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Flipped Classroom Learning Model through STEM Approach to Improve the Ability of Mathematical Creative Thinking

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Abstract

In recent years, there has been a growing interest in innovative teaching methodologies to improve student engagement and learning outcomes. The integration of the flipped classroom model with the STEM approach has shown promising potential in fostering critical and creative thinking skills among students. This study aims to find out whether the flipped classroom learning model through the STEM approach can be used to enhance students' creative thinking skills in the subject matter of a three-variable linear equation system for Grade X at MA Mathalibul Huda Mlonggo in the 2022/2023 academic year. The method used in this study is an experimental method with a one-group pretest-posttest experimental design. The research results found that the flipped classroom learning model through the STEM approach was able to improve students' mathematical creative thinking abilities in the material of a system of three-variable linear equations. This can be seen from the T-test result, which obtained the results so that sig.(2-tailed) <α=0,05. Therefore, it can be concluded that the flipped classroom learning model with the STEM approach is able to improve students' mathematical creative thinking skills in the subject matter of a three variables linear equation system for Grade X at MA Mathalibul Huda Mlonggo for the 2022/2023 academic year. This is also reinforced by the results of the normalized gain test which has a value of 0,39, indicating a moderate category of improvement. Hence, it can be concluded that the flipped classroom learning model through the STEM approach is able to improve students' mathematical creative thinking skills in the subject matter of the three-variable linear equation system Grade X at MA Mathalibul Huda Mlonggo in the 2022/2023 academic year.

Keywords: Flipped classroom learning model, STEM, creative thinking

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INTRODUCTION

The 4.0 industrial revolution is a condition of the 21st-century era when massive changes occur in various fields through a combination of technologies that reduce barriers between the physical, digital, and biological worlds (Fonna, 2019; Estiana et al., 2023). As a result of this change, all countries are

required to prepare human resources (HR) that are able to adapt and compete on a global scale. According to Lase (Lase, 2019; Khanifah et al, 2023), one of the keys to keeping up with the 4.0 industrial revolution is to improve human resource quality through education, from basic education to higher education.

Technological advances in the 21st century are expected to assist in meeting the demands of the where education must be able to develop students' skills and abilities in solving problems (Rachmad et al., 2023; Rahiem, 2021). The skills needed in the 21st century include critical thinking and problem-solving skills, collaboration skills, communications skills, as well as creativity and innovation skills, and they are commonly known as the 4C acronym. Through these four skills, one of the skills that needs to be improved in the 21st century is creative thinking skills (Agnesiana et al., 2023; Ellyzabeth Sukmawati et al., 2022). According to Immanuel (Imanuel et al., 2021), thinking creatively is one of the most important abilities in the 21st century or the era of the 4.0 industrial revolution and is the highest competency in Bloom's taxonomy.

The research conducted by Dyers stated that $\frac{2}{3}$ students' creativity is acquired through education, while $\frac{1}{3}$ is attributed from genetics. In contrast, the intelligence of students obtained $\frac{1}{3}$ from education, while $\frac{2}{3}$ obtained from genetics (Wahyudi et al., 2019). Moreover, the indicators of mathematical creative thinking ability are divided into four categories, as stated by (Hafiziani Eka Putri et al., 2017): fluency, which refers to generating ideas or concepts across various categories; flexibility, which involves generating diverse ideas or concepts; originality, which relates to having new ideas or concepts to solve problems; and elaboration, which refers to the ability to develop ideas or concepts to solve problems in detail. One of the creativity aspects that needs to be improved is creativity in mathematics.

Based on the 2018 PISA, the results were obtained that Indonesia was ranked 73 out of 79 countries. Fom these results, it can be seen that the mathematics learning achievement of Indonesian students still needs to improve. In addition, only 1% of Indonesian students have the highest level of proficiency in mathematics at the level of five or six, which at the six level requires students' creative thinking skills in solving PISA problems (PISA, 2018). Therefore, it can be assumed that Indonesian students' mathematical creative thinking skills are still low and need improvement (Putri, 2023; Imanuel et al., 2021).

An effort that can be done to improve students' mathematical creative thinking abilities is to form a learning environment that can assist in improving students' mathematical creative thinking abilities. One way is to use the Flipped classroom learning model with a STEM approach in learning activities. The Flipped classroom learning model is commonly known as the reverse class learning model. The meaning of the reverse classroom learning model is a reversed version of the traditional learning model, where activities are typically carried out in classroom, become activities carried out at home, and activities that are usually carried out at home become activities carried out in classroom. This learning model is also known as a learning model that utilizes technology in its learning activities (Ayçiçek & Yelken, 2018). According to Yulianti & Wulandari, (2021), Flipped classroom is a learner-centred learning model that can develop 4C skills (critical thinking, problem-solving, collaboration, communications, creativity, and innovation). The results of research conducted by Sinta, et al (Damayanti et al., 2020) also state that groups of students who utilize the traditional Flipped classroom learning model have higher creative thinking abilities rather than those who use traditional learning models with direct instruction.

The STEM approach means the result of innovation to meet 21st-century education standards. This learning approach combines two or more STEM fields, namely Science, Technology, Engineering, and Mathematics (Ismayani, 2016). The research results of showed that STEM positively affected the ability to think creatively, critically, and problem-solving abilities (Amin & Ibrahim, 2022). The STEM approach to learning can also train students cognitively, skills, and effectively. Besides, students are invited to directly practice the theories they learn (Mejias et al., 2021; Sukmawati et al., 2023).

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Based on the background above, this study aims to determine the improvement in students' mathematical thinking skills in the three-variable linear equation system material using the Flipped Classroom Learning Model through the STEAM approach. This research has significant urgency and contribution in the development of mathematics education because: First, focusing on students' mathematical thinking skills can contribute to enhancing students' ability to understand and solve complex mathematical problems. Strong mathematical thinking skills are crucial in developing an understanding of mathematical concepts and problem-solving abilities.

Second, the implementation of the Flipped Classroom Learning Model is an innovative step in education. This learning model can increase student engagement and learning effectiveness by utilizing technology to enrich students' learning experiences outside the classroom. Lastly, the integration of the STEAM approach in mathematics education provides students with the opportunity to develop interdisciplinary skills and understand the relevance of mathematics in real-world contexts. This approach can offer a more holistic learning experience and prepare students to face future challenges that require critical and creative thinking. Therefore, this research is expected to make a significant contribution to the development of innovative and effective mathematics teaching strategies and help improve students' learning achievements in mathematical thinking.

METHOD

The research utilized quantitative research with experimental methods. The research design employed was a one-group pretest-posttest design (Sugiyono, 2019). This study was conducted at MA Mathalilbul Huda Mlonggo, involving all Grade X students for the 2022/2023 academic year. The sample selection in this study was carried out using a cluster random sampling technique to select an experimental class. This technique resulted in Grade X MIPA 2 students being chosen as the experimental class. The experimental class received treatment using the Flipped Classroom Learning Model through the STEM approach. The material used in this research was the three-variable linear equations system.

A cluster random sampling technique was employed to select the experimental class, ensuring a representative sample of Grade X MIPA 2 students for the study. To ensure the validity of the data collected, rigorous measures were taken during the data collection process, such as clear instructions, standardized procedures, and consistent application of the research protocol. The data collected from the pretest and posttest assessments were analyzed using appropriate statistical methods to assess the impact of the intervention on students' mathematical creative thinking abilities. Statistical analysis techniques were applied to determine the significance of the results and draw valid conclusions from the research findings.

RESULTS AND DISCUSSION

The implementation of the Flipped Classroom Learning Model through the STEM approach holds promise in enhancing students' mathematical creative thinking abilities. By integrating technology, collaborative learning, and real-world applications, this innovative pedagogical approach aims to engage students actively in the learning process. Through the Flipped Classroom model, students have the opportunity to access instructional materials outside of class, allowing for more interactive and personalized learning experiences. The STEM approach further enriches this learning environment by emphasizing critical thinking, problem-solving, and creativity, essential skills for navigating complex mathematical concepts.

As educators and researchers delve into the impact of the Flipped Classroom Learning Model with the STEM approach on students' mathematical creative thinking, the focus shifts towards evaluating the effectiveness of this teaching methodology. By fostering a student-centered learning environment that encourages exploration, experimentation, and interdisciplinary connections, this approach seeks to cultivate a deeper understanding of mathematical concepts and their practical applications. The combination of the Flipped Classroom model and the STEM approach not only aims to improve students' mathematical skills but also nurtures their ability to think innovatively and apply mathematical principles in diverse contexts.

Understanding the significance of exploring innovative teaching methodologies in enhancing students' learning outcomes, this study delves into the impact of implementing the Flipped Classroom Learning Model with the STEM approach on Grade X MIPA 1 students. By utilizing a cluster random sampling technique, the research aims to provide insights into the effectiveness of this pedagogical approach in improving students' mathematical thinking skills and problem-solving abilities. The selection of Grade X MIPA 1 as the experimental class underscores the importance of tailored educational interventions to cater to specific academic needs and foster holistic skill development among students.

This research was started by collecting data on PTS scores for students grade X in the 2022/2023 academic year, which consisted of seven classes. The PTS value will be used to find out whether there is a difference in the average of the seven classes. After knowing the average difference, then proceed with the sample selection process to determine the class used for research. The selection of the sample was carried out using a *cluster random sampling* technique. Through this technique, students of grade X MIPA 1 were selected as the experimental class where they received certain treatment, using the Flipped classroom learning model with the STEM approach to the material of a three-variable linear equation system.

This learning process begins by providing pre-test questions that have been adjusted to indicators of students' mathematical creative thinking abilities which were then continued with the learning process using the Flipped classroom learning model through the STEM approach to the material of a three-variable linear equation system. After the learning process was carried out using the Flipped classroom learning model, students were then provided post-test questions related to a three-variable linear equation system that has been adjusted to indicators of students' mathematical creative thinking abilities.

Based on the data from pre-test and post-test results, then proceed to the T-test and normalized gain test which aims to determine the increase in students' mathematical creative thinking skills before and after using the Flipped classroom learning model through the STEM approach. Before the T-test was carried out, the researcher conducted a normality and homogeneity test first. Based on the results of the normality test that has been carried out with SPSS, the following results are obtained:

Table 1. Normality Test Results

Data Type	Total of Students	Means	Significance (Kolmogorov-Smirnov)
Pre-test	36	74,31	0,078
Post-test		84,22	0,098

Based on the results in **Table 1**, the significance value of the pretest results $= 0{,}078 > 0{,}05$, means that the pre-test results of students' mathematical creative thinking abilities are normally

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distributed. It is similar to the post-test results of students' mathematical creative thinking abilities, normally distributed with significance values $= 0{,}098 > 0{,}05$. After the normality test was carried out, the homogeneity test was also conducted using the F-test. The results of the homogeneity test can be seen in Table 2, as follows:

Table 2. Homogeneity Test Results

Data Type	Total of Students	Variance	F_{count}	F_{table}
Pre-test	36	27,590	1,562	1,757
Post-test		17,663		

Based on the results of the homogeneity test in Table 2, it can be seen that $F_{count} < F_{table}$. Thus, the pre-test and post-test results of students' mathematical creative thinking abilities are in a homogeneous state. The results of the T-test aim to determine whether there are differences before and after getting treatment using the Flipped classroom learning model with the STEM approach. The results of the T-test can be seen in Table 3.

Table 3. T-test results

Data Type	Total of Students	Means	Sig. (2-tailed)
Pre-test	36	74,31	0,000
Post-test		84,22	

Based on Table 3, it can be seen that $sig.(2-tailed) < \alpha = 0{,}05$. Thus, it can be concluded that there are significant differences in the ability to think creatively mathematically between using the conventional learning model and the Flipped classroom learning model through the STEM approach. Therefore, it can be concluded that the use of Flipped classroom learning model through the STEM approach can improve students' mathematical creative thinking skills in the material of a three-variable linear equation system. The results of the normalized gain test can strengthen this. The test used in this study uses the following formula (Sundayana, 2016).

$$Normalized\ gain = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score}$$

Table 4. Normalized Gain Categories

Normalized Gain Value	Interpretation
$-1{,}00 \leq g < 0{,}00$	There is a decrease
$g = 0{,}00$	Remain
$0{,}00 < g < 0{,}30$	Low
$0{,}30 \leq g < 0{,}70$	Medium
$0{,}70 \leq g \leq 1{,}00$	High

After calculating using the normalized gain formula, the results indicate that the average normalized gain value is 0.39. Based on these results, the increase in students' mathematical thinking

skills before and after using the Flipped Classroom Learning Model through the STEAM approach is included in the medium category. Thus, it can be concluded that by using the Flipped Classroom Learning Model through the STEAM approach, students' mathematical thinking skills in the material of a three-variable linear equation system can be improved.

In discussing these findings, it is important to consider the significance of the medium category in the context of educational research. While an average normalized gain value of 0.39 falls within the medium range, it signifies a substantial improvement in students' mathematical thinking skills. This indicates that the implementation of the Flipped Classroom Learning Model through the STEAM approach has a positive impact on enhancing students' abilities to think critically and analytically in solving mathematical problems related to linear equations.

Furthermore, the medium category suggests that there is room for further enhancement in students' mathematical thinking skills through continued implementation and refinement of the Flipped Classroom Learning Model. Future research could explore additional strategies within the STEAM approach to deepen students' understanding of mathematical concepts and foster a more comprehensive development of their problem-solving skills. Overall, the findings underscore the effectiveness of innovative teaching methods in promoting growth in students' mathematical thinking abilities.

This is in line with the results of research conducted by Anis and Boedy (Khoirotunnisa' & Irhadtanto, 2020) which stated that the traditional Flipped classroom type learning model of video-assisted learning is better than conventional learning on students' creative thinking abilities on flat sided geometric material. According to Yulianti & Wulandari, (2021), flipped classroom is a learner-centred learning model that can develop 4C skills (critical thinking and problem solving, collaboration, communications, creativity, and innovation). It is similar to the results of Amin's research (Amin & Ibrahim, 2022), which stated that STEM had a positive effect on creative, critical thinking skills, and problem-solving abilities.

Incorporating these findings highlights the growing body of research supporting the effectiveness of learner-centered and innovative teaching models, such as the Flipped Classroom approach and STEM education. By emphasizing the development of critical thinking, problem-solving, and creativity, these models offer students opportunities to engage actively in their learning process and acquire essential skills for success in an evolving educational landscape. The alignment of these studies underscores the importance of implementing modern teaching methodologies that cater to the diverse needs and learning styles of students, ultimately enhancing their overall academic performance and skill development.

CONCLUSION

Based on the findings of the conducted research, it can be concluded that using the Flipped classroom learning model through the STEM approach can assist in improving students' mathematical creative thinking skills in the subject matter of a three-variable linear equation system. The increase in students' mathematical creative thinking skills is included in the medium category with an average normalized gain value of 0,39.

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