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Students' Mathematical Logical Thinking Skills through Kite Making in STEM Education

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ABSTRACT

This study investigates the enhancement of students' mathematical and logical thinking skills through kite-making activities using the STEM approach. Conducted with 28 ninth-grade students at SMP Negeri 03 Bengkulu Tengah, this qualitative descriptive research utilized observation, documentation, and interviews for data collection. Data were analyzed using the Miles and Huberman model, focusing on integrating geometry, measurement, and symmetry within the kite-making process. The findings reveal that STEM-based kite-making activities significantly improve students' logical reasoning and problem-solving skills by contextualizing abstract mathematical concepts into practical tasks. Students demonstrated the ability to sequence steps systematically, provide logical arguments, and draw accurate conclusions. These results emphasize the potential of project-based learning in fostering higher-order thinking skills. This study suggests that incorporating similar activities in the curriculum can enhance students' cognitive and practical competencies. Further research is recommended to explore its implementation across diverse educational levels and environments.

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1. INTRODUCTION

The STEM (Science, Technology, Engineering, and Mathematics) approach is growing in education as an effective method to prepare students for the challenges of the 21st century. STEM integrates interrelated and relevant disciplines into everyday life, focusing on theory and encouraging student creativity and experimentation, thus creating a more meaningful learning experience [1], [2]. Implementing STEM in educational institutions plays a vital role in improving the motivation and quality of learning by helping students develop skills in solving problems and applying the knowledge they learn [3], [4], [5], [6], [7], [8].

One way to contextually apply the STEM approach is through kite-making. This activity incorporates various STEM concepts, such as the field of science; students learn about the balance that affects the Kite's ability to fly. In technology, students use tools and materials to cut, assemble, and decorate the Kite. Engineering includes designs or sketches and appropriate materials to bind the Kite so that it is strong and lasts long when flown. Mathematics includes geometry, such as calculating area and symmetry, and measurement, such as lengths and angles. Thus, kite-making helps students relate mathematical ideas to practical experiments and develop logical thinking skills needed in everyday life [9], [10].

Thinking logically is essential in classroom learning, group discussions, and solving specific problems. Logical thinking skills allow students to connect ideas logically and systematically. According to Hadi and several other experts, logical thinking ability is a structured thinking process based on facts to produce valid conclusions [11], [12]. Based on this statement, mathematical and logical thinking is one of the abilities that need to be developed in every stage of learning to achieve optimal results.

Mathematical, logical thinking ability is an essential ability that students must have, especially in STEM-based learning, to analyze, connect information, and make decisions rationally [13], [14], [15]. In learning with the STEM approach, logical thinking skills are key to understanding mathematical concepts more deeply, recognizing patterns, and solving problems effectively and efficiently [16], [17]. This shows that mathematical and logical thinking skills are essential in developing students' excellent cognitive skills.

Based on the description above, the STEM approach to kite-making allows students to not only gain understanding but also hone their mathematical and logical thinking skills, which can improve their learning outcomes [18], [19], [20]. This article describes students' mathematical and logical thinking skills through kite-making with the STEM approach.

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2. METHOD

The type of research used is descriptive qualitative research. This research aims to describe students' mathematical and logical thinking abilities when making kites. This research was conducted in the odd semester of the 2024/2025 academic year at SMP Negeri 03 Bengkulu Tengah. The subjects in this study were students of class IX A SMP Negeri 03 Bengkulu Tengah, totalling 28 students. This class has 12 male students and 16 female students. Most students come from family backgrounds with middle to lower income levels, affecting their access to various educational resources. These students had previously gained a basic understanding of STEM concepts through Math and Science subjects included in the school curriculum, but their understanding varied. STEM provides an essential foundation for learning and applying mathematical concepts in the kite-making activity.

Learning activities were carried out with group work, where the class was divided into seven small groups of 4 students. Each group was given tools and materials to make kites, such as scissors/cutters, plastic, wrapping paper, skewers, glue, ice cream sticks, and yarn. In the initial stage, students discussed the mathematical concepts applied in the kite-making process. In the second stage, students work in groups to design and make the Kite, where they must calculate the right size and proportion and apply geometry and

measurement concepts. In the last stage, after the Kite is completed, students record the results of discussions with their groups and present the results of their work.

This study's data collection techniques included observation, documentation, and interviews. The observation technique is carried out directly during learning activities, namely observing student interactions, how students collaborate in groups, and when students work on LKPD. This observation is to see the suitability between students' explanations and actions in the activity and verify the interview findings. Documentation was carried out on the LKPD, which was used to determine students' abilities with the mathematical concepts taught through the kite-making process and assess their mathematical and logical thinking skills based on their work. Documentation also provides concrete evidence that can be compared with interviews to understand students' thinking further. Interviews were conducted when students presented their work, documented through audio, video, and photo recordings, and interviews with some students after the activity to explore their experiences and understanding in completing a mathematical, logical thinking project. By conducting these interviews, information from observation and documentation can be complemented, and personal insights can be provided on how students see and use learning. In addition, groups were interviewed based on the work's success, i.e., the kites created, to explore further the relationship between group collaboration and the work produced.

This research uses the Miles and Huberman model data analysis technique [21], which consists of data reduction, data presentation, and conclusion drawing. After data collection, data reduction was conducted to select important information related to logical thinking skills. Data reduction helps researchers filter out irrelevant information and focus on essential elements to facilitate decision-making. Furthermore, data presentation provides a clear picture and makes it easier for researchers to draw valid conclusions. The last stage is drawing findings, where researchers draw temporary findings from the data obtained. After the data is complete, conclusions are made, which must be clarified and verified during the research. Table I below shows this study's logical thinking indicators [22].

Table I. Indicators of Mathematical Logical Thinking

No.	Indicator	Description
1.	Orderly thinking	Students mentioned everything they knew and asked for correct information about kite making.
2.	Argumentative skills	Students can correctly express the reasons for all the steps of making a kite to conclude.
3.	Drawing conclusions	Students provide appropriate conclusions at each step of the solution.

3. RESULTS AND DISCUSSION

3.1. Results

Several indicators of mathematical and logical thinking ability can be observed, including order of thinking, argumentative ability, and inference. Students fulfilling the thinking sequence indicator can systematically compile and structure problem-solving

steps. Students satisfied with the argument gauge ability can provide clear and logical reasons for problem-solving. Students who fulfil the inference indicator can draw the correct conclusions based on the available information. The results of the analysis of logical thinking skills are as follows.

1. Thinking sequence indicator

In this aspect, the researcher analyzed students' ability to organize problem-solving steps logically and structure through kite-making. One of the questions the researcher asked is how students can sequence problem-solving steps in designing and making miniature kites. The following is an excerpt of the researcher's interview (P) with the subject (S).

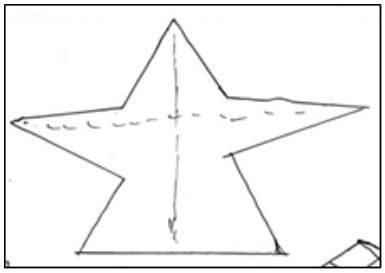

Figure 1. Miniature kite sketch

P : "When making this miniature Kite, what steps did you take?"

S : "First, we read the LKPD that was distributed to learn the information provided. Then, we tried to work on the LKPD to make it easier to understand. After that, we determined the type of Kite we wanted and tried to make the design on paper. Then, we looked for the most suitable size and material. Here, we used skewers as the skeleton and plastic for the kite body."

P : "What is your next step after determining the type and material?"

S : "Next, we measured the length of the skewers for the skeleton with a ruler and cut out the right-sized plastic to cover it. This step is essential because any incorrect size can make the Kite unable to fly."

Figure 2. Miniature Kite

P : "Then what do you do after cutting the material?"
S : "We started assembling the kite frame using thread to tie the skewer in the centre, crossing twice at the top and bottom. The aim is to make the kite frame more sturdy."
P : "After that, what is the next step?"
S : "We tie the left and right ends of the Kite to form an arch. This is important so that our Kite can fly well."
P : "What did you do after the left and right parts were bound?"
S : "Then, we tied the bottom part using skewers and thread using the cross technique to strengthen the bottom of the Kite. Then, we shaped the top part with yarn to make it look like a triangle and maintain balance."
P : "So, are the steps you described interrelated and done in sequence?"
S : "Yes, that is right. Each step must be done correctly so the Kite can be appropriately shaped and fly."
P : "Why is sequence important?"
S : "If the order is not correct, the parts of the Kite may not be firmly attached, or the shape may become unbalanced, making the Kite unable to fly."

Based on the interview results above, students can analyze, apply, and provide explanations of mathematical concepts in making kites kites. Some points that can be taken from the analysis of the interview. 1) Size measurement and material selection process. Students show logical thinking skills with their understanding of the importance of size and design accuracy that affects the function of the Kite. 2) Determining the shape and structure of the frame, such as using the cross technique to strengthen the frame, is an application of symmetry and balance. 3) Using tying techniques to form curved, like shapes allows the Kite to rise and fly steadily. 4) The formation of balance and symmetry, such as the triangular shape, helps the wind pressure evenly to maintain the balance of the flying Kite. Based on the analysis, students have good mathematical and logical thinking skills in the indicator of a sequence of thinking. This is shown by students' ability to measure length and proportion, geometry and structural stability, symmetry, and balance.

2. Indicators of argumentative ability

In this aspect, the researcher analyzed the ability to argue in students' mathematical, logical thinking through making miniature kites. One of the questions asked by the researcher is how students determine the shape of the kite parts. The following is an excerpt of the researcher's interview (P) with the subject (S).

P : "Why did you tie the left and right ends of the Kite to make it curved?"
S : "We curved the left and right ends so the Kite can fly stably. This curved shape helps reduce wind friction, allowing the Kite to rise."
P : "Why do you use skewers with thread to tie the bottom of the Kite?"
S : "We chose skewers because they are firm and the correct size. In addition, the skewers also help to stabilise the bottom of the Kite so that it will not be easily

damaged or detached."

P : "Why is the rope at the top made triangular?"

S : "Because the triangular rope can help divide the wind pressure evenly across the top of the Kite. This will make the Kite more stable and less prone to tilting or falling in the light."

Based on the interview results above, the indicators of students' argumentative ability in determining the shape of the Kite reflect good mathematical and logical thinking skills. Students can relate science principles to their kite design; for example, when students explain how the curved shape at the end of the Kite can reduce wind friction to increase stability when flying and use a triangular rope to divide the wind power evenly. In addition, students could select appropriate materials to provide stability and durability to the Kite, demonstrating rational thinking and applying mathematical and scientific concepts in making the Kite.

3. Inference indicator

In this aspect, the researcher analyzed the inference in students' mathematical, logical thinking through making miniature kites. One of the questions asked by the researcher is whether students can provide conclusions about the relationship between the size and shape of the Kite. The following is an excerpt of the researcher's interview (P) with the subject (S).

Figure 3. Miniature Kite

P : "What did you learn from making this miniature Kite?"

S : "We learned every step in making a kite is essential. For example, precise measurements and strong ties will stabilize the Kite. Shape modifications also affect how the Kite flies."

P : "What can you conclude about the importance of shape size in making miniature kites?"

S : "We can conclude that the Kite's size and shape significantly impact its flying success. Improper measurements can make the Kite lopsided and unable to fly, while an improper shape can cause instability."

P : "So, what is the conclusion for making this miniature Kite?"

S : "In conclusion, we must consider every step of making a kite, size, shape, or bond. All of these affect the stability and success of the Kite when flying."

Based on the results of interviews and analysis, students showed the ability to analyze the relationship between size, shape, and bond strength in making miniature kites. Students concluded that the proper measurement and appropriate shape affect the stability and success of the Kite when flying. Students can also connect the results of making miniature kites logically and systematically, such as how errors in size or shape can cause instability, thus showing students' ability to draw conclusions based on systematic observations and science principles.

The results of this study show that students not only understand the fields of science and math through kite-making but also how these concepts relate to each other in solving real-world problems. This resulted in a broader understanding of how the STEM approach equips students with the logical thinking skills needed to create innovative solutions.

3.2. Discussion

Based on the analysis of the sequence of thinking, students showed good mathematical and logical thinking skills by systematically arranging the steps of making miniature kites. At this stage, students utilize mathematical concepts in length measurement and proportion and apply geomancy concepts, such as balance and symmetry, which play an essential role in the stability of the kite structure. In the STEM context, logical thinking skills reflect students' understanding of the engineering process, where each step must be performed correctly to achieve the desired result. This shows that logical thinking skills are critical in the STEM approach, as they help students solve complex problems [23].

Based on the analysis of the indicators of the ability to argue through making miniature kites. Students demonstrated their ability by providing rational reasons for choosing specific shapes and materials. Students can explain how each design decision (curved shape, binding technique, and material selection) relates to broader science and math principles. Students explained that the curved shape of the kite tip helps reduce wind friction, which is an application of scientific principles. This aligns with previous research showing that the STEM approach can encourage students to develop strong argumentation skills as they directly link theory with practice [24], [25].

The inference indicator refers to the student's ability to conclude and connect existing information to gain a deeper understanding through making miniature kites. Students demonstrate this ability by concluding the relationship between the size, shape, and stability of the Kite. Students also concluded that the correct measurements and appropriate design greatly influence the Kite's success when flying. The conclusion drawn by students that each step in kite making has a vital role in successful flying reflects an understanding based on science and mathematical principles. This shows that project-based learning in STEM can improve students' ability to draw conclusions based on systematic and logical experimental results [26].

Thus, previous research shows that students who learn through project-based learning can better relate science and math concepts to real-world situations. This study's findings are similar to prior research results, where students could explain and relate science principles in their kite designs [27]. However, this study contributes further by adding more detailed aspects of mathematical and logical thinking skills, such as order of thinking, argumentation skills, and inference, also found in previous research [28] on developing students' critical thinking in STEM projects.

4. CONCLUSION

Based on the results and discussion above, project-based learning through making miniature kites allows students to develop mathematical and logical thinking skills. Students not only master skills in measuring and designing kites but also establish strong argumentation skills and draw conclusions based on observations and applicable principles. For educators, it is recommended that this kite-making activity be adapted to the level of education and the environment in which students learn. For example, the activity could introduce basic math and science concepts at the primary level. In contrast, at the secondary level, the activity could be enriched with a more complex analysis of engineering and technology. Future research could also explore the limitations of this study, such as the small sample size and qualitative scope, and suggest that further research expand the sample and use a quantitative approach to obtain broader results. Implementing these findings is highly relevant in the broader discussion of STEM approaches, as project-based learning develops skills and helps students prepare themselves to solve real-world problems, where logical thinking skills are crucial.

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