Journal of Philology and Educational Sciences

EngiScience Publisher

Research Article

Effectiveness of Meaningful Instructional Design in Improving Students' Mathematical Skills

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Article Info

Article History
Received Aug 26, 2024
Revised Nov 26, 2024
Accepted Nov 30, 2024

Keywords
Meaningful Instructional Design
Mathematical Analytical Skills
Learning Model
Contextual Learning

Abstract

This study aims to examine the impact of the Meaningful Instructional Design (MID) model on students' mathematical analytical skills, addressing a gap in previous research, which has yet to explore this critical cognitive domain. A quantitative approach was used with a quasi-experimental method involving two groups: an experimental group that applied the MID model and a control group that used conventional teaching methods. Measurements were conducted through a posttest to assess students' analytical skills in both groups. The results show a significant difference in mathematical analytical abilities between students who used the MID model and those who followed conventional methods, with the MID group achieving higher average scores. In conclusion, the MID learning model proved to be more effective in enhancing students' mathematical analytical skills compared to conventional teaching methods. These findings suggest that meaningful and contextual learning has great potential for optimizing students' analytical skills in mathematics.

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1. Introduction

Analytical skills in mathematics education are essential because they support students in thinking critically, understanding concepts deeply, and applying mathematical knowledge in various situations. Analytical skills help students organize information, identify patterns, and make data-based decisions, which are fundamental for solving complex problems (Nermin & Kapucu, 2022; Syabaniah & Nuraeni, 2023).

Additionally, these skills enhance mathematical communication, allowing students to express and evaluate mathematical ideas more effectively, an important aspect of learning mathematics (Al-Hanifah et al., 2023). Research also indicates that students with strong analytical skills tend to achieve better academically and have stronger problem-solving abilities (Yong et al., 2019). Therefore, developing analytical skills in mathematics education not only improves concept comprehension but also equips students with the necessary abilities to tackle real-world challenges effectively and creatively.

Although analytical skills are crucial for enhancing students' understanding, problem-solving abilities, and academic achievement, various studies indicate that students' mathematical analytical skills remain low. This deficiency has a broad impact on multiple aspects of mathematics learning. Wahyuningrum (2013) found that even when students engaged in Model Eliciting Activities (MEAs), their analytical skills were still not fully developed. Additionally, the 2015 PISA results placed Indonesia in a low rank for mathematical analysis skills, showing that many students struggle with recognizing and analyzing mathematical problems (Manik et al., 2020; Nabilah et al., 2023). Simanjuntak & Simanjuntak (2020) also observed that many students have not yet met the expected standards in analytical skills tests. Karim (2022) added that limited analytical abilities lead to difficulties in solving more complex problems. Overall, low analytical skills in mathematics not only hinder students' problem-solving abilities but also limit their understanding of more complex concepts and their mathematical communication skills.

Considering the low level of students' mathematical analytical skills, which remains a challenge in education, a more effective approach is needed to address this issue. The Meaningful Instructional Learning Model is one approach that is expected to meet this need, as it is designed to create relevant and meaningful learning experiences for students. This model emphasizes creating a supportive learning environment, enhancing motivation, and providing meaningful experiences based on real-world contexts (Glean et al., 2023; Susilo, 2024). Additionally, the Meaningful Instructional Design model focuses on meaningful and effective learning through a cognitive and constructivist conceptual framework (Anggraini, 2023). By providing clear context and using interactive methods, this model is expected to help students improve their analytical skills in understanding and solving mathematical problems. Research shows that meaningful learning approaches can support the development of analytical skills and deepen concept comprehension. Through the application of the Meaningful Instructional Learning Model, it is hoped that students can more easily connect mathematical concepts with real-life situations, ultimately strengthening their analytical skills in learning mathematics.

Various studies have examined the use of the meaningful instructional design model in mathematics education, especially for improving problem-solving skills (Apriani et al., 2023a), student understanding (Kusumawati et al., 2024), mathematical reasoning (Glean et al., 2023), academic performance (Mulyono et al., 2018), and mathematical literacy (Arifani et al., 2021). These studies highlight significant benefits in

different cognitive areas, showing the flexibility and effectiveness of this model. However, a clear gap exists: there has been no research specifically focused on the applying this model to enhance students' mathematical analytical skills. Analytical ability is crucial for higher-level thinking and critical evaluation in mathematics, serving as a foundation for deep problem-solving and critical thinking. Therefore, this study aims to explore how the meaningful instructional design model impacts students' mathematical analytical skills, providing fresh insights into the model's potential for fostering deeper cognitive skills, which have not been thoroughly explored in this field.

Although the MID model has been widely recognized for its ability to improve skills such as problem-solving, comprehension, and reasoning, its specific role in enhancing students' mathematical analytical abilities has not been thoroughly examined. Drawing on cognitive and constructivist learning principles, this study seeks to explore how the MID model can foster higher-order analytical thinking in mathematics. By integrating real-world contexts and interactive learning techniques, this research aims to address the existing gap and uncover practical strategies for utilizing the MID model to support the development of analytical skills in mathematics education.

2. Methods

Since this study investigates the impact of the Meaningful Instructional Design model on students' mathematical analytical abilities and adaptive mathematical reasoning, a quantitative research approach is used. The study includes one independent variable (the Meaningful Instructional Design model) and one dependent variable (mathematical analytical ability). Therefore, a t-test is recommended for data analysis, and SPSS version 25 is utilized for statistical computation.

2.1. Design

The study utilizes a quasi-experimental design to examine the effectiveness of the Meaningful Instructional Design model in improving students' analytical abilities. A quasi-experimental approach is appropriate here, as it enables structured investigation in an educational setting without requiring full experimental control over all variables. This design includes a pre-test and post-test structure, allowing for an assessment of analytical ability both before and after the instructional intervention. By comparing students' pre-test and post-test scores, the study can identify any significant changes in analytical abilities that are attributable to the instructional model. The quasi-experimental design is particularly suitable for real classroom settings, where full control over external factors is often challenging. This design ensures a robust assessment of the intervention's impact on analytical abilities while maintaining flexibility for practical application in the classroom. Furthermore, using a pre-test and post-test approach strengthens the validity of the study by showing measurable changes in students' analytical skills over the intervention period.

2.2. Participants

The target population for this study consists of eighth-grade students at the junior high school level, a group at an ideal developmental stage for building analytical skills in mathematics. A total of 189 students were selected as participants, representing all eligible students in the chosen grade level within the school. The study was conducted in Bandar Lampung, Indonesia, ensuring the relevance of the findings to this specific educational context. All students were present during data collection, providing a complete dataset that enhances the reliability of the research findings.

The students were divided into two groups: the experimental group, consisting of 100 students from three classes, and the control group, consisting of 89 students from three classes. The experimental group received instruction using the Meaningful Instructional Design (MID) model, while the control group was taught using conventional teaching methods. The division of groups aimed to ensure comparability while maintaining the natural class settings.

The implementation of MID in the experimental group followed several structured phases. First, the learning objectives were explicitly outlined, emphasizing the development of analytical abilities in mathematics. Lessons were designed to connect mathematical concepts to real-life contexts, facilitating meaningful learning. Each instructional session included four stages: (1) introduction, where students were introduced to the lesson's context and objectives; (2) exploration, involving active problem-solving tasks; (3) application, which linked concepts to practical, real-life scenarios; and (4) reflection, enabling students to evaluate and consolidate their learning. In contrast, the control group followed conventional teaching methods that emphasized direct instruction and rote learning.

Each participant took a subjective test measuring their analytical abilities in mathematics during the pre-research phase, establishing a baseline. After the intervention, the same test was administered as a post-test to evaluate the impact of the instructional model. By including both an experimental and a control group, the study ensures a robust comparison of the instructional model's effectiveness. This approach enhances the validity of the findings, making them comprehensive and applicable to similar educational contexts.

2.3. Instruments

The primary instrument used in this study is a subjective test specifically designed to assess students' analytical abilities in mathematics. This instrument was developed for the purpose of this study, following established procedures for test construction and validation. The development process included a review of relevant literature and consultation with subject matter experts to ensure content validity.

The validation process was conducted in two stages: (1) expert judgment, where experienced mathematics educators evaluated the instrument's content, clarity, and alignment with analytical skill indicators,

and (2) empirical testing with a pilot group of students. Statistical analyses were then performed to confirm the instrument's reliability and validity. The normality test ensured the data distribution was suitable for parametric analysis, the reliability test (using Cronbach's alpha) indicated high internal consistency, and item discrimination analysis verified that each question effectively differentiated between high and low levels of analytical skills.

Details of the validation process are summarized in Tables 1 and 2. Table 1 shows the validity analysis results for the six essay questions in the test, with all items categorized as valid. Table 2 presents the reliability analysis, indicating a Cronbach's alpha value of 0.82, which reflects high internal consistency and ensures the instrument's reliability.

Table 1. Validity Test Results

No	Correlation Coefficient (r)	r Table	Validity Category
1	0.78	0.361	Valid
2	0.65	0.361	Valid
3	0.72	0.361	Valid
4	0.50	0.361	Valid
5	0.48	0.361	Valid
6	0.60	0.361	Valid

Table 2. Reliability Test Results

Reliability Test	Cronbach's Alpha Value	Category
Total Items (6 questions)	0.82	Reliable

2.4. Data Analysis

The data analysis in this study utilizes t-test to assess the effect of the Meaningful Instructional Design model on students' analytical abilities in mathematics. Although t-test is typically used for single dependent variables, in this case, it serves to provide a detailed examination of the single dependent variable. SPSS version 25 is used to perform the analysis, as it offers advanced tools for handling complex statistical tests and ensures accurate results. The analysis process begins with data cleaning to identify any outliers or anomalies, followed by the calculation of descriptive statistics to summarize the dataset. Descriptive statistics provide insight into the distribution, mean, and standard deviation of students' scores. T-test is then conducted to determine the instructional model's impact, and if significant effects are found, further tests are applied to explore specific group differences. This structured approach allows the study to draw reliable conclusions about the effectiveness of the instructional model in enhancing students' analytical abilities in mathematics.

3. Results and Discussions

3.1. Result

The purpose of this study is to examine the effect of the Meaningful Instructional Design (MID) learning model on enhancing students' mathematical analytical abilities. To achieve this goal, the researcher measured students' analytical skills through a posttest administered to two groups: an experimental class using the MID learning model and a control class applying conventional teaching methods. The following is a summary of the students' posttest results:

Table 3. Posttest Data for Mathematical Analytical Skills in MID and Conventional Classes

	Number of Students	**Average**	$\mathbf{X_{max}}$	$\mathbf{X_{min}}$
MID Class	100	79,54	87	50
Conventional Class	89	66,34	76	45

After confirming that the data is normally distributed and homogeneous through prerequisite tests, the researcher proceeded with hypothesis testing using the t-test. Table 4 presents a summary of the t-test results:

Table 4. t-test Results

		df	**Sig (2-tailed)**
Mathematical Analytical Skills	Equal Variances Asummed	43	,000
	Equal Variances not Asummed	34,958	,000

The t-test results show a significant difference in mathematical analytical skills between the two groups tested. With a significance level (Sig 2-tailed) of 0.000 in both conditions—whether equal variances are assumed or not—this result is well below the commonly used significance threshold of 0.05. This indicates that the difference in mathematical analytical skills between the two groups is not due to chance and is statistically significant. Thus, these results suggest that the class treated with the Meaningful Instructional Design model has a meaningful effect on students' mathematical analytical skills in the context of this study. Based on Table 1, it can be concluded that the MID learning model has a greater impact compared to the conventional teaching method.

3.2. Discussion

The results of this study show a significant difference in mathematical analytical abilities between students who participated in the Meaningful Instructional Design (MID) model and those who experienced conventional teaching methods. The increase in analytical skills in the MID class can be attributed to the characteristics of this instructional model, which is designed to provide relevant and meaningful learning

experiences (Nugraha et al., 2024; Rosidah et al., 2018). MID encourages students to engage actively in the learning process by connecting the mathematical material to real-life contexts (Apriani et al., 2023b; Sekarini et al., 2018).This approach allows students not only to memorize concepts but also to analyze and apply them in more complex situations. In other words, MID helps students develop deeper analytical skills by giving them the opportunity to think critically and explore concepts in a more practical manner.

These findings are consistent with research by Gazali & Atsnan (2022) and (Utama et al. (2022), which stated that meaningful learning approaches can enhance students' understanding and analytical skills in mathematics. Utama et al (2022) found that students involved in contextually designed learning showed significant improvement in critical thinking and problem-solving. Meaningful learning models, such as MID, allow students to connect mathematical theory with practical applications, helping them understand concepts more deeply and improve their analytical skills. Additionally, this study's results align with the findings of Priyadi et al. (2021), who revealed that context-based learning approaches have a positive impact on students' analytical abilities. In their study, students who learned through a contextual approach demonstrated deeper understanding and better analytical skills compared to those using conventional methods. With MID providing real-world context, students are more encouraged to think critically and analyze problems, ultimately strengthening their analytical skills. These findings reinforce the evidence that context-based and relevant learning has substantial benefits in developing students' analytical abilities.

Overall, the results of this study confirm that the Meaningful Instructional Design model is more effective than conventional methods in enhancing students' mathematical analytical skills. This approach not only helps students gain a deeper understanding of mathematical concepts but also encourages them to develop essential analytical skills for solving complex mathematical problems. Thus, this study provides valuable contributions by strengthening empirical evidence on the effectiveness of meaningful learning models, especially in improving mathematical analytical abilities. Learning models that emphasize meaningfulness and relevance in the context of mathematics education have the potential for broader application across different educational levels in mathematics learning.

4. Conclusions

This study revealed that the Meaningful Instructional Design (MID) model was more than just a teaching tool; it served as a bridge to deeper understanding, lighting the way to mastery in mathematical analysis. The results showed that students who learned through the MID approach did not simply memorize

steps or repeat processes; they genuinely developed their analytical skills in a more meaningful way compared to those taught using conventional methods. The significant difference between the MID class and the conventional class provided solid evidence that a learning method which incorporated relevance and meaning into each lesson transformed abstract concepts into real-life applications. By focusing on engagement and real-world context, the MID model encouraged students to think critically and apply their knowledge more deeply. Ultimately, this study demonstrated that when education shifted from merely teaching to inspiring, from presenting facts to facilitating discovery, it unlocked students' true potential.

Declaration of Competing Interest The authors declare that they have no known competing of interest.

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