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Exploring the relationship between problem-solving ability and mathematical disposition in 10-11 year's old students using model-eliciting activities

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Abstract

Background: Problem-solving ability and mathematical disposition are essential skills in mathematics education, particularly in developing critical thinking and practical application among students. Model-Eliciting Activities (MEAs) have been introduced as an instructional approach aimed at enhancing these skills by integrating real-world problems into learning. However, the effectiveness of MEAs in establishing a significant relationship between problem-solving ability and mathematical disposition remains unclear, necessitating further investigation.
Aim: This study aims to analyze the association between problem-solving ability and mathematical disposition after implementing Model-Eliciting Activities (MEAs) in instruction.
Method: This study employed a quantitative design with a cross-sectional approach, involving 30 fifth-grade students from SDN 02 Bojongsari, Depok, Indonesia, as participants. Data were collected using a problem-solving ability test and a mathematical disposition questionnaire. Subsequently, the data analysis was carried out using chi-square tests.
Result: The results of the study showed that the $\chi 2$ value of 0.731 is less than $\alpha = 0.947$, indicating that there is no significant relationship between mathematical problem-solving ability and mathematical disposition.
Conclusion:
The study concluded that no association was found between problem-solving ability and mathematical disposition among elementary school students after implementing MEAs in instruction. Additionally, although there is a tendency for students with a high mathematical disposition to demonstrate stronger problem-solving skills, this correlation is not strong enough to be considered significant.

INTRODUCTION

Mathematics, with its patterns, logical sequences, and abstract nature, is often perceived as challenging (Junarti et al., 2022). One reason is that its hierarchical structure demands comprehensive learning, requiring students to master foundational concepts before progressing to more complex topics, both in terms of material understanding and

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mathematical skills (Roslina et al., 2023; Wahyuningrum & Suryadi, 2014). Additionally, the lack of deep conceptual understanding and practical application further contributes to the difficulties students experience in learning mathematics (Wahyuni et al., 2023). These challenges highlight the importance of teaching approaches that not only build conceptual knowledge but also foster critical and analytical thinking. According to (Van de Walle, 2008), students acquire new understanding by actively seeking connections, analyzing patterns, evaluating methods, and engaging in reflective thinking. Problem-solving-based learning, as a key approach in mathematics education, strengthens students' mathematical thinking while simultaneously building constructive behavioral habits, particularly among elementary school students.

Problem-solving skills are crucial for elementary school students because these skills form the foundation for cognitive and social development (Nguyen et al., 2021; Son et al., 2020). In this context, problem-solving skills, students can identify and understand problems, design strategies to overcome them, and evaluate the results of the solutions applied (Kardoyo et al., 2020; Meli et al., 2018). This process not only enhances critical and analytical thinking skills but also helps students develop confidence and independence (Akbari & Sahibzada, 2020). For example, in mathematics lessons, students might be given word problems that require them to analyze situations, determine relevant information, and devise step-by-step solutions. Additionally, science experiments often involve identifying hypotheses, testing variables, and drawing conclusions based on observed data. These activities not only bridge classroom concepts with real-life situations but also teach students practical ways to address everyday challenges, such as organizing tasks, resolving conflicts, or making decisions in unfamiliar situations (Yu et al., 2015). By habituating students to practice problem-solving from an early age through such activities, they will be better prepared to handle both academic and social challenges, equipping them with skills essential for navigating complexities in and beyond the classroom.

An important factor that influences how students approach problem-solving in mathematics is their mathematical disposition, which refers to their attitudes, beliefs, and tendencies regarding learning mathematics. A positive mathematical disposition includes confidence in one's mathematical abilities, persistence in tackling problems, and a willingness to engage with mathematical tasks even when they are challenging (Husniah et al., 2021; Kamid et al., 2021). Students with a positive mathematical disposition are more likely to view challenges as opportunities for growth, which in turn enhances their resilience and motivation in learning mathematics (Fitriani et al., 2023). Disposition is a crucial aspect of mathematics education because it not only impacts how students engage with content but also shapes their long-term attitudes toward the subject (Ulia & Kusmaryono, 2021). Developing a strong mathematical disposition in elementary school students can be particularly impactful as it lays the foundation for future success in mathematics (Fadillah et al., 2020). For example, students with high levels of curiosity and enthusiasm toward problem-solving are more inclined to explore multiple solution strategies and reflect on their learning process. This aligns with the goals of problem-solving-based learning, where students are encouraged to think critically and evaluate their own approaches. Research has shown that students who possess a positive mathematical disposition are more likely to persist in finding solutions, even when faced with difficult problems (Ramdani et al., 2021).

Several previous studies have examined similar topics. (Yurniwati & Selpiani, 2023) identified a positive correlation between mathematical disposition and problem-solving skills in elementary students, but their analysis was limited to a survey-based correlation without investigating instructional strategies that could enhance both aspects. (Mutia et al., 2023) explored cognitive processes in problem-solving, focusing on analogical thinking and its relationship with mathematical disposition. However, this study primarily analyzed students' cognitive behaviors without proposing practical interventions and was confined to college students, leaving gaps in application across other educational levels. (Rahayu et al., 2022) examined the role of mathematical disposition in solving inferential statistics problems among university students, categorizing students based on their disposition but not addressing broader instructional methods. Similarly, (Claudia et al., 2021) applied a semiotic approach to analyze how high school students with strong mathematical dispositions interact with symbols and concepts. While providing valuable insights, the study lacks recommendations for improving mathematical skills across varying abilities. Based on previous research, no studies have used a learning approach for this topic. Therefore, this study addresses the gap by using the Model-Eliciting Activities approach to examine the relationship between problem-solving and mathematical disposition. MEAs offer the advantage of fostering deeper learning outcomes beyond short, narrow answers (Baker & Galanti, 2017). They enhance students' ability to visualize problems, apply metacognitive models, and transfer knowledge to new situations. (Ekmekci & Krause, 2011) found that MEAs motivate students to refine and articulate their mathematical thinking. These benefits highlight the potential of MEAs to improve problem-solving skills through the lens of mathematical disposition. Therefore, this study aims to analyze the relationship between mathematical problem-solving ability and mathematical disposition after using Model-Eliciting Activities in learning.

METHODS

Design

The research design used is a quantitative study with a cross-sectional design. Cross-sectional studies are useful for exploring reciprocal relationships between variables (Luu-Thi) (Sugiyono, 2017). In this study, the reciprocal relationship refers to the association between students' problem-solving ability and mathematical disposition. This design was chosen because it allows for data collection at a single point in time, making it more efficient for identifying relationships between variables. Additionally, this approach is suitable for revealing patterns and correlations within the studied population without requiring an extended period.

Participants

The participants in this study are 30 fifth-grade students from SD Negeri 02 Bojongsari Depok. The selection of elementary school students as subjects is based on the consideration that, according to Piaget (Ruseffendi, 2005), elementary school students are at the concrete and early semi-formal thinking stages. At this stage, their mathematical mindset is still in moderate development, allowing the researcher to explore and measure the effectiveness of the intervention applied. By using this age group, the study aims to provide clearer insights into how learning can affect the cognitive development of mathematics at an early stage.

Data Collection

Data collection in this study involves tests and questionnaires. The tests used in this research are designed to measure problem-solving ability, while the questionnaires are used to assess mathematical disposition. The indicators for problem-solving ability are (a) Students' ability to solve non-routine mathematical problems, including understanding mathematical problems; (b) The ability to plan problem-solving strategies by transforming problems into mathematical models and determining other concepts used in solving problems; and (c) The ability to solve problems by identifying which numbers make the formulated mathematical sentences correct. Meanwhile, mathematical disposition (Sumarmo, 2010) refers to students' attitudes and perceptions of themselves when interacting with mathematics, which includes: self-confidence, expectations and metacognition, enthusiasm and serious attention in learning mathematics, persistence in facing and solving problems, high curiosity, and the ability to share opinions with others.

Data Analysis

The data analysis techniques used include chi-square tests. The chi-square test is used to determine whether there is a significant association between problem-solving ability and students' mathematical disposition. Additionally, the contingency coefficient test is used to measure the strength of the association between these two variables. All tests are conducted using IBM SPSS Statistics 26 to ensure the accuracy and reliability of the analysis results. The findings from this analysis are expected to provide in-depth insights into the relationship between problem-solving ability and mathematical disposition after the implementation of MEAs (Model-Eliciting Activities) learning.

RESULTS AND DISCUSSION

Result

Implementation of Model-Eliciting Activities (MEAs) for the Volume of Cubes

Problem Introduction

In this study, the problem introduction phase begins with the teacher presenting a real-world scenario that requires calculating the volume of cubes. For example, ask students to assist an interior designer who wants to fill a space with cubic storage boxes. Provide information about the dimensions of the space and the size of each cube.

Activity Presentation

Invite students to use actual unit cubes to construct cubes of various sizes. Students should measure the length, width, and height of each cube and then determine the volume of each cube.

Figure 1. Students' activity in manipulating unit cubes

Figure 1 depicts students actively manipulating unit cubes in a hands-on geometry activity. The image shows students stacking and arranging the cubes to form rectangular prisms, including both cubes and blocks. Through this activity, students explore the concepts of length, width, height, and volume by physically measuring and counting the unit cubes. This visual and tactile approach aids in their understanding of geometric principles and volume calculation, providing a concrete basis for grasping abstract mathematical concepts.

Data Collection

Ask students to fill in a table that lists various cube sizes and their corresponding volumes. The table should include columns for the cubes' length, width, height, and volume. Students need to complete the table based on their measurements and calculations. Students are asked to fill in the table provided by the teacher. They are required to connect the length, width, height, and volume of rectangular vertical prisms (cubes and blocks) by stacking unit cubes. The format for filling out problem one can be seen in Table 1.

Table 1. Determining the Volume of a Cube

No	Length	Wide	Elevate	Volume of Cubes (= number of unit cubes arranged)
1	2	4	3	....
2	3	5	4	....
3	....	4	2	24
4	6	5	......	60
...				

Application of the Model

After collecting data, students are asked to formulate a mathematical formula or model that can relate the length, width, and height of a cube to its volume. Students need to identify the relationship between the dimensions of the cube and its volume and explain how the formula can be applied to calculate the volume of a cube based on the length, width, and height values provided by the teacher. This process involves analyzing the collected data, applying relevant mathematical concepts, and testing the model to ensure its accuracy and reliability across different cases.

The modeling process using worksheets involves students' concentration on coordinating information and relationships, as well as identifying existing patterns (Ramadhona & Perdana, 2022; Yalyn et al., 2022). Problems in LKS contain the potential for the emergence of models related to elements, relationships, and operations between elements, patterns, and rules that regulate relationships. In MEAs, worksheets must feature problems relevant to students' real experiences, even with different data, to provide meaningful solutions in their daily lives.

Reflection and Discussion

At the reflection stage, students are asked to discuss their results and evaluate the effectiveness of the model they created. Afterward, students should discuss any errors that may have occurred and ways to correct them. Allow students to share their strategies for solving problems and addressing the challenges they encountered.

Application in a Broader Context

To deepen understanding, apply the model that has been developed to other situations, such as designing a box with a specific volume for various purposes, or solving problems involving the volume of cubes in real-world contexts. In this context, students are given geometry problem-solving tasks such as "Cube A has an edge of 17 cm. Cube B has an edge of 12 cm. Inside cube A is inserted cube B. Then cube A, on the outside of cube B, is filled with sand until it is full. What is the volume of sand in cube A?"

Next, the answers related to the problem can be viewed as shown in Figure 2.

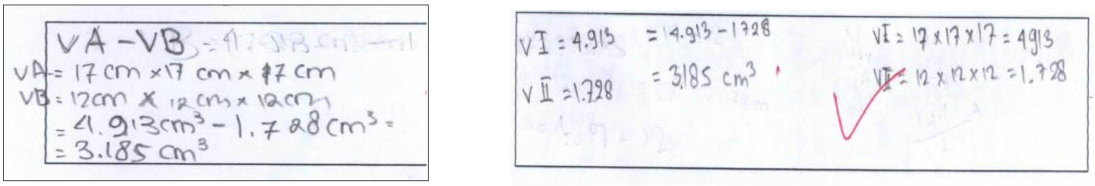

Figure 2. Student Answers

Student Answers illustrate students' good mathematical problem-solving abilities. Students can express their abilities with good mathematical ethics. However, for a student, technically calculating, the student can solve the problem, but the mathematical representation shown by the student is seen as not being able to master expressing his thoughts mathematically. Various teaching methodologies can significantly enhance students' representation skills. For instance, project-based learning (PjBL) has proven effective in developing mathematical representation by encouraging students to apply their understanding in real-world contexts (Ratnasari et al., 2018). Similarly, inquiry-based learning deepens students' grasp of mathematical concepts by allowing them to explore and express their ideas through hands-on experimentation and collaborative discussions (Sejati et al., 2021). These approaches not only strengthen representation skills but also foster critical thinking and problem-solving abilities (Priyadi et al., 2021).

Descriptive Analysis of Mathematical Problem-Solving Ability Scores

The statistical representation used to describe students' mathematical problem-solving abilities is a table containing data on the number of students, mean and standard deviation as well as a bar chart of the results of the mathematical problem-solving ability test as in Table 2.

Table 2. Descriptive Statistics of Problem-Solving Scores Based on Student Ability Level

Student Ability Level	N	Minimum	Maximum	Mean	Std. Deviation
High	8	100	100	100	.000
Middle	15	60	80	70.67	10.328
Low	7	20	40	37.14	7.559

Table 1 describes students' mathematical problem-solving abilities after MEAs learning with the following explanation. The average result of the mathematical problem-solving ability test was 70.67. The standard deviation of the results of the mathematical problem-solving ability test is 23.92, meaning that the results of the student's mathematical problem-solving ability tests are heterogeneous. Data on students' mathematical problem-solving abilities generally informs that 50% of students with problem-solving abilities are included in the ability category at the middle level with an average score of 71, followed by 29% at the top level with an average score of 100 and 21% of students are at the bottom with an average score of 37. This distribution suggests that while MEAs have a positive impact on many students, there remains a notable gap between high and low performers, requiring targeted interventions to support those struggling with problem-solving.

Descriptive Analysis of Mathematical Disposition Scores

The description of the student's mathematical disposition test results after learning in the research is explained as follows.

Table 3. Descriptive Statistics of Mathematical Disposition Scores Based on Student Ability Level

Student Ability Level	N	Minimum	Maximum	Mean	Std. Deviation
High	10	151	173	160.30	7.196
Middle	11	135	150	142.82	4.331
Low	9	101	133	121.89	10.373

Table 3 describes students' mathematical disposition after MEAs learning, namely the average result of the mathematical problem-solving ability test is 142.37. The standard deviation of the results of the mathematical problem-solving ability test is 17.13, meaning that the results of the student's mathematical problem-solving ability tests are heterogeneous. Data on students' mathematical disposition informs that 36% of students have a mathematical disposition that is at the middle level with an average score of 142.82, followed by 34% at the top level with an average score of 160, and 30% of students at the lower level with an average -average score 121.89. This distribution suggests that while a substantial portion of students have a favorable mathematical disposition (top and middle levels), a significant percentage still requires improvement, particularly those in the lower level. The overall variation, as indicated by the standard deviation, underscores differences in students' receptiveness to MEAs, suggesting that further targeted interventions might be necessary to uplift students with lower dispositions while continuing to support those performing at higher levels.

The Relationship Between Mathematical Problem-Solving Ability and Mathematical Disposition

Linkage analysis (association) was carried out to test whether there was a relationship between mathematical problem-solving ability and mathematical disposition. The statistical test used is contingency table analysis. Contingency table analysis requires categorical data arranged in a contingency table, and therefore the test result data in this study was converted into categorical data on a nominal scale. Conversion is conducted with the conditions in Table 4.

Table 4. Conversion of Test Result Data Categorization

Conversion Terms	Category
Student's score ≥ score average +(0.5 x Std. Dev)	High
score average - (0.5 x Std. Dev) < Student's score < score average + (0.5 x Std. Dev)	Middle
Student's score ≤ score average - (0.5 x Std. Dev)	Low

The conversion results of the test scores are adjusted to the maximum score for each test and give the following results.

Table 5. Categorization Conversion Results

Mathematical Ability	Student Ability Level		
	High	Middle	Low
Mathematical Problem-Solving Ability	x < 58.71	58.71 < x < 82.63	x > 82.63
Mathematical Disposition	x < 133.71	133.805 < x< 150.935	x > 150.935

Data from the conversion of categorization to scores on mathematical problem-solving ability and mathematical disposition are as in Table 5. Contingency is used to test whether the two students' abilities are mutually related or not. The categorical data grouping is summarized in the following contingency table.

Table 6. Category Frequency Distribution of the Relationship between Problem-Solving Ability and Mathematical Disposition

Category		Mathematical Disposition			Total
		High	Middle	Low	
Mathematical Problem-Solving Ability	High	3	3	2	8
	Middle	4	6	5	15
	Low	3	2	2	7
Total		10	11	9	30

Table 6 shows the distribution of mathematical problem-solving ability based on mathematical disposition. Out of a total of 30 students, 8 students have high mathematical problem-solving ability, with 3 students having high disposition, 3 students having medium disposition, and 2 students having low disposition. A total of 15 students exhibits medium problem-solving ability, with 4 students having high disposition, 6 students having medium disposition, and 5 students having low disposition. Meanwhile, 7 students demonstrate low problem-solving ability, consisting of 3 students with high disposition, 2 students with medium disposition, and 2 students with low disposition. This data indicates that the distribution of mathematical disposition is related to the level of mathematical problem-solving ability, with a larger number of students having medium disposition and varying levels of ability across all disposition categories. Testing whether there is a relationship between mathematical problem-solving ability and mathematical disposition gives results as in Table 7 below.

Table 7. Results of the Interrelationship Test Problem Solving Ability and Mathematical Disposition

Pearson-Chi Square's Test		
χ^2	Df	Asymp.Sig (2-sided)
0.731[a]	4	0.947

In Table 7, the value of χ^2 = 0.731 is presented with Asymp. Sig (2-sided) which is smaller than α = 0.947 and causes H_0 to be accepted. The test results that accepted H_0 concluded that there was no significant relationship between mathematical problem-solving ability and mathematical disposition. The strength or weakness of the relationship between mathematical problem-solving ability and mathematical disposition is known through the size of the contingency coefficient figures obtained by SPSS calculations and providing the results in Table 8.

Table 8. Contingency Coefficients for Interrelationships Problem Solving Ability and Mathematical Disposition

	Value	Approx. Sig.
Contingency Coefficient (C)	0.154	0.947
N of Valid Cases	30	

Based on the calculation of the contingency coefficient on the research data as shown in Table 8, namely C = 0.154 with P-value = 0.947, it explains that there is no significant relationship between mathematical problem-solving ability and mathematical disposition. The higher the performance of a student's mathematical problem-solving ability, the higher the mathematical disposition, and vice versa. This is possible because disposition is an ability in the context of attitudes, so for mathematical disposition abilities to emerge, habituation is needed that is built up over a relatively extended period.

Discussion

This study found that after implementing MEAs, no significant association was observed between problem-solving ability and mathematical disposition among elementary school students. Although students with a high mathematical disposition tended to demonstrate stronger problem-solving skills, the correlation was not substantial enough to be considered significant. The data revealed instances where students with high mathematical disposition exhibited low problem-solving abilities, and vice versa. This suggests that other factors may have a more substantial influence on students' mathematical problem-solving skills. For instance, comprehension of mathematical concepts, logical and analytical abilities, and prior experience with solving mathematical problems could be more critical determinants of problem-solving performance.

The lack of a significant association between problem-solving ability and mathematical disposition among elementary school students is due to differences in cognitive development stages. At the elementary school age, students' abstract and logical thinking abilities are still developing (Cheng et al., 2021). Although students may have a positive mathematical disposition, they not necessarily be able to apply these skills in more complex problem-solving contexts. Critical and analytical thinking skills, which are essential for problem-solving, are often not fully developed in students at this age (Dwyer & Walsh, 2020; Flores et al., 2012). Moreover, emotional and motivational factors also play a crucial role in the relationship between mathematical disposition and problem-solving ability. A positive mathematical disposition does not always accompany good problem-solving skills if students face anxiety or lack motivation toward mathematics. Fear or anxiety towards mathematics can hinder students' ability to effectively use the knowledge and strategies they possess (Gabriel et al., 2020; Hoffman, 2010). Therefore, even if students have a positive attitude towards mathematics, this is not always reflected in their ability to solve challenging problems (Jusra & Iskandar, 2020).

Additionally, the learning environment also influences students' ability to solve mathematical problems (Wang et al., 2017). A less supportive environment, such as a non-interactive teaching approach or lack of opportunities to practice problem-solving in real-life situations, can limit students' ability to apply their mathematical disposition in practical contexts (Mtui, 2021). If students are not provided with sufficient learning experiences in problem-solving, their mathematical disposition may not manifest in their ability to effectively solve problems (Clark et al., 2014). Differences in the measurement of problem-solving ability and mathematical disposition may contribute to variations in research results. The instruments used to assess mathematical disposition not fully capture students' actual attitudes or behaviors in authentic problem-solving scenarios, potentially leading to inconsistencies (Andrews et al., 2017). Moreover, limited exposure to relevant learning experiences and the use of less effective teaching approaches could be factors that obscure the relationship between these variables. These combined influences suggest that the connection between mathematical disposition and problem-solving ability among elementary school students is multifaceted and not easily discernible, requiring further investigation with more refined measurement tools and instructional strategies.

Implication

These findings have several important implications for mathematics education. First, educators must understand that developing a positive mathematical disposition requires time and consistent effort. Teachers must create a supportive learning environment, provide positive feedback, and encourage students to view mathematics as an interesting and valuable field. Second, educators should be aware that mathematical problem-solving ability is not solely dependent on mathematical disposition. Therefore, the curriculum and teaching strategies should be designed to develop both cognitive abilities and positive attitudes toward mathematics. This could involve the use of student-centered teaching methods, challenging yet achievable problem-solving tasks, as well as opportunities for reflection and discussion about the problem-solving process. Third, it is important to provide students with opportunities to develop metacognitive skills, such as reflecting on their thinking processes and the strategies they use in problem-solving. These metacognitive skills can help students become more effective and persistent problem solvers, regardless of their initial disposition towards mathematics.

Limitation and Suggestion for Further Research

This study has several limitations that need to be considered. First, the research was conducted with elementary school students within a relatively diverse age range, where their cognitive development stages might differ. This could affect their ability to solve mathematical problems and may not fully reflect their mathematical disposition. Second, the measurement of mathematical disposition and problem-solving ability was conducted using specific instruments, which might not fully capture students' attitudes, knowledge, or skills in real-life situations. Additionally, emotional factors such as math anxiety were not directly measured, which could provide an incomplete picture of the relationship between mathematical disposition and problem-solving ability.

Future research is advised to pay closer attention to students' cognitive development stages in the analysis, possibly by dividing the sample based on age or more specific cognitive development levels. Research could also develop or select more holistic measurement instruments that not only assess mathematical disposition and problem-solving ability separately but also consider emotional and motivational factors. Moreover, a more in-depth qualitative approach, such as interviews or observations focused on students' thinking processes during problem-solving, could provide richer insights into how mathematical disposition influences problem-solving ability. Further research could also explore pedagogical interventions designed to strengthen the relationship between mathematical disposition and problem-solving ability, such as through the use of problem-based learning or other interactive approaches.

CONCLUSIONS

This study examines the relationship between problem-solving ability and mathematical disposition in elementary school students following the implementation of Model-Eliciting Activities (MEAs). The findings reveal no significant association between these two variables. While there is a tendency for students with a higher mathematical disposition to exhibit better problem-solving skills, the correlation is not statistically significant. Notably, some students with a high mathematical disposition displayed low problem-solving abilities, and vice versa. This suggests that other factors, such as a deeper understanding of mathematical concepts, logical and analytical skills, and prior experience with problem-solving, may play a more critical role in influencing problem-solving ability.

The implications of these findings are significant for mathematics education. While fostering a positive mathematical disposition is important, the results suggest that this alone is not enough to improve students' problem-solving abilities. A more holistic teaching approach is needed—one that not only emphasizes mathematical disposition but also strengthens students' understanding of mathematical concepts, logical reasoning, and analytical skills. The study underscores the importance of providing diverse learning experiences to develop problem-solving skills. Teachers should incorporate activities that encourage critical and analytical thinking, as well as opportunities for students to reflect on and discuss their problem-solving strategies. Overall, this research indicates that mathematical problem-solving ability is shaped by the complex interaction of various cognitive and non-cognitive factors. Therefore, more integrated educational strategies are required to cultivate effective and sustainable problem-solving skills in students.

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AUTHOR CONTRIBUTIONS STATEMENT

All authors contributed significantly to the development of this research. Author 1 was responsible for conceptualizing the study, designing the methodology, and leading the data collection and analysis process. Authors 2 and 3 provided critical input in the interpretation of the data, contributed to the literature review, and assisted in drafting the manuscript. Both authors reviewed and approved the final version of the manuscript. Author 4 played a crucial role in assisting with the research fieldwork. All authors reviewed and approved the final version of the manuscript.

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