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# Evaluating the M6 learning model and realistic mathematics education (RME) approach in enhancing critical thinking skills in mathematics: A focus on students' logical-mathematical intelligence

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**Abstract**

**Background**: Critical thinking skills are essential in the 21st century; however, Indonesian students often show low critical thinking abilities in mathematics. This issue arises partly from limited use of instructional methods that foster critical thinking among junior high school students.

**Aim**: This study aims to assess the effectiveness of the M6 learning model and Realistic Mathematics Education (RME) in enhancing students' critical thinking abilities in mathematics, considering their levels of logical-mathematical intelligence.

**Method**: A quasi-experimental design was employed with a sample of 318 seventh-grade students from State Middle Schools in Cirebon Regency in the 2023/2024 academic year. Stratified cluster random sampling produced three groups: 107 students in the first experimental group, 105 in the second, and 106 in the control group. Instruments included a critical mathematical thinking skills test and a logical-mathematical intelligence test, with hypothesis testing conducted using two-way analysis of variance with unequal cells.

**Results**: The analysis revealed significant differences in students' critical thinking abilities based on the learning model and logical-mathematical intelligence levels, with notable interactions between these variables.

**Conclusion**: The study concludes that the M6 and RME learning models influence critical mathematical thinking skills differently across logical-mathematical intelligence categories. These findings underscore the importance of aligning instructional models with students' intelligence profiles to optimize learning outcomes in critical thinking.

## INTRODUCTION

Critical thinking skills are essential in the 21st century, particularly in mathematics, as they enable students to solve complex problems, deepen understanding, and foster creativity, ultimately leading to sound and valid decisions (Alqahtani & Alsalem, 2023; Basak & Yucel, 2024; Alharbi, 2022; Hazaymeh & Alomery, 2022; Oikonomidis & Sofianopoulou, 2023). Recognizing this, the Indonesian government encourages the integration of critical thinking in mathematics education to better prepare students for future success (Ministry of Education and Culture, 2013). Students with strong critical

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thinking skills gain unique advantages in problem-solving, as these skills facilitate reflective and reasonable judgments by allowing individuals to assess assumptions, uncover hidden values, make predictions, analyze evidence, and evaluate conclusions (Küçükaydın et al., 2023; Yaki, 2022; Lin, 2024; Purwanto et al., 2022). However, Indonesian students' critical thinking abilities in mathematics remain low, as reflected in below-average TIMSS and PISA rankings, affecting junior high students in particular; studies show that almost 70% of these students struggle with critical thinking-based problem-solving tasks (Susandi et al., 2019; Susandi et al., 2020, 2022; Umam & Susandi, 2022). Interviews with teachers suggest that this issue may stem from a predominant use of teacher-centered instructional models, where students are passive and minimally involved, leading to disengagement and limited development of critical thinking skills.

The M6 and Realistic Mathematics Education (RME) learning models are known to actively engage students and enhance critical mathematical thinking. In the M6 model, each phase encourages analytical, evaluative, and inferential skills to improve students' critical thinking abilities in mathematics (Susandi et al., 2020, 2022). Similarly, the RME model promotes independent knowledge construction through relatable, real-world problem-solving, where teachers act as facilitators (Fauzan et al., 2022; Ndiung et al., 2021). This approach often outperforms traditional methods because it aligns with students' daily contexts, making concepts easier to grasp (Suparatulatorn et al., 2023; Wulandari, 2020). Another crucial factor influencing critical mathematical thinking is students' logical-mathematical intelligence. This intelligence, blending logical reasoning with numerical skills, helps students systematically solve problems (Örge Yaşar & Başbayrak, 2023). Students with higher logical-mathematical intelligence typically show persistence with difficult questions, while those with lower levels may seek quick solutions or avoid challenges altogether (Bayram & Keskin, 2019; Xu, 2021).

Several studies have been conducted regarding the M6 learning model and the RME learning model. Research conducted by (Susandi et al., 2022), concluded that the M6 learning model can improve critical thinking skills in mathematics because learning activities require students to develop critical thinking skills in mathematics. The research results of (Kusumaningsih & Herman, 2018), concluded that the RME learning model can improve students' algebra skills because students are given real problems in class learning. Research conducted by (Karaca & Özkaya, 2017), concluded that learning using the RME learning model is better than learning using the classical learning model when viewed from student learning achievement. Research conducted by (Ulandari et al., 2019), concluded that teaching materials based on the RME model can improve mathematical problem solving abilities effectively. Research conducted by Nguyen et al. (2020), concluded that the use of the RME learning model was successful in increasing student learning achievement. Research conducted by Susandi & Widyawati (2022) concluded that the RME learning model was effective in improving the ability to think critically in mathematics. Based on the research mentioned above, it can be concluded that the M6 learning model and the RME learning model can improve various abilities

in mathematics. One of these abilities is the critical thinking skill in mathematics which will be studied in this study.

Based on the research above, no one has researched how the effectiveness of the M6 learning model and the RME learning model is compared when viewed from the perspective of logical mathematical intelligence. In the research above, it only discusses how the M6 learning model and the RME learning model can improve critical mathematical thinking skills without involving logical mathematical intelligence. In fact, logical mathematical intelligence is also important in supporting the development of critical mathematical thinking skills. Therefore, it is necessary to conduct research related to the effectiveness of the M6 learning model and the RME learning model to improve critical thinking skills when viewed from the perspective of logical mathematical intelligence.

## METHODS

### *Design*

This research utilized a quasi-experimental approach structured with a factorial design, chosen due to its suitability for studies where complete control over all variables and full group randomization is impractical. This design allows for testing causal relationships between variables while accommodating real-world limitations commonly encountered in educational research. The independent variables in this study include the learning models—namely the M6 model and Realistic Mathematics Education (RME)—along with students' levels of logical-mathematical intelligence. The dependent variable is the critical thinking ability in mathematics, specifically in analyzing, evaluating, and drawing conclusions.

### *Participants*

The target population for this research comprised all seventh-grade students from junior high schools within Cirebon Regency. To ensure diverse representation, stratified cluster random sampling was employed, dividing students into three categories—high, medium, and low-performing schools—each representing one level within the cluster. This sampling technique yielded a total sample size of 318 students, distributed into three groups: experimental group one with 107 students, experimental group two with 105 students, and a control group consisting of 106 students.

### *Instruments*

Data were gathered using two primary instruments: a logical-mathematical intelligence test and a critical mathematical thinking skills assessment. The logical-mathematical intelligence test comprised 25 multiple-choice questions specifically designed to measure students' reasoning and problem-solving abilities in mathematical contexts. The test items were carefully developed according to established indicators to ensure comprehensive assessment. Meanwhile, the critical mathematical thinking skills test involved two essay-based questions aimed at evaluating students' analytical, evaluative, and inferential abilities in mathematical problem-solving. To gauge students' initial

competencies, documentation was gathered from their first-semester test scores in mathematics, enabling a baseline comparison across groups.

The instruments underwent rigorous testing for validity and reliability. Each item was assessed for content validity, difficulty level, discrimination power, and reliability. Only items meeting the following criteria were included: a difficulty level between 0.3 and 0.7, discrimination power (r_xy) of 0.3 or higher, and reliability (r_11) of 0.7 or higher. Out of 30 items initially tested for the logical-mathematical intelligence assessment, 25 items met these standards and were subsequently included in the final instrument.

### *Data Analysis*

Before testing the hypotheses, data prerequisites were confirmed through several statistical procedures. To establish data normality, the Lilliefors method was applied, while data homogeneity was verified using the Bartlett method. Additionally, a one-way analysis of variance (ANOVA) was conducted to ensure group balance, confirming that the groups shared similar baseline abilities. With these assumptions satisfied, data analysis was conducted using two-way ANOVA with unequal cells to examine the interaction between the learning models and levels of logical-mathematical intelligence on critical mathematical thinking abilities. This analysis was complemented by Scheffe's method for multiple comparisons, allowing for a detailed exploration of differences between the groups and the specific impact of each variable on the outcome measures.

## RESULTS AND DISCUSSION

### *Result*

Based on the results of the normality test and homogeneity test, the mathematical critical thinking ability test data can be said to have a normal and homogeneous distribution. Next, a two-way analysis of variance test was carried out with different cells. A summary of the two-way analysis of variance test with unequal cells is presented in Table 1.

**Table 1.** Summary of Two Way Analysis of Variance with Different Cells

| Source | $JK$ | $dk$ | $RK$ | $F_{obs}$ | $F_{\alpha}$ | Test Decision |
|---|---|---|---|---|---|---|
| Model (A) | 3045,8765 | 2 | 1522,9383 | 11,0283 | 3,00 | $H_0$ rejected |
| KML (B) | 18512,4572 | 2 | 9256,2288 | 67,0284 | 3,00 | $H_0$ rejected |
| Interaction(AB) | 1522,3251 | 4 | 380,5812 | 2,7560 | 2,37 | $H_0$ rejected |
| Galat | 43775,7861 | 317 | 138,0940 | - | - | - |

Based on Table 1, the following conclusions are obtained. (1) there are differences in the influence of learning models on students' critical mathematical thinking abilities; (2) there are differences in the influence of each category of logical mathematical intelligence on students' mathematical critical thinking abilities; (3) there is an interaction between the learning model and logical mathematical intelligence on students' critical mathematical thinking abilities. Based on the results of the variance analysis of two paths with unequal cells, it was found that $H_{0A}$ was rejected, $H_{0B}$ was rejected, and $H_{0AB}$ was rejected. Thus, it is necessary to carry out further tests between rows, further tests

between columns, further tests between cells in the same row, and further tests between cells in the same column. In this research further tests used the Scheffe' method of multiple comparison tests. Before looking at the results of the multiple comparison test, the following is a summary of the inter-cell means complete with marginal means in Table 2.

**Table 2.** Means in Learning Model Cells and Logical Mathematical Intelligence

| Model | Logical Mathematical Intelligence | | | Marginal Mean |
|---|---|---|---|---|
| | High | Middle | Low | |
| M6 | 84,7564 | 77,5674 | 66,2439 | 76,1892 |
| RME | 82,3451 | 75,8760 | 63,3043 | 73,8418 |
| PL | 81,5645 | 64,7865 | 57,5432 | 67,9647 |
| Marginal Mean | 82,2222 | 72,7433 | 62,3638 | |

From the results of the ANOVA calculation, it was found that $H_{0A}$ was rejected, meaning that not all learning models had the same influence on students' mathematical critical thinking abilities. If there are three lines, it is necessary to continue with the Scheffe' test for comparison between lines. The results of the Scheffe' test for comparisons between lines can be summarized in Table 3.

**Table 3.** Multiple Comparison Test Results between Lines

| No. | $H_0$ | $F_{hit}$ | $2.F_{0,05:2:317}$ | Test Decision |
|---|---|---|---|---|
| 1 | $\mu_{1.} = \mu_{2.}$ | 8,7548 | 6,00 | $H_0$ rejected |
| 2 | $\mu_{2.} = \mu_{3.}$ | 8,6574 | 6,00 | $H_0$ rejected |
| 3 | $\mu_{1.} = \mu_{3.}$ | 28,3478 | 6,00 | $H_0$ rejected |

Based on Table 3, the following conclusions are obtained. (1) the M6 learning model produces better mathematical critical thinking skills than the RME learning model. (2) the RME learning model produces better critical thinking skills in mathematics than the direct learning model. (3) the M6 learning model produces better mathematical critical thinking skills than the direct learning model. From the results of the ANOVA calculation, it was found that $H_{0B}$ was rejected, meaning that not all categories of students' logical mathematical intelligence had the same influence on students' mathematical critical thinking abilities. If there are three columns, it is necessary to continue the Scheffe' test for comparison between columns. Scheffe' test results for comparison between columns can be seen in Table 6.

**Table 4.** Multiple Comparison Test Results between Columns

| No. | $H_0$ | $F_{hit}$ | $2.F_{0,05:2:317}$ | Test Decision |
|---|---|---|---|---|
| 1 | $\mu_{.1} = \mu_{.2.}$ | 38,7643 | 6,00 | $H_0$ rejected |
| 2 | $\mu_{.2} = \mu_{.3}$ | 38,2368 | 6,00 | $H_0$ rejected |
| 3 | $\mu_{.1} = \mu_{.3}$ | 160,3498 | 6,00 | $H_0$ rejected |

Based on Table 4, the following conclusions are obtained. (1) students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with moderate logical mathematical intelligence. (2) students with moderate logical mathematical intelligence have better critical mathematical thinking abilities than

students with low logical mathematical intelligence. (3) students with high logical mathematical intelligence have better critical mathematical thinking abilities than students with low logical mathematical intelligence.

From the results of the ANOVA calculation, it was found that $H_{0AB}$ was rejected, meaning that there was an interaction between the learning model and students' logical mathematical intelligence on their ability to think critically in mathematics in data presentation material. Therefore, it is necessary to continue with the Scheffe' test for comparisons between cells in the same row and comparisons between cells in the same column. Scheffe' test results for comparisons between cells in the same row and comparisons between cells in the same column can be seen in Table 5 and Table 6.

**Table 5.** Multiple Comparison Test Results between Cells in the Same Row

| No. | $H_0$ | $F_{hit}$ | 8. $F_{0,05:8:317}$ | Test Decision |
|---|---|---|---|---|
| 1 | $\mu_{11} = \mu_{12}$ | 3,6785 | 15,52 | $H_0$ accepted |
| 2 | $\mu_{12} = \mu_{13}$ | 15,2783 | 15,52 | $H_0$ accepted |
| 3 | $\mu_{11} = \mu_{13}$ | 38,6753 | 15,52 | $H_0$ rejected |
| 4 | $\mu_{21} = \mu_{22}$ | 4,3267 | 15,52 | $H_0$ accepted |
| 5 | $\mu_{22} = \mu_{23}$ | 23,9863 | 15,52 | $H_0$ rejected |
| 6 | $\mu_{21} = \mu_{23}$ | 49,6743 | 15,52 | $H_0$ rejected |
| 7 | $\mu_{31} = \mu_{32}$ | 34,9743 | 15,52 | $H_0$ rejected |
| 8 | $\mu_{32} = \mu_{33}$ | 9,9654 | 15,52 | $H_0$ accepted |
| 9 | $\mu_{31} = \mu_{33}$ | 72,8654 | 15,52 | $H_0$ rejected |

Based on Table 5, the following conclusions are obtained. (1) (a) In the M6 learning model, students with high logical mathematical intelligence have critical thinking skills that are as good as students with moderate logical mathematical intelligence; (b) Students with moderate logical mathematical intelligence produce equally good mathematical critical thinking abilities compared to students with low logical mathematical intelligence; (c) Students with high logical mathematical intelligence have better critical mathematical thinking abilities than students with low logical mathematical intelligence; (2) (a) In the RME learning model, students with high logical mathematical intelligence have equally good mathematical critical thinking skills compared to students with moderate logical mathematical intelligence; (b) Students with moderate logical mathematical intelligence have better critical mathematical thinking abilities than students with low logical mathematical intelligence; (c) Students with high logical mathematical intelligence have better critical mathematical thinking abilities than students with low logical mathematical intelligence; (3) (a) In the direct learning model, students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with moderate logical mathematical intelligence; (b) Students with moderate logical mathematical intelligence have equally good mathematical critical thinking abilities compared to students with low logical mathematical intelligence; (c) Students with high logical mathematical intelligence have better critical mathematical thinking abilities than students with low logical mathematical intelligence.

**Table 6.** Multiple Comparison Test Results between Cells in the Same Column

| No. | $H_0$ | $F_{hit}$ | 8. $F_{0,05:8:355}$ | Test Decision |
|---|---|---|---|---|
| 1 | $\mu_{11} = \mu_{21}$ | 1,2976 | 15,52 | $H_0$ accepted |
| 2 | $\mu_{21} = \mu_{31}$ | 0,5432 | 15,52 | $H_0$ accepted |
| 3 | $\mu_{11} = \mu_{31}$ | 1,2897 | 15,52 | $H_0$ accepted |
| 4 | $\mu_{12} = \mu_{22}$ | 0,8762 | 15,52 | $H_0$ accepted |
| 5 | $\mu_{22} = \mu_{32}$ | 16,3426 | 15,52 | $H_0$ rejected |
| 6 | $\mu_{12} = \mu_{32}$ | 22,7985 | 15,52 | $H_0$ rejected |
| 7 | $\mu_{13} = \mu_{23}$ | 3,7532 | 15,52 | $H_0$ accepted |
| 8 | $\mu_{23} = \mu_{33}$ | 4,9865 | 15,52 | $H_0$ accepted |
| 9 | $\mu_{13} = \mu_{33}$ | 12,6547 | 15,52 | $H_0$ accepted |

Based on Table 6, the following conclusions are obtained. (1) In the category of high logical mathematical intelligence, the M6 learning model, RME learning model, and direct learning model produce equally good mathematical critical thinking abilities. (2) (a) In the moderate logical mathematical intelligence category, students who receive the M6 learning model produce mathematical critical thinking skills that are as good as students who receive the RM learning model; (b) Students who receive the RME learning model produce better critical thinking skills in mathematics than students who receive the direct learning model; (c) Students who receive the M6 learning model produce better critical thinking skills in mathematics than students who receive the direct learning model. (3) In the low logical mathematical intelligence category, the M6 learning model, the RME learning model, and the direct learning model produce equally good mathematical critical thinking abilities.

## *Discussion*

Based on the results of research and hypothesis testing, the following is an explanation of the four research hypotheses.

### *1. First Hypothesis*

From the results of two-way variance analysis calculations with unequal cells, the results showed that there were differences in mathematical critical thinking abilities between students who received the M6 learning model, the RME learning model, and the direct learning model. Furthermore, based on the results of the follow-up test after the two-way ANOVA using the first Scheffe' test, it is in accordance with the initial hypothesis expressed in this research which states that the M6 learning model produces students' mathematical critical thinking skills better than the RME learning model. From the results of the first Scheffe' test, this means that there are differences in students' mathematical critical thinking abilities in the M6 learning model and the RME learning model. This is in accordance with research conducted by (Susandi et al., 2020), which states that the use of the M6 learning model is better than other learning models. More specifically, research conducted by (Susandi et al., 2022), stated that the critical thinking skills in mathematics of students who used the M6 learning model were better than the critical thinking skills in mathematics of students who used other learning models. This is because in the M6 learning model the students are grouped into several groups. Each member in a different group can actively share information with each other regarding the

material being discussed, so that students can gain more scientific information from the learning (Susandi & Widyawati, 2022). This is different from the RME learning model, although groups are formed which make students active, but the students only get less scientific information because students only get information from their group members, not from other group members (Nguyen & Pham, 2023).

Based on the results of the follow-up test after the two-way ANOVA with the second Scheffe' test, it is in accordance with the initial hypothesis expressed in this research which states that the RME learning model produces students' mathematical critical thinking abilities better than the direct learning model. From the results of the second Scheffe' test, this means that there are differences in students' mathematical critical thinking abilities in the RME learning model and the direct learning model. This is because in the RME learning model each student is required to play an active role in carrying out real problem solving in their group so that each student has a good understanding when presenting the results of their discussion in front of the class (Altıner et al., 2023; Susandi & Widyawati, 2022. In contrast to the direct learning model, students only hear, see, and receive knowledge transfer from the teacher so that student activity becomes less because the teacher dominates the learning process in the classroom (Yaghmour & Obaidat, 2022).

Based on the results of the follow-up test after the two-way ANOVA with the first Scheffe' test, it is in accordance with the initial hypothesis expressed in this research which states that the M6 learning model produces students' mathematical critical thinking skills better than the direct learning model. From the results of the third Scheffe' test, this means that there are differences in students' mathematical critical thinking abilities in the M6 learning model and the direct learning model. This is because in the M6 learning model students are required to be active in analyzing, evaluating and concluding activities so that students' mathematical critical thinking skills develop well in learning (Susandi et al., 2022). This is different from the direct learning model where students only get information from the teacher so that students become more passive in learning in class (Sezer, 2024).

### *2. Second Hypothesis*

From the results of two-way variance analysis calculations with unequal cells, it was found that there were differences in the influence between each category of logical mathematical intelligence on students' mathematical critical thinking abilities. In other words, there are differences in mathematical critical thinking abilities between students with high logical mathematical intelligence, students with moderate logical mathematical intelligence, and students with low logical mathematical intelligence. Based on the calculation results from the follow-up test after the two-way ANOVA with the first Scheffe' test, it is in accordance with the initial hypothesis expressed in this research which states that students with high logical mathematical intelligence have better critical mathematical thinking abilities than students with moderate logical mathematical intelligence. From the results of the first Scheffe' test, this means that there are differences in students' mathematical critical thinking abilities between students with

high logical mathematical intelligence and students with moderate logical mathematical intelligence. This is also in accordance with research conducted by (Er, 2023), which states that the mathematical critical thinking abilities of students with high logical mathematical intelligence are better than students with moderate or low logical mathematical intelligence. This is because students with high logical mathematical intelligence tend to be more active in learning in class so that students with high logical mathematical intelligence are able to solve problems quickly and precisely (Al Hosni & Al-Manthari, 2021). It is different for students with moderate logical mathematical intelligence, although they are active in learning in class, but students with moderate logical mathematical intelligence sometimes experience difficulties in solving a problem so that students with moderate logical mathematical intelligence are not always able to solve a problem quickly and precisely (Al Hosni & Al-Manthari, 2021).

Based on the results of the follow-up test after the two-way ANOVA with the second Scheffe' test, it is in accordance with the initial hypothesis expressed in this research which states that students with moderate logical mathematical intelligence have better mathematics learning achievements than students with low logical mathematical intelligence. From the results of the second Scheffe' test, this means that there is a difference in the mathematical critical thinking abilities of students with moderate logical mathematical intelligence and students with low logical mathematical intelligence. This is because students with moderate logical mathematical intelligence tend to be able to solve a problem encountered in learning even though they sometimes encounter difficulties in implementing it, but in the end students with moderate logical mathematical intelligence can solve the problem correctly (Örge Yaşar & Başbayrak, 2023). In contrast, students with low logical mathematical intelligence tend to be passive when learning in class is carried out so that they cannot solve problems encountered in learning quickly and precisely (Örge Yaşar & Başbayrak, 2023).

Based on the results of the follow-up test after the two-way ANOVA with the third Scheffe' test, it is in accordance with the initial hypothesis expressed in this research which states that students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with low logical mathematical intelligence. From the results of the third Scheffe' test, this means that there are differences in the mathematical critical thinking abilities of students with high logical mathematical intelligence and students with low logical mathematical intelligence. This is because students with high logical mathematical intelligence tend to like looking for solutions that involve numbers so they can solve a problem they face in learning, especially problems related to mathematical problems (Meena & Lakshmi, 2023). In contrast, students with low logical mathematical intelligence tend to be passive and do not like looking for solutions that involve numbers so they cannot solve problems they encounter in learning quickly and precisely, especially problems related to mathematics.

### *3. Third Hypothesis*

From the results of two-way variance analysis calculations with unequal cells, it was found that there was an interaction between the learning model and logical mathematical

intelligence on the ability to think critically in mathematics. Based on the results of the average comparison test between lines in each learning model, with a significance level of 0.05, it can be concluded that:

In the M6 learning model, students with high logical mathematical intelligence have mathematical critical thinking skills that are just as good as students with moderate logical mathematical intelligence. This is not in accordance with the research hypothesis which states that in the M6 learning model, students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with moderate logical mathematical intelligence. This hypothesis was not fulfilled because these students were used as a source of information for students with moderate or low logical mathematical intelligence. This makes students with high logical mathematical intelligence not optimal in learning the material because they have to provide information to students with moderate or low logical mathematical intelligence (Örge Yaşar & Başbayrak, 2023). However, students with logical mathematical intelligence are enthusiastic about learning. This is because the learning model used is relatively new so that students are motivated to seek information from other groups, especially seeking information from students who are considered smart in the class, although some students only record the answers they get without asking where the answers came from (Susandi et al., 2022).

Students with moderate logical mathematical intelligence produce critical mathematical thinking skills that are just as good as students with low logical mathematical intelligence. This is not in accordance with the research hypothesis which states that in the M6 learning model, students with moderate logical mathematical intelligence have better mathematical critical thinking abilities than students with low logical mathematical intelligence. This hypothesis was not fulfilled because students with logical mathematical intelligence were enthusiastic in learning to seek information from other groups even though there were some students who only wrote the answers without asking where the answers were obtained (Örge Yaşar & Başbayrak, 2023). However, students with low logical mathematical intelligence in discussions also actively seek information about the material being discussed in learning (Meena & Lakshmi, 2023). Even some students with low logical mathematical intelligence are motivated to ask questions for recorded answers when seeking information from students who are considered smart in class. This is what makes the mathematical critical thinking abilities of students with low logical mathematical intelligence able to compete with students with moderate logical mathematical intelligence. Furthermore, students with high logical mathematical intelligence have better critical mathematical thinking abilities than students with low logical mathematical intelligence. This is in accordance with the research hypothesis which states that in the M6 learning model students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with low logical mathematical intelligence. This hypothesis is fulfilled because students with high logical mathematical intelligence in classroom learning, if seen from their characteristics, are always quick and precise in solving problems, especially problems related to mathematics (Chirove et al., 2022). On the other hand, the

characteristics of students with low logical mathematical intelligence tend to be slow in solving problems, especially problems related to mathematics (Chirove et al., 2022). From this explanation, although students with low logical mathematical intelligence in discussions actively seek information about the material being discussed in the lesson, even some of the students with low logical mathematical intelligence are motivated to ask questions for the answers recorded when looking for information from students who are considered intelligent in class. However, these students have to take a long time to understand the answers they have obtained so they cannot compete with the mathematical critical thinking skills produced by students with high logical mathematical intelligence.

In the RME learning model, students with high logical mathematical intelligence have equally good mathematical critical thinking abilities compared to students with moderate logical mathematical intelligence. This is not in accordance with the research hypothesis which states that in the RME learning model students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with moderate logical mathematical intelligence. This hypothesis was not fulfilled because students with logical mathematical intelligence were playing an active role when working in their respective groups. The ideas presented during presentations in front of the class do not only come from the ideas of students with high logical mathematical intelligence (Susandi & Widyawati, 2022). Students with moderate logical mathematical intelligence also always actively ask questions when working in groups to students with high logical mathematical intelligence so that when presenting in front of the class students with moderate logical mathematical intelligence can also argue as well as students with high logical mathematical intelligence. Students with moderate logical mathematical intelligence have better critical thinking skills than students with low logical mathematical intelligence. This is in accordance with the research hypothesis which states that in the RME learning model students with moderate logical mathematical intelligence have better mathematical critical thinking abilities than students with low logical mathematical intelligence. This hypothesis was fulfilled because some students with low logical mathematical intelligence were not active in group work. Some of these students submitted the results of their group work to students with high or medium logical mathematical intelligence so that during the presentation students with low logical mathematical intelligence just remained silent without giving ideas to the group members. However, students with moderate logical mathematical intelligence are always active in group work and presentations in front of the class. This is what makes students with low logical mathematical intelligence unable to compete with students with moderate logical mathematical intelligence. Students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with low logical mathematical intelligence. This is in accordance with the research hypothesis which states that in the RME learning model students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with low logical mathematical intelligence. This hypothesis was fulfilled because some students with low logical mathematical intelligence were not active in group work. Some of these students submitted all the assignments they received to

students with high or medium logical mathematical intelligence so that during the presentation students with low logical mathematical intelligence just remained silent without giving ideas to group members (Chirove et al., 2022). From this explanation, students with low logical mathematical intelligence tend to dislike problems related to mathematics. However, students with high logical mathematical intelligence are always active in group work and presentations in front of the class. This is what makes students with low logical mathematical intelligence unable to compete with students with high logical mathematical intelligence.

In the direct learning model, students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with moderate logical mathematical intelligence. This is in accordance with the research hypothesis which states that in the direct learning model students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with moderate logical mathematical intelligence. This hypothesis was fulfilled because some students with logical mathematical intelligence were not paying attention when the teacher explained in front of the class. The student even joked with his classmates. In contrast, students with high logical mathematical intelligence concentrate to pay attention when the teacher explains the material in front of the class. In fact, these students actively ask the teacher when asked about material they don't understand. Students with moderate logical mathematical intelligence have critical mathematical thinking skills that are just as good as students with low logical mathematical intelligence. This is not in accordance with the research hypothesis which states that in the direct learning model, students with moderate logical mathematical intelligence have better mathematical critical thinking abilities than students with low logical mathematical intelligence. This hypothesis was not fulfilled because some students with logical mathematical intelligence were not paying attention when the teacher explained in front of the class. The student even joked with his classmates. Another thing is that students with low logical mathematical intelligence concentrate to pay attention when the teacher explains the material in front of the class. These students even actively ask friends who are considered smart in the class about material they don't yet understand. Students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with low logical mathematical intelligence. This is in accordance with the research hypothesis which states that in the direct learning model, students with high logical mathematical intelligence have better mathematical critical thinking abilities than students with low logical mathematical intelligence. This hypothesis was fulfilled because even though students with low logical mathematical intelligence always paid attention to the teacher's explanation. These students even actively ask questions to students who are considered smart in class (Yaghmour & Obaidat, 2022). However, if we look at the characteristics of the logical mathematical intelligence category, it states that students with high logical mathematical intelligence are faster in absorbing what they have received, especially in mathematics, when compared to students with low logical mathematical intelligence who need more time to understand the material they have received. accepted. This means that the mathematical critical thinking abilities of

students with low logical mathematical intelligence are still below those of students with high logical mathematical intelligence.

### *4. Fourth Hypothesis*

From the results of two-way variance analysis calculations with unequal cells, it was found that there was an interaction between the learning model and logical mathematical intelligence on the ability to think critically in mathematics. Based on the results of the mean comparison test between columns in each category of logical mathematical intelligence, with a significance level of 0.05, the conclusion is that:

In the category of high logical mathematical intelligence, students who receive the M6 learning model produce mathematical critical thinking skills that are as good as students who receive the RME learning model and the direct learning model. This is in accordance with the research hypothesis because basically students with high logical mathematical intelligence if subjected to any learning model, their mathematical critical thinking abilities will be equally good. This is reinforced by the opinion of (Ehlert et al., 2022), that the characteristics of students with high logical mathematical intelligence are students who like to find solutions to problems, are able to think and arrange solutions in a logical order, and like activities that involve numbers, sequences, measurements, and estimates. Based on these characteristics, it can be concluded that students who have high logical mathematical intelligence in any condition, including the different learning models applied, are always happy when solving a problem, especially problems related to mathematics.

In the category of moderate logical mathematical intelligence, students who received the M6 learning model produced mathematical critical thinking skills that were as good as students who received the RME learning model. This is not in accordance with the research hypothesis which states that in the category of logical mathematical intelligence, students who receive the M6 learning model produce better mathematical critical thinking skills than students who receive the RME learning model. This hypothesis was not fulfilled because when learning in class used the M6 learning model, some of the students with logical mathematical intelligence were not optimal in carrying out analysis, evaluation and concluding activities. Some of the students only did one of the three activities. Apart from that, students with moderate logical mathematical intelligence are still less active when working in groups because the students are still dependent on students who are considered smart in the class. This is why the objectives of the M6 learning model are not fully achieved. However, in the RME learning model, students with logical mathematical intelligence are already active in learning. These students understand their respective responsibilities to understand the material being studied and what will be presented in front of the class. Students who receive the RME learning model produce better critical thinking skills in mathematics than students who receive the direct learning model. This conclusion is in accordance with the research hypothesis which states that for students with moderate logical mathematical intelligence, students who receive the RME learning model produce better mathematical critical thinking skills than students who receive the direct learning model. This

hypothesis is proven because in the RME learning model students with logical mathematical intelligence are actively involved during group work and presentations in front of the class so that the learning objectives are achieved. However, in the direct learning model students tend to be passive because the teacher dominates in learning so that students only receive knowledge from the teacher. Students who receive the M6 learning model produce better critical thinking skills in mathematics than students who receive the direct learning model (Susandi et al., 2022). This conclusion is in accordance with the research hypothesis which states that for students with moderate logical mathematical intelligence, students who receive the M6 learning model produce better mathematical critical thinking skills than students who receive the direct learning model. This hypothesis is proven because in the M6 learning model students who are mathematically logical are getting a lot of information from other friends when carrying out analyzing, evaluating and concluding activities to find information even though some of the students only record answers without asking where the answers came from. However, in the direct learning model students tend to be passive because the teacher dominates in learning so that students only receive knowledge from the teacher.

In the low logical mathematical intelligence category, students who received the M6 learning model produced mathematical critical thinking skills that were as good as students who received the RME learning model and the direct learning model. This is in accordance with the research hypothesis because basically students with low logical mathematical intelligence if subjected to any learning model, their mathematical critical thinking abilities will be just as good. This happens because students with low logical mathematical intelligence under any conditions, including differences in learning models applied, tend to be less active in learning (Örge Yaşar & Başbayrak, 2023). This causes students with low logical mathematical intelligence to find it difficult to solve problems, especially problems related to mathematics (Koolnaphadol et al., 2022).

### *Implication*

The results of this research can be used as input for teachers and prospective teachers to improve the quality of the learning process. Students' critical mathematical thinking abilities can be improved by paying attention to appropriate learning models in terms of students' logical mathematical intelligence. The M6 learning model and the RME learning model can be used as an alternative if mathematics teachers and prospective teachers carry out the mathematics learning process. Apart from that, in improving students' critical thinking skills in mathematics, teachers should pay attention to other factors that influence the learning process, namely other multiple intelligences possessed by students.

### *Limitation and Suggestion for Further Research*

Based on the conclusions of the research results, other researchers can conduct further research related to learning models and logical mathematical intelligence so that more effective learning models can be obtained to be applied to students who have high, medium and low intelligence. Apart from that, it is also hoped that other researchers can

develop this research by paying attention to other independent variables such as spatial intelligence and others.

## CONCLUSIONS

The analysis of the research data indicates that the M6 learning model is the most effective approach for enhancing students' critical thinking skills in mathematics, followed by the RME learning model, with both outperforming the direct learning model. Students with higher levels of logical-mathematical intelligence consistently demonstrate stronger critical thinking abilities compared to their peers with moderate or low intelligence levels. Specifically, within the M6 model, students with high and moderate logical-mathematical intelligence show comparable critical thinking skills, both surpassing those with lower intelligence. Similarly, the RME model benefits students with high and moderate intelligence levels more than those with low intelligence, while in the direct learning model, only students with high logical-mathematical intelligence stand out significantly. Across all models, the M6 and RME approaches yield more favorable outcomes for students with varying levels of logical-mathematical intelligence compared to the direct learning model, highlighting the effectiveness of active learning models in fostering critical thinking skills in mathematics.

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## AUTHOR CONTRIBUTION STATEMENTS

Ardi Dwi Susandi contributed to the conceptualization and design of the study, as well as data analysis and interpretation. He also played a lead role in drafting the manuscript and revising it critically for important intellectual content.

Sudirman was responsible for data collection, management, and preliminary analysis. He also provided substantial input on the methodology and assisted in revising the manuscript to enhance clarity and coherence.

Binti Khoiriyah contributed to the literature review, helped interpret the findings, and reviewed the manuscript to ensure academic rigor and alignment with the study's objectives. She also provided feedback on the final draft.

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