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Can Metaphorical Thinking Learning Model Enhance Students' Mathematical Literacy in Area Conservation?

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Abstract

Primary students often face challenges with mathematical literacy. One practical approach to overcoming these challenges is the metaphorical thinking learning model, which utilizes metaphors to help students better visualize and grasp mathematical concepts. This study seeks to determine the impact of the metaphorical thinking learning model on students' mathematical literacy, particularly in the context of area conservation. For this research, we adopted a post-test-only control group design involving experimental and control groups with fourth-grade students. Participants were selected using a simple random sampling method. We collected data through a testing instrument designed to evaluate the students' mathematical literacy skills. The analysis used an independent t-test, preceded by normality and homogeneity tests, to ensure the data met the necessary prerequisites. The findings revealed a significant difference in mean scores, with the significance value falling below 0.05. This indicates that the metaphorical thinking learning model positively influences students' mathematical literacy. The results emphasize the model's effectiveness in enhancing the mathematical literacy of primary students. Furthermore, this study substantially affects various aspects of mathematical literacy. The areas most notably improved include the ability to formulate mathematical situations, followed by employing concepts, facts, procedures, and reasoning. The least affected aspects were interpreting, applying, and evaluating mathematical outcomes.

INTRODUCTION

Mathematical literacy refers to an individual's skills to formulate, apply, and understand mathematical facts, concepts, and procedures in real-world contexts (Martin et al., 2023; Maysarah et al., 2023; OECD, 2023). In the context of problem-solving, mathematical literacy requires students to not only be able to master the material, but students can successfully use mathematical knowledge in solving everyday problems (Almarashdi & Jarrah, 2022). Therefore, students with adequate mathematical literacy are expected to describe, explain, and predict everyday phenomena logically to make the right decisions (Fanggidae et al., 2024; Üredi & Doğanay, 2023). Therefore, students are expected to have adequate mathematical literacy so that they can not only problem-solve but also use knowledge of mathematics meaningfully to be critical in solving their problems.

For primary students, mathematical literacy is not only limited to counting skills and recognizing mathematics in the abstract but also using basic mathematical concepts logically and more concretely to make decisions in solving real-world problems (Erria et al., 2023; Purwanti & Mujiasih, 2021; Tasman et al., 2022). Mathematical literacy allows primary students to practice communicating mathematical ideas verbally and in writing (Iswara et al., 2022). A strong mathematical literacy foundation for primary students can support cognitive development that leads to higher-order thinking skills, including problem-solving (Topal & Yenmez, 2024), critical thinking (Dhianti Haeruman et al., 2024), and creative thinking (Kontrová et al., 2021). Therefore, the need for mathematical literacy for primary students is to recognize and use mathematical knowledge meaningfully from an early age to succeed in using higher-order thinking skills at the next level, especially in their lives.

In Indonesia, the curriculum that embodies mathematical literacy is the independent curriculum (Fachrudin, 2022). Mathematical literacy in primary school curriculum is important in reformation and education development. (Sujatha & Vinayakan, 2022). In this, mathematical literacy is known as numeracy literacy (Utami & Amir, 2023). Numeracy literacy has an identical goal to mathematical literacy, which is to equip students to have individual skills and knowledge to apply concepts and interpret quantitative information in everyday life (Han et al., 2017). Numeracy literacy or mathematical literacy has the content, context, and process of a problem. The process is assessed based on formulating, employing, interpreting, and evaluating a problem-solving (Fachrudin, 2022). In primary education, the assessment of mathematical literacy for primary students is usually done through various methods, such as written tests, minimum competency assessment, and observation in a project-based or problem-solving learning (Muna & Fathurrahman, 2023).

Area conservation refers to a specific quantitative value of a particular shape area that does not change even after the area is changed (Ekawati et al., 2019). In the independent curriculum, the area conservation is in the material area measurement cluster (Han et al., 2017). Concerning problem-solving-based area conservation by primary students, primary students conserve area by reorganizing the area sections of a flat plane to another flat plane without changing the total area, which is done in various ways (Sari & Fong, 2022). To solve this, primary students need to integrate concepts, formulas, and area partitions (Nisa' & Ekawati, 2019; Wickstrom et al., 2017). This kind of solution to mathematical literacy will require formulating, employing, interpreting, and evaluating a problem-solving process (Fachrudin, 2022). Therefore, area conservation is important for primary students in terms of practicing the concept of area in depth because students need to logically partition the area sections of a flat plane into other flat planes without changing the area.

Although mathematical literacy and area conservation are important for primary students, based on previous study findings, both are still experiencing problems. Students' mathematical literacy in Indonesia is still low, as seen from the Programme for International Student Assessment (PISA) results from 2000 to 2018 (Murtadlo et al., 2023; Tasman et al., 2022). Students had difficulties in finding divergent solutions during the formulating, employing, and interpreting process (Utami & Amir, 2023). Low mathematical literacy is caused by several factors, including failure to use logical reasoning in various contexts (Murtadlo et al., 2023), low concept understanding, and failure to find problem-solving strategies (Iswara et al., 2022; Putra & Mukhtar, 2022; Supriatna et al., 2022; Vitantri & Syafrudin, 2022). Regarding area conservation, most students experience difficulties elaborating on the problem, and the solution still focuses on procedural formulas. In this, students cannot see that decomposing a shape into other shapes will make the shape's area invariant (Ekawati et al., 2019). In this, students often fail to integrate concepts, formulas, and area partitions (Fadilah et al., 2019).

Metaphors refer to more concrete analogies to connect more abstract concepts (Troyer & McRae, 2022). One of the learnings that has metaphoric characteristics is the metaphorical thinking learning model. Previous studies confirmed that metaphors in metaphorical thinking learning could enhance mathematics achievement (Pantaleon et al., 2024; Purba & Sirait, 2024). Concerning the problem of low mathematical literacy and area conservation, the researcher suspects that metaphors in metaphorical thinking can also improve it. This can be approached from the opinion of (Usmadi et al., 2023), regarding metaphorical thinking learning activities and mathematical literacy aspects in terms of formulating, using, and interpreting (OECD, 2023). In formulating, metaphors help students change real situations into mathematical models that are easier to understand. For example, by likening area to "the amount of space occupied," students can understand that even if the shape of an object changes, its area remains the same. In employing, metaphors can enhance students' mathematical reasoning skills by linking new concepts with familiar experiences. For example, likening the process of dividing a geometric shape to cutting a cake into sections helps students understand that the total area does not change even if the shape is changed. In interpreting, by understanding that the area remains constant even though the shape changes, students can be more critical in evaluating the calculation results and implementation in real situations.

Unfortunately, no study has examined the implementation of a metaphorical thinking learning model for mathematical literacy for primary students. Existing related studies are still conducted separately. In this case, they can be categorized into two groups. The first group studied the metaphorical thinking learning model, but it did not affect mathematical literacy in area conservation. Among them are studies on metaphorical thinking learning models for mathematical communication skills (Purba & Sirait, 2024), mathematical reasoning (Endra & Villaflor, 2024; Lestari & Andinny, 2020), mathematical disposition (Deal et al., 2024), mathematical learning achievement (Usmadi et al., 2023), higher-order thinking (Rahmawati et al., 2022; Syahida Zahro, 2022), problem-solving and mathematical resiliency (Fransiska et al., 2022), and mathematics learning interest (Febriyanti & Putra, 2020). The second group studied metaphorical thinking learning models related to mathematical literacy but not related to area conservation and existed at the middle and high school levels. Among them is a study of mathematical literacy on trigonometry material in senior high school (Hanifah, 2021) and mathematical literacy in arithmetic materials in junior high school (Yanto & Wardono, 2021).

Based on the above studies, there is a gap study; namely, no study analyzes the effect of metaphorical thinking learning on mathematical literacy in the area of conservation for primary students. The only existing study is the implementation of metaphorical thinking learning other than mathematical literacy in the area of conservation or metaphorical thinking learning involving middle or high school level. On the other hand, the exploration of mathematical literacy in terms of formulating, employing, and interpreting for primary students is needed to identify weaknesses and advantages in problem-solving (Utami & Amir, 2023). Therefore, the formulation of this study is about how metaphorical thinking learning can affect primary students' mathematical literacy in area conservation for primary students and how this affects mathematical literacy aspects, more specifically in terms of formulating, employing, and interpreting. Thus, this study aims to evaluate the impact of the metaphorical thinking learning model on primary students' mathematical literacy, specifically in the context of area conservation, by analyzing improvements in their ability to formulate, employ, and interpret mathematical concepts. Finally, this study is expected to provide alternative learning to enhance mathematical literacy and provide important findings on which aspects can be significantly improved, especially in teaching area conservation materials.

METHODS

This study used experimental methods with a post-test-only control group design presented in Table 1. The post-test-only control group design was implemented using two groups, experimental and control (Creswell & Creswell, 2018). The experiment class used the metaphorical thinking learning model, while the control class used the conventional learning model. The experimental group was taught using the metaphorical thinking learning model for four weeks, with two lessons per week, each lasting 90 minutes. The learning materials included real-world metaphors, such as comparing area measurement with building puzzles and standardized and non-standardized measuring tools. The teacher guided students through metaphorical reasoning using structured worksheets.

Table 1. Post-test Only Control Design

Group	Treatment	Post-test
Experiment	X	O1
Control	-	O2

Source: (Creswell & Creswell, 2018)

Description:
X = Treatment using a metaphorical thinking learning model
O1 = Post-test experiment class
O2 = Post-test control class

This study implements a metaphorical thinking learning model using a six-stage adapted from a Usmadi et al. (2023), that is, connect, relate, explore, analyze, transform, and experience. Connect refers to learning activities connecting two or more different things, objects, or concepts. Relate refers to learning activities that connect new concepts with previously acquired knowledge. Explore refers to a learning activity explaining the similarities between several concepts and designing a model representing the concept. Analyze refers to the learning activity that analyzes the things that have been designed. Transform refers to the learning activity with one concept based on the previous step to conclude. Experience refers to the learning activity of applying the finding results obtained as a new concept.

The adaptation towards the metaphorical thinking learning model activity is to design learning activities to support the development of students' mathematical literacy process, especially in the area of conservation material. The mathematical literacy process is focused on formulating, employing, and interpreting (OECD, 2023). Formulating refers to formulating situations that occur in everyday life into problems that can be solved mathematically. Employing refers to using concepts, facts, procedures, and mathematical reasoning for problem-solving that is formulated mathematically in order to get a mathematical conclusion. Interpreting refers to interpreting, applying, and evaluating mathematics results in the context of real-life problems. In this process, students reflect on mathematical outcomes and then communicate explanations and arguments in the context of the problem. Table 2 shows the activity of the metaphorical thinking learning model that is integrated with the process of teaching mathematical literacy in material area conservation.

Table 2. Integration and activity of metaphorical thinking learning model based on mathematical literacy

Integration of metaphorical thinking learning and mathematical literacy	Metaphorical thinking learning activity based on mathematical literacy in area conservation
Connect-Formulating	– The teacher starts by showing two objects with different shapes but the same area (for example, a rectangle and a triangle). – Students are asked to connect concept areas with everyday experiences, such as comparing the desk area with the whiteboard area. – Students discuss whether changing shape influences the area of an object. – Teacher guides students in formulating mathematics problems based on real situations (e.g., "How can we ensure the area stays the same even if the shape changes?").
Relate-Formulating	– Students connect previously learned concept areas with new problems in area conservation. – The teacher gives examples of calculation areas with various geometric shapes and asks students to compare the results. – Students hypothesize about how areas remain constant even when shape changes.
Explore-Employing	– Students explore by cutting and reassembling geometric shapes to understand the concept of area conservation. – The teacher assigns students to look for patterns of similarity between the areas of the changed shapes. – Students design a mathematics model using the area formula to prove that the area remains the same after shape transformation.
Analyze-Employing	– Students analyze the model they have created to ensure that the area remains the same after the shape change.

	– Students using area formulas and geometry principles to prove mathematically that transformations do not change the area. – Class discussions are conducted to compare analysis results and correct errors in calculation or modeling.
Transform-Interpreting	– Students conclude how the area remains constant even though the shape changes. – Students evaluating whether the method used is effective in proving area conservation. – Students construct mathematics arguments based on their analysis.
Experience-Interpreting	– Students implement concept area conservation in real-life situations, for example, by designing tile layout patterns or folding paper. – Students communicate and explain their findings to classmates through a presentation or written report. – The teacher provides a real-world problem scenario where students must apply the concept of area conservation to find a solution.

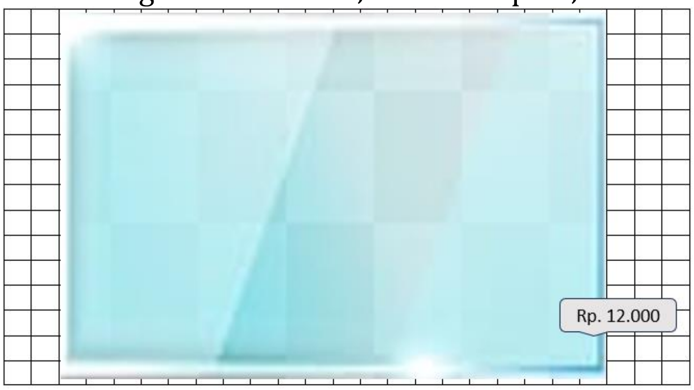
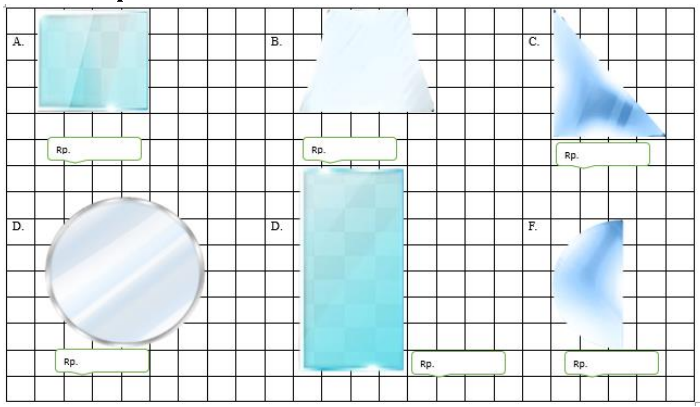
Source: (OECD, 2023: Usmadi et al., 2023)

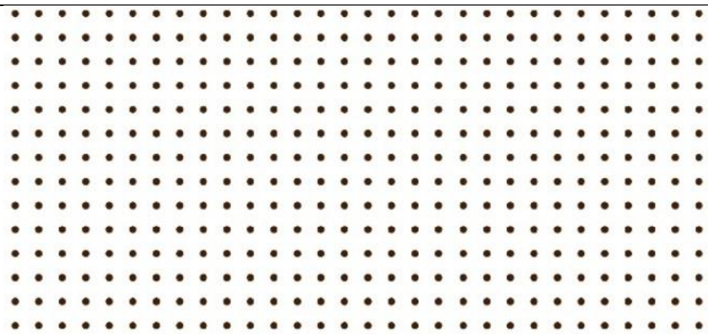
Samples were collected using a simple random sampling technique to provide equal opportunity for each student in the population to be selected as research samples (Creswell & Creswell, 2018). Therefore, the selection of samples is done randomly so that the study results are more objective and not impacted by subjective factors. Research samples were 50 out of 85 fourth-grade students in Sidoarjo City. The sample size was determined using the Slovin formula with an error rate of 10%, resulting in 46 students as the minimum sample criteria. This is because 50 students confirmed their willingness to participate in the study. In this, according to Creswell and Creswell (2018), the more sample members who participate, the more representative the sample size will be of the population. Therefore, the sample determined in this study was 50 students.

The mathematical literacy test (ToML) is the instrument to measure mathematical literacy. ToML is based on mathematical literacy indicators by OECD (2023), in terms of formulating situations mathematically, employing concepts, facts, procedures, and mathematical reasoning, and interpreting, applying, and evaluating mathematical outcomes. In this, ToML consists of 2 essay problems about content area conservation adapted from Ekawati et al. (2019). Problem 1 on area measurement of the plane by presenting the area formula first before students decide to find another strategy for a piece of the plane. Problem 2 is about plane area measurement, which involves instructing students to draw planes with the same area but different shapes in area conservation.

Before use, ToML was checked for validity and reliability. The validity test uses the provisions of the 5% level; if the significance value (is more than 0.05), then the data is declared valid, and vice versa. Meanwhile, the reliability test uses Cronbach's alpha value; if Cronbach's alpha value (is more than 0.6), the data is declared reliable. Based on the test results that have been carried out, the validity test of the six items gets a significance value (more than 0.05), so the test instrument data is declared valid. Meanwhile, the reliability test results get a Cronbach's alpha value of 0.885> 0.6, so the data is declared reliable. ToML used in this study is presented in Table 3.

Table 3. Test of Mathematical Literacy

Problems	Description
1	His uncle tasked Ali to give appropriate price tags to the glass he would sell. His uncle gives a standard price for a piece of glass rectangle measuring 20 cm x 15 cm, which is Rp 12,000.  For each of the following glass pieces, provide price tags that match the price column provided.  a. How to solve the problem above? b. Write down your solution steps below! c. What is the final calculation result of the problem above?
2	Draw two plane images that have the same area but different shapes. After that, state the relationship between the two shapes. a. Draw the two figures above in the column below!



b. Check the area relationship to be the same between the two figures above!
c. What is the final calculation result of the problem above?

Data collection through techniques, namely tests. After applying the learning model, the test technique gave ToML to the experiment and control classes. The test is presented in the form of a post-test. Students' mathematical literacy data were assessed based on a scoring rubric adapted from three aspects of mathematical literacy OECD (2023), namely formulating, employing, and interpreting. Table 4 shows the scoring rubric to assess students' mathematical literacy.

Table 4. Mathematical Literacy Rubric

Aspects	Description	Score
Formulating Situations Mathematically	Identifying the problem, using accurate visual representations, and connecting with previous concepts correctly.	4
	Although there are a few mistakes, identifying the problem well, using enough visual representations, and connecting with previous concepts.	3
	Identifying the problem in general but less precisely in visual representation or connection with previous concepts.	2
	Unable to identify the problem correctly, inappropriate visual representation, and not connecting concepts correctly.	1
Employing Concepts, Facts, Procedures, and Mathematical Reasoning	Applying the concept area correctly using appropriate procedures and developing problem-solving strategies logically and coherently.	4
	The area concept is applied well, although there are a few procedural errors or problem-solving logic.	3
	Applying the concept area, there are still many unclear errors in procedures or strategies.	2
	The area concept cannot be applied correctly, and the problem-solving strategy is not logical.	1

Interpreting, Applying, and Evaluating Mathematical Outcomes	Explaining the solution clearly with correct terms, evaluating the solution with strong arguments, and appropriately connecting the results to the actual context.	4
	Explaining the solution well, but there are slight errors in evaluating the solution, which lacks depth.	3
	Explaining the solution generally, but there are many shortcomings in evaluation and connecting to real context.	2
	Unable to explain the solution correctly, not evaluating the result, and not connecting it to the actual context.	1

Source: (Norrahman, 2021)

The study was carried out in five stages: preparation, implementation of experiment class, control class, test, and data analysis. The preparation stage includes (1) a literature review on metaphorical thinking, mathematical literacy, and area conservation; (2) making and testing the validity of mathematical literacy test; (3) determining the population, sample, and sample size, which is 50 fourth grade students; (4) agreeing on research time and teachers with the school. The research time was 4 weeks, with 1 week of 2 meetings, so the total implementation in the experimental and control classes was eight meetings, with one meeting lasting 90 minutes. The teacher was conducted by the researcher in the experiment class and control class to minimize the teacher differences variable.

The implementation stage of the experiment class was carried out through the six syntaxes of the metaphorical thinking learning model, including: (1) In the first and second meetings (Connect & Relate), students were introduced to the concept of area conservation by comparing two shapes with the same area and connecting the concept with previous experience; (2) In the third and fourth meetings (Explore & Analyze), students explored the concept by cutting and rearranging the shape puzzle and analyzing the exploration results using mathematical principles; (3) In the fifth and sixth meetings (Transform), students draw conclusions based on their analysis and evaluate the effectiveness of the method used; (4) Finally, in the seventh and eighth meetings (Experience), students apply the concept of area conservation in real problems, such as tile layout design, and present their finding results.

The implementation stage of the control class was carried out through conventional learning with lecture methods and problem exercises. (1) The teacher explained the area formula directly, and then students worked on problems without active exploration, discussion, or deep reflection. (2) Learning focuses more on procedural problem-solving than conceptual understanding. The next stage was the test, which was conducted in one 90-minute session at the last meeting. All students from both classes took the mathematics test (post-test), which measured mathematical literacy in concept area conservation. The last stage is data analysis.

Data analysis is done descriptively and inferentially based on mathematical literacy test data assessed based on the scoring rubric.

Data analysis techniques are carried out through prerequisite tests and main tests. Prerequisite tests include normality tests and homogeneity tests. The main test was conducted through descriptive and independent t-tests. A normality test (Shapiro Wilk) was used to determine customarily distributed data, and a homogeneity test used Levene's method to determine the variance similarity between the two classes. The normality test uses the provisions of the 5% significance level; if the significant value >0.05, then the data is usually distributed, and the homogeneity test uses the provisions of the significance level >0.05, then the data is homogeneously distributed.

Descriptive analysis was done by calculating the mean value and visualizing it as a bar chart. In addition, the effect size was calculated. The effect size test is used to measure the magnitude of the effect after treatment. The effect size test uses Cohen's formula with the effect size (ES) value criteria, namely 0.0≤ES≤0.2 (low), 0.2≤ES≤ 0.8 (medium), and ES≥0.8 (significant). An Independent t-test is used to determine the impact of the metaphorical thinking learning model on enhancing students' mathematical literacy in an area of conservation and determine the effect of the metaphorical thinking learning model on each mathematical literacy indicator. With the provisions of using a 5% significance level, if the significant value (2-tailed) <0.05, there is a significant difference, meaning that hypothesis H0 is rejected and Ha is accepted and vice versa.

RESULTS

This study used data analysis techniques, including the normality test, homogeneity test, descriptive statistics, and independent t-test, to test the difference in post-test results between the experiment and control classes. The analysis results of each test are presented as follows.

1. Normality Test Results

Normality test was conducted using IBM SPSS Statistics 26 software toward students' mathematical literacy data. The test results are in detail in Table 5, which presents the significance value (Sig.) for each data type in both classes.

Table 5. Normality Test Results with One-Sample Shapiro Wilk

	Shapiro Wilk		
	Statistic	df	Sig.
Post-test Control	.935	25	.114
Post-test Experiment	.939	25	.141
Liliefors Significance Correction			

Source: IBM SPSS Statistic 26

The significance value of the experiment class post-test is 0.141 (greater than 0.05), so it is normally distributed, while the significance value of the control class post-test is 0.114 (greater than 0.05), so it is normally distributed. This normal distribution is essential to validate further statistical analysis.

2. Homogeneity Test Results

The homogeneity test was conducted using IBM SPSS Statistics 26 software with Levene's method statistic toward students' mathematical literacy data. The results of this test are in detail in Table 6, showing the significance level of students' mathematical literacy post-test scores for both classes.

Table 6. Homogeneity Test Result

Data Type	Sig. Level	Status	Explanation
Experiment dan Control	0.134	> 0.05	homogeneous

Source: IBM SPSS Statistic 26

The significance value of the post-test experiment class and control class is 0.134 (greater than 0.05). This provides that the post-test data for mathematical literacy is homogeneously distributed. Equality of variance determines that both classes provide the same variability in mathematics performance and can analyze statistics more accurately and validly.

3. Descriptive Statistics Results, Effect Size Results, and Visualizations

Descriptive statistics results include mean, standard deviation, effect size, and visualization. Descriptive statistics were tested using IBM Statistics 26 towards students' mathematical literacy data. Meanwhile, the effect size was tested using Cohen's d formula. The test results are in detail in Table 7, which shows the effect size criteria for students' mathematical literacy post-test scores based on the two groups.

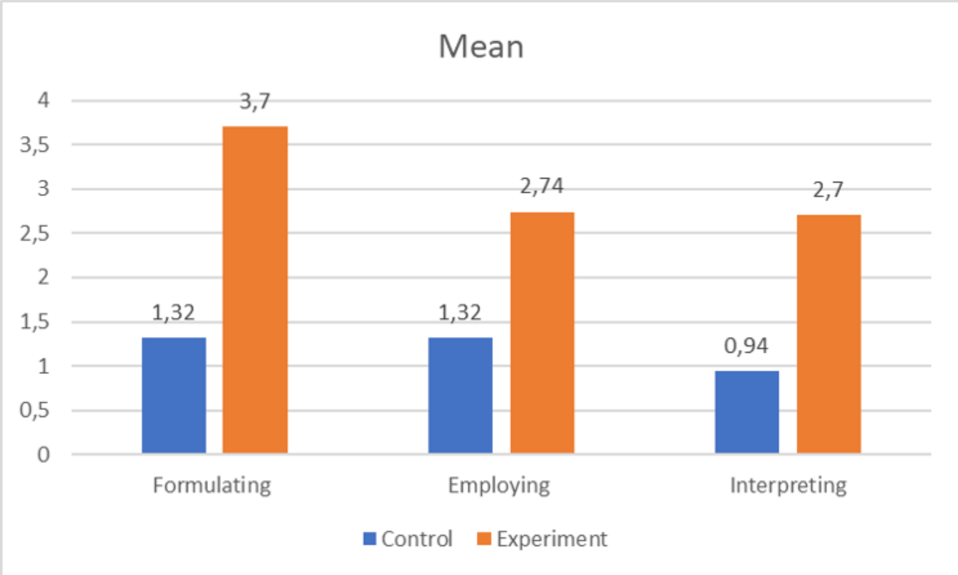
Table 7. Descriptive Statistic and Effect Size Result

Group	N	Mean	Std. deviation	Effect Size Value	Criterion
Experiment class	25	18.28	3.781	3.451	Besar
Control class	25	7.16	2.544		

Source: IBM SPSS Statistic 26

The results of the descriptive statistical analysis of the ToML experiment class after implementing the metaphorical thinking learning model gave a mean post-test score of 18.28 with an accuracy of 76%. In contrast, the conventional class gave a mean post-test score of 7.16 with an accuracy of 30%. In other words, the mean value of the experiment class is higher than the conventional class. In addition, the standard deviation value of each class shows that the data spreads quite far from the

Mean, with a standard deviation of 2.544 for the experiment class and a standard deviation of 3.781 for the control class. The descriptive statistical analysis results of effect size show a value of 3.451 ≥ 0.8. Based on Cohen's criteria,≥ 0.8 is the big criterion. This shows that the metaphorical thinking learning model has a big effect on students' mathematical literacy compared to conventional learning.



Source: IBM SPSS Statistic 26

Figure 1. Visualization of differences in scores on mathematical literacy aspects

Figure 1 visually presents the differences in mean values in the mathematical literacy aspects of formulating, employing, and interpreting. In formulating, the experiment and control classes show a mean value of 3.7 and 1.32, while in employing, the experiment and control, respectively, show a mean value of 2.74 and 1.32. While interpreting, the experiment and control classes show a mean value of 2.7. This shows that there is enhancing in the aspect of mathematical literacy in the experiment class. Thus, visually, there is a higher enhancement of students' mathematical literacy in the metaphorical thinking learning model than in the conventional learning model. The greatest enhancement occurs in formulating; the next lowest consecutive ones are employing and interpreting.

4. Hypothesis Test Results

Independent t-tests were conducted using IBM SPSS Statistics 26 software toward the students' mathematical literacy data. The results of this test are shown in detail in Table 8, showing the significance level of students' mathematical literacy post-test scores for both classes.

Table 8. Independent t-Test Result

Group	Sig (2-tailed)	t-count	t-table	Result
Experiment class and control class	.000	12.201	1.677	H0 Rejected

Source: IBM SPSS Statistic 26

The significance value of the post-test experiment class and control class is 0.000 (smaller than 0.05). The null hypothesis (H0) is firmly rejected, while the alternative hypothesis (Ha) is accepted. These results show a statistically significant enhancement in students' mathematical literacy in those who participated in the metaphorical thinking learning model compared to students who followed the conventional learning model. This result underlines the impact of the metaphorical thinking learning model in enhancing students' mathematical literacy. To present the significance of the impact of the metaphorical thinking learning model on mathematical literacy aspects in more detail, the significance of the three aspects of mathematical literacy is analyzed in Table 9.

Table 9. Hypothesis test results for aspects of mathematical literacy

Group	Aspect of Mathematical Literacy	Sig. (2-tailed)	Result
Experiment class and control class	Formulating	.000	H0 Rejected
	Employing	.000	H0 Rejected
	Interpreting	.000	H0 Rejected

Source: IBM SPSS Statistic 26

The independent test results on three aspects of the mathematical literacy experiment class and control class are different. The significance value of the three mathematical literacy processes is 0.000 (less than 0.05). Thus, the null hypothesis (H0) is firmly rejected, while the alternative hypothesis (Ha) is accepted. This shows that all aspects of mathematical literacy in terms of formulating, employing, and interpreting are significant by the metaphorical thinking model.

DISCUSSION

This study found that the metaphorical thinking learning model significantly affects students' mathematical literacy in primary school with a big effect category. Because no study matches this study, no previous findings are the same. Nonetheless, some study findings can be said to be similar. For example, Hasnarika's (2022) research found that the metaphorical thinking approach significantly enhances middle school students' mathematical representation. Another study by Abdillah et al. (2023) found that the metaphorical thinking approach positively affects mathematical critical thinking, an important component of mathematical literacy.

This study found that the metaphorical thinking learning model significantly affected mathematical literacy aspects such as formulating, applying, and interpreting. In this, the biggest effect was in formulating situations mathematically, followed by applying mathematical concepts, facts, procedures, and reasoning, and the lowest in interpreting, applying, and evaluating mathematical results. A study by Hasnarika (2022) also, the metaphorical thinking approach can enhance students' mathematical representations related to mathematically formulating situations. In addition, the study by Abdillah et al. (2023) showed that the metaphorical thinking approach can enhance students' mathematical critical thinking, including applying mathematical concepts and procedures. These findings are consistent with our research results, which show that the metaphorical thinking learning model significantly affects various aspects of mathematical literacy, with the greatest effect on formulating situations mathematically.

The significance of the effect of the mathematical literacy aspect is inseparable from each stage of the metaphorical thinking learning model. In the connect stage, students are invited to connect two or more different objects or concepts, which can significantly facilitate formulating skills in mathematical literacy. For example, students can be asked to relate the concept of flat plane area to real situations, such as calculating the garden area or room floor. This approach helps students understand mathematical concepts in a context that is relevant to everyday life, making it easier for them to formulate situations mathematically (Makrufah & Fiangga, 2021). Then, in the Relate stage, students relate the new concept to their pre-existing knowledge, which can facilitate formulating skills. By connecting new concepts with existing knowledge, students can more easily formulate mathematically complex situations (Bernard & Senjayawati, 2019).

The explore stage allows students to explore the similarities between several concepts and design models that represent these concepts, thus facilitating skill employment. For example, students can explore the relationship between different flat plane shapes and design models to calculate their areas. This process helps students apply concepts, facts, procedures, and mathematical reasoning in solving problems that support skill employment (Bernard & Senjayawati, 2019). At the Analyze stage, students analyze the model or concept designed to solve the problem, which can facilitate skill employment. By analyzing the model, students can assess the effectiveness of their approach and make necessary adjustments. This is important in applying mathematical concepts, facts, procedures, and reasoning (Makrufah & Fiangga, 2021).

At the transform stage, students make conclusions from the analysis that has been done, which can facilitate interpreting skills. By making conclusions, students can interpret mathematical results and understand their implications in the context of the problem. This stage is important for developing the skills of interpreting, applying, and evaluating mathematical results (Makrufah & Fiangga, 2021). Finally, In the Experience stage, students apply the findings obtained as new concepts in different situations, which can facilitate interpreting skills. By applying learned concepts in new contexts, students can strengthen their understanding and enhance their skills in interpreting mathematical concepts (Setiawan et al., 2018).

The Metaphorical Thinking Learning Model is aligned with the theory of Constructivism and Conceptual Metaphor Theory. Constructivism states that learners construct knowledge through experience and reflection, emphasizing active involvement in the learning process (Prideaux, 2007). Therefore, this model encourages students to connect new mathematical concepts with their familiar experiences, thus facilitating deeper understanding. This is also under Conceptual Metaphor Theory, where individuals understand abstract ideas by relating them to concrete experiences (Sundary et al., 2020). In this case, integrating metaphors in mathematics learning can help students relate abstract concepts to real-world situations, making learning more accessible and meaningful (Febriyanti & Putra, 2020).

The results of this study suggest that metaphors, as the main characteristic of metaphorical thinking, can be used by teachers as a strategy in learning to enhance students' mathematical literacy. Metaphors bridge the gap between abstract mathematical concepts and students' prior knowledge, making learning more relevant (Sundary et al., 2020). For example, comparing the concept of area to a "puzzle" concretizes students' mathematical knowledge. This strategy is in line with the idea that metaphors facilitate the understanding of new information by connecting it to familiar experiences (Usmadi et al., 2023). In this, metaphors function as cognitive tools that assist students in organizing and structuring mathematical knowledge (Falani et al., 2023). In the end, it is hoped that the metaphor strategy in learning can awaken the imagination so that it can also enhance their interest in mathematics (Febriyanti & Putra, 2020).

This study has several practical, theoretical, and policy contribution implications. These implications are based on the novelty value of this study compared to previous study results. This study provides a comprehensive overview of analyzing the significance of the effects of metaphorical thinking learning on enhancing the three components of mathematical literacy, especially at the primary school level. Other studies have not previously examined the same, so it is a novelty to facilitate three mathematical literacy processes: formulating, employing, and interpreting. In this, there is interaction with connecting, relating, exploring, analyzing, transforming, and experiencing activities. Formulating occurs in connecting and relating activities; Employing occurs in exploring and analyzing activities; Meanwhile Interpreting occurs in Transform and Experience. The practical implication for teachers is to provide alternative learning, namely through a metaphorical thinking learning model that can enhance mathematical literacy. On the other hand, the theoretical implications still need to be further elaborated, namely, adding empirical evidence that analogy-based learning models can stimulate the mathematical literacy process.

Regarding the policy implications, metaphorical thinking learning can be one of the learning considerations that can be integrated into the primary school curriculum. Integrating metaphorical thinking learning into the primary school curriculum can be done through concrete examples at each stage. At the connect stage, the teacher can ask students to connect the concept area with everyday objects, such as comparing the surface of a book with a tablet screen. In the related stage, students can relate their prior knowledge of multiplication to the calculation area, strengthening their understanding. In the explore stage, students can investigate different shapes and their areas by making models using paper charts, making the learning more experience-based. In the analysis stage, students can compare the areas of various objects in the classroom, encouraging critical thinking. In the transformation stage, students can apply their understanding by designing a simple floor plan and integrating math concepts creatively. Finally, at the Experience stage, students can present their designs and reflect on their learning process. This activity is aligned with the stages of the metaphorical thinking learning model and can be easily integrated into the primary school curriculum to enhance mathematical literacy.

The findings of this research are not only limited to primary schools in Indonesia but also to the global education system. The success of the metaphorical thinking learning model in enhancing mathematical literacy shows its potential to be applied in a variety of more general educational contexts. The integration of metaphorical thinking in mathematics teaching can help overcome the common challenge of understanding abstract concepts, a concern for many educators in various countries (Usmadi et al., 2023). Of course, the implications of this research are not only limited to the primary school level in Indonesia but also to the global education system. The success of the metaphorical thinking learning model in enhancing mathematical literacy shows its potential to be applied in a variety of more general educational contexts. The integration of metaphorical thinking in mathematics teaching can help overcome the common challenge of understanding abstract concepts, which is a concern for many educators in various countries.

CONCLUSION

This study demonstrates that metaphorical thinking significantly enhances mathematical literacy by improving students' ability to formulate, employ, and interpret mathematical concepts. These findings highlight the importance of integrating metaphor-based teaching strategies in primary education to make abstract mathematical concepts more accessible. Therefore, the metaphorical thinking learning model can be a solution to the low mathematical literacy of primary students, especially in the area of conservation. These findings fill the gap left by previous studies that no study comprehensively analyzes the effects of metaphorical thinking learning on each component of mathematical literacy in terms of formulating, employing, and interpreting.

The practical implication for teachers is to consider alternative learning through metaphors to enhance mathematical literacy. Meanwhile, the theoretical implication is to add empirical evidence that the analogy-based learning model can stimulate the mathematical literacy process. Although the study controlled for baseline differences through randomization, potential confounding factors such as prior mathematical knowledge, teacher differences, and classroom environment may have influenced the outcomes. Future studies should consider a pre-test to better control for these variables. On the other hand, the significance of mathematical literacy also needs to be tested by involving students other than primary school students and other than the topic area conservation to generalize the implementation of the effect of the metaphorical thinking learning model.

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