEAM approach encourages collaboration through projects involving solving mathematical problems. These projects allow students to work together and understand the perspectives of others. STEAM also has a positive impact on mathematical critical thinking skills. The use of technology and problem-based learning models helps students to develop analytical and evaluation skills. The integration of STEAM in learning provides an opportunity for students to develop their creativity. This approach encourages students to solve problems in different ways and be open to a variety of ideas.

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