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Enhancing Mathematical Representation Skills through the MID Model: Does Cognitive Style Matter?

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Abstract

The ability to represent mathematical ideas is a fundamental component of mathematical understanding and communication. However, many students still struggle to express mathematical concepts in varied forms such as visual, symbolic, or verbal representations. This study aims to examine the effectiveness of the Meaningful Instructional Design (MID) learning model in improving students' mathematical representation skills, while also considering the role of students' cognitive styles. A quasi-experimental research design was implemented involving two groups: an experimental group taught using the MID model and a control group taught using conventional expository methods. The participants were selected using a cluster random sampling technique from a population of junior high school students. Data were collected through a validated mathematical representation test and a cognitive style questionnaire. The collected data were then analyzed using two-way ANOVA with a 5% level of significance, following prerequisite tests for normality and homogeneity using SPSS version 25 and Microsoft Excel. The results showed that students who learned through the MID model exhibited significantly higher mathematical representation skills than those taught using the expository model. Furthermore, students' cognitive styles also had a significant main effect on their representation abilities. Despite these main effects, the interaction between the learning model and cognitive style was not statistically significant. These findings indicate that the MID model is a robust instructional approach that can enhance students' mathematical representation skills across different cognitive style profiles. The study highlights the importance of adopting meaningful learning frameworks that prioritize concept-building and student engagement, regardless of learners' individual differences.

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INTRODUCTION

The ability to express mathematical ideas using various forms such as symbols, tables, diagrams, and graphs is a crucial aspect of students' mathematical development. This representational skill is not only necessary for solving problems but also for building a deeper understanding of abstract mathematical concepts (Carter, 2012). Through effective representation, students can bridge their intuitive ideas with formal mathematical expressions, making complex problems more accessible. Use of appropriate representations supports students in describing problems clearly and selecting appropriate strategies for solving them (Mainali, 2021; Pedersen et al., 2021). Saputri & Kamsurya (2020) similarly emphasized that mathematical representation plays an important role in analyzing situations, communicating reasoning, and drawing conclusions. Despite this, many students continue to struggle with creating accurate or meaningful representations. In many cases, learners resort to imitating examples provided by teachers rather than developing their own understanding. This suggests a lack of meaningful engagement and points to the need for instructional approaches that actively foster representational thinking in the learning process.

Observations conducted at Nurul Iman Islamic Middle School in East Lampung show that students face considerable difficulties in solving problems that require the construction of mathematical representations. These challenges often include misinterpreting given information, choosing inappropriate models or diagrams, and failing to reflect on the logic of their responses. When students do not fully understand the relationship between problem components, they are unable to represent mathematical ideas accurately (Laamena & Laurens, 2021; Kolar & Hodnik, 2021). This issue is further compounded by the use of conventional teaching methods, which tend to focus on teacher explanations followed by procedural exercises. As a result, students become overly reliant on teachers' guidance or class notes when approaching mathematical problems (Blazar & Pollard, 2023). They are rarely given opportunities to explore multiple ways of representing a situation or concept independently. Consequently, students treat representation as a mechanical step rather than as a thinking process that helps them make sense of mathematics. This learning condition hinders students from developing flexible and transferable representation skills that are essential for long-term mathematical understanding.

To address these ongoing challenges, a more adaptive and meaningful instructional approach is needed to support students' representation development. One instructional model that aligns with this need is the Meaningful Instructional Design (MID) model. This model encourages students to engage actively in constructing knowledge by connecting new material with prior understanding (Assingkily, 2024; Daulay et al., 2023; Glean et al., 2023). The MID model consists of three structured phases: lead-in, reconstruction, and production. These stages are designed to help students reflect on their existing knowledge, rebuild their conceptual frameworks, and express their understanding through personalized representations. Kurniawan et al. (2022) explained that each phase plays a critical role in guiding learners from experience to meaningful expression. Research conducted by Rosidah et al. (2018) confirmed that the MID model enhances students' representational thinking, especially when it is implemented alongside activities that promote reflection. Unlike traditional models, MID does not rely on rote procedures but instead creates space for students to develop deep connections between concepts and the ways they represent them. This makes MID a promising strategy for developing students' ability to generate meaningful and contextually appropriate mathematical representations.

In addition to instructional strategy, students' cognitive characteristics also influence how they approach representation tasks. One important internal factor is cognitive style, which refers to the habitual ways in which individuals perceive, process, and respond to information (Sassetti et al., 2022; Sternberg, 1987). In mathematics, students with reflective cognitive styles are typically more deliberate and careful in analyzing problems and selecting representation forms (Salam, 2023; Sirota et al., 2021). On the other hand, impulsive students may rush through problem-solving steps, leading to incomplete or incorrect representations. These tendencies affect not only the quality of their answers but also their ability to learn from errors and refine their thinking. Despite the importance of cognitive style, it is often overlooked in classroom instruction. Most instructional designs adopt a one-size-fits-all approach, assuming that all students engage with content in the same way. This can result in mismatched teaching strategies that fail to support certain learners. Incorporating cognitive style awareness into instructional planning allows educators to better accommodate diverse thinking patterns and provide opportunities for all students to succeed in constructing accurate and meaningful mathematical representations.

The Meaningful Instructional Design (MID) learning model has been widely recognized for its effectiveness in improving various mathematical skills. Several studies have demonstrated that MID supports the development of students' reasoning abilities (Indriani, 2024; Wirdaningsih, 2024), enhances mathematical communication (Situmorang et al., 2021), and strengthens problem-solving skills (Ana et al., 2022; Apriani et al., 2023). It has also been found to positively influence students' analytical and representational abilities (Irma, 2023; Via, 2024) and facilitate conceptual understanding through contextual and visual learning strategies (Kusumawati et al., 2024; Pitriani & Suardipa, 2023). At the same time, cognitive style has been identified as a critical factor affecting how students process information and perform in mathematics. Research has shown that students with reflective cognitive styles tend to demonstrate better critical thinking compared to those with impulsive styles (Suningsih et al., 2024; Syamsulrizal et al., 2025). Other studies have emphasized the role of cognitive style in the success of problem-based learning environments (Lefrida et al., 2023; Lubna et al., 2023), and its relationship with academic performance, mathematical reasoning, and representation (Alabdulaziz et al., 2022; Evendi et al., 2022; Sianturi et al., 2022; Son et al., 2020).

Although the effectiveness of the MID model and the influence of cognitive style have been examined in different studies, there is a lack of research that explores the interaction between meaningful instructional approaches and students' cognitive styles, particularly in relation to mathematical representation skills. Understanding this intersection is essential for designing instructional models that are responsive to individual differences. Therefore, this study seeks to address this gap by investigating how the MID model impacts students' mathematical representation skills when viewed from the lens of cognitive style.

METHOD

This study used a quantitative approach with a quasi-experimental method. The research design applied was a posttest-only factorial design, which involved two independent variables: the instructional model and cognitive style. The purpose of the research was not only to examine the individual effects of each variable on students' mathematical representation skills but also to explore whether there was an interaction between them. The experimental group received instruction using the Meaningful Instructional Design (MID) model, while the control group received conventional instruction through an expository model. Students' cognitive styles were classified into two categories based on a diagnostic questionnaire: reflective and impulsive. The factorial design of this study is shown in the following table:

Table 1. Design Analysis

Learning Model	Cognitive Style	
	Reflective (G1)	Impulsive (G2)
MID Model (P1)	A1	A2
Expository (P2)	B1	B2

Explanation:
A1 = Students with reflective style taught using MID
A2 = Students with impulsive style taught using MID
B1 = Students with reflective style taught using expository model
B2 = Students with impulsive style taught using expository model

The participants of this study were eighth-grade students at SMP Islam Nurul Iman Labuhan Maringgai, located in East Lampung, during the 2023/2024 academic year. A total of 61 students were involved in the study. The sampling technique used was cluster random sampling. Two classes were selected as research samples. Class VIII.I, consisting of 27 students, was assigned as the experimental group and was taught using the MID model. Meanwhile, Class VIII.II, with 34 students, served as the control group and received expository instruction. Students' cognitive styles were determined using a validated questionnaire, which grouped them into reflective or impulsive categories.

The instruments used in this research included tests, questionnaires, and documentation. The primary focus of the instruments was to measure students' mathematical representation skills. The test consisted of essay-type questions designed based on indicators of representation ability aligned with the 2013 curriculum and the objectives of the study. A total of eight items were developed to assess students' understanding in expressing mathematical ideas through visual, symbolic, tabular, and graphical forms. Each item was scored using a rubric ranging from 0 to 4. The raw scores obtained were then converted to a scale of 0 to 100 using the following formula:

$$Score = \frac{Ideal\ Raw\ Score}{Idean\ Maximum\ Score} \times 100$$

To ensure the quality of the instruments, validation was carried out through expert judgment for content validity, as well as statistical tests for reliability, item difficulty, and item discrimination. The cognitive style questionnaire used to classify students had also been validated prior to its implementation.

The data obtained from the posttest were analyzed using quantitative techniques. The analysis aimed to determine the effect of the MID instructional model on students' mathematical representation skills, as well as the influence of their cognitive styles. Additionally, the analysis sought to identify whether there was a statistically significant interaction between the instructional model and cognitive style in shaping students' representation ability. A two-way ANOVA was applied at a significance level of 0.05. Before conducting the ANOVA, normality and homogeneity tests were performed to ensure that the data met the necessary assumptions for parametric analysis. Data processing and analysis were conducted using SPSS version 25 and Microsoft Excel to calculate and convert student scores.

RESULTS AND DISCUSSION

Results

To ensure the validity of statistical analysis, preliminary tests were conducted, including normality and homogeneity tests. The normality test was performed using the Kolmogorov-Smirnov method with a significance level of 0.05. The results showed that the post-test scores for students' mathematical representation ability produced a p-value of 0.174, indicating that the data were normally distributed. Likewise, the p-value from the cognitive style questionnaire data was 0.069, which also exceeded 0.05, confirming that the cognitive style data were normally distributed as well.

Next, a homogeneity test was conducted using Levene's Test of Equality of Error Variances to determine whether the variances between groups were equal. The test produced a significance value of 0.228 for mathematical representation ability, which was greater than 0.05. This indicates that the variances between the experimental and control groups were homogeneous. In addition, Box's Test of Equality of Covariance Matrices yielded a significance value of 0.603, which also exceeded 0.05. These results confirmed that the assumption of homogeneity was met and that the data were appropriate for further analysis using a two-way ANOVA.

After confirming the data met all assumptions, a two-way ANOVA was performed to examine the effects of the instructional model (MID vs. expository), cognitive style (reflective vs. impulsive), and their interaction on students' mathematical representation ability. The analysis was conducted using SPSS version 25 with a significance level of 0.05.

Table 1. Two-Way ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Instructional Model	732.462	1	732.462	24.583	0.000
Cognitive Style	194.891	1	194.891	6.541	0.015
Instructional Model * Style	36.379	1	36.379	1.222	0.276
Error	1598.203	54	29.593		
Total	3169.935	58			

Based on the table above, the instructional model had a significant effect on students' mathematical representation ability, as indicated by the p-value of 0.000. This result shows that students who were taught using the Meaningful Instructional Design (MID) model performed significantly better than those who were taught using the expository model. The cognitive style variable also showed a statistically significant effect with a p-value of 0.015. This means that students with different cognitive styles "reflective and impulsive" achieved different levels of mathematical representation performance.

However, the interaction between the instructional model and cognitive style was not statistically significant, as shown by the p-value of 0.276. This result suggests that the effectiveness of the MID model on students' representation ability was consistent across different cognitive style groups. In other words, the advantage of using the MID model did not depend on whether students were reflective or impulsive in their cognitive processing. In conclusion, both the instructional model and cognitive style had independent effects on students' ability to represent mathematical ideas. However, no interaction effect was found between the two variables. These findings demonstrate the effectiveness of the MID model in enhancing mathematical representation skills and support its use in diverse classroom environments, regardless of students' cognitive preferences.

Discussion

The analysis results of this study indicate that students who received instruction through the Meaningful Instructional Design (MID) model achieved better performance in terms of mathematical representation skills compared to those who learned using conventional methods. This aligns with findings from Wirdaningsih (2024), who reported that the application of the MID model supports students in translating abstract mathematical concepts into various representational formats. The structured stages in the MID approach, particularly those that emphasize prior knowledge, conceptual reconstruction, and expression, offer a foundation for students to develop accurate and meaningful representations. Previous research by Indriani (2024) also emphasizes that the MID model promotes student-centered learning through visualization and concept reinforcement. These results are consistent with the work of Rosidah et al. (2018), who highlight that reflective thinking and conceptual mapping "elements integrated in the MID model" contribute to students' representational understanding. Compared to more conventional models that emphasize memorization, MID encourages deeper engagement and a stronger connection between understanding and representation.

The second important finding concerns the role of cognitive style. Statistical analysis revealed that students' representational abilities were significantly influenced by their cognitive styles, particularly between reflective and impulsive types. Students identified as reflective were found to construct more accurate and structured mathematical representations. This result supports Syamsulrizal et al. (2025), who noted that reflective learners tend to analyze problems more thoroughly, which leads to more appropriate representational choices. Additionally, Lefrida et al. (2023) and Lubna & Prayogi (2023) observed that reflective learners often take more time to process information and visualize solutions, which results in better quality of representation. These findings reinforce the theory that cognitive style affects not only the way students interpret problems, but also how they externalize their understanding through representations. This is in line with the perspective presented by Ho & Kozhevnikov (2023), who stated that cognitive style plays an important role in shaping the way individuals approach learning, especially in subjects that require visualization and symbolic reasoning such as mathematics.

The final analysis showed that there was no statistically significant interaction between the instructional model and cognitive style. Although each of these factors independently influenced student performance, their combination did not result in an amplified or diminished effect on representation ability. In simpler terms, the benefits of the MID model were experienced equally by students regardless of their cognitive style classification. This outcome is in line with research by Apriani et al. (2023), who found that the MID model improved learning outcomes across different student profiles without showing significant interaction effects. Likewise, Son et al. (2020) concluded that meaningful and well-structured instructional approaches tend to be effective across a broad spectrum of learners, regardless of variations in individual learning characteristics. This consistency suggests that the MID model may serve as a flexible and inclusive instructional framework capable of supporting student understanding through mathematical representation in diverse classroom settings.

CONCLUSION

The findings of this research demonstrate that the application of the Meaningful Instructional Design (MID) model significantly enhances students' ability to represent mathematical concepts. Learners who were exposed to this instructional approach showed greater proficiency in using various forms of representation, including symbolic, visual, and tabular expressions, when compared to peers who followed traditional expository teaching methods. Additionally, students' cognitive styles were found to play a meaningful role in shaping their representation outcomes. Reflective learners generally produced higher-quality representations than their impulsive counterparts. Despite the individual effects of both the learning model and cognitive style, the interaction between these two variables did not result in a statistically significant difference. This suggests that the benefits of the MID model are consistently experienced across different types of cognitive processing. In conclusion, the study reinforces the value of implementing learning models that emphasize meaningful engagement and conceptual construction, as they support the development of mathematical representation skills across a diverse range of learners.

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