



Enhancing Understanding of Data Presentation Concepts through the Realistic Mathematics Education Approach Assisted by Smart Data Board (PADAPI) Media

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ABSTRACT

Understanding of data presentation concepts remains a challenge in mathematic learning at the elementary school level. This study aims to analyze the improvement of understanding of data presentation concepts and to compare the improvement of conceptual understanding among groups that received instruction using the Realistic Mathematics Education (RME) approach assisted by Smart Data Board (PADAPI) media, the RME approach, and conventional instruction. This study employed a quasi-experimental method with a nonequivalent pretest-posttest control group design. The research subjects consisted of 92 third-grade elementary school student divided into two experimental classes and one control class. Data were collected through pretests and posttests using a conceptual understanding test on data presentation consisting of 20 essay items that had been declared valid and reliable. Data were analyzed using descriptive statistics (mean and N-Gain) and inferential statistics through the Shapiro–Wilk, Levene, Wilcoxon, and Kruskal–Wallis tests. The results showed that the RME group obtained the highest improvement with an average N-Gain score of 0.48 (moderate category), followed by the RME group assisted by PADAPI with an average N-Gain score of 0.41 (moderate category), while the conventional group obtained an average N-Gain score of 0.19 (low category). The Kruskal–Wallis test results indicated significant differences in the improvement of conceptual understanding among the learning groups ($p = 0.011$). These findings indicate that the Realistic Mathematics Education (RME) approach, both with and without PADAPI media assistance, provides better improvement in conceptual understanding compared to conventional instruction. The results imply that the RME approach can be used as an alternative in mathematics instruction to enhance students' conceptual understanding, while PADAPI media can be utilized as a supporting tool to help students visualize, organize, and present data more concretely.



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Introduction

Data presentation is one of the mathematics topics in Phase B of the Merdeka Curriculum that requires students to be able to collect, group, sort, and present simple data in tabular form. Mastery of this topic not only requires the ability to perform data presentation procedures but also conceptual understanding so that students can interpret the information presented and use it in various real-life situations. Therefore, conceptual understanding of data presentation needs to be developed from elementary school as a foundation for students in studying statistics at higher education levels. However, research by [Astuti, Adzani, Aysah, & Arifin \(2024\)](#) shows that elementary school students' conceptual understanding of data presentation still needs improvement. The results of that study revealed that students had not fully mastered the basic concepts of data presentation. The difficulties experienced include distinguishing raw data from presented data, grouping data according to their characteristics, determining the frequency of each category, using tally marks as a recording tool, reading information in tables, and drawing conclusions based on available data. These findings indicate that most students still focus on procedural completion without understanding the underlying concepts of data presentation. As a result, students experience difficulties in representing data and interpreting the information contained in tables.

These findings indicate that learning needs to be designed so that students are actively involved in forming their own understanding. So far, data presentation learning has largely emphasized mastery of problem-solving procedures, causing students to tend to memorize sequences of steps without understanding the reasons or concepts behind them. Consequently, the knowledge acquired is mechanical and less meaningful. To address this condition, a learning approach is needed that presents situations or problems close to students' lives so that mathematical concepts can be understood through real, active, and meaningful learning experiences.

One approach that can be applied to address these problems is Realistic Mathematics Education (RME). According to Freudenthal ([in Fakhrany et al., 2024](#)), mathematics is not viewed as a collection of formulas to be memorized, but rather as a human activity that develops through learning experiences. Based on this view, the learning process begins with situations or problems derived from contexts familiar to students. Subsequently, students are guided to process these problems through a process of mathematization until they discover more formal mathematical concepts. In its implementation, RME places students as the main subjects of learning by providing opportunities to investigate problems, exchange ideas, provide reasons, and evaluate their thinking outcomes. Thus, mathematical concepts are understood through a process of knowledge construction derived from learning experiences, not merely through memorization activities.

In this study, the RME approach was combined with Smart Data Board (PADAPI) media specifically designed to support data presentation learning. This integration was carried out through the stages of RME learning, beginning with the presentation of contextual problems close to students' lives. Subsequently, students actively collected and grouped data using the components of PADAPI media, determined frequencies using tally marks, and presented data in tabular form by utilizing PADAPI media as a concrete tool. The results of data presentation were then discussed among students or groups to compare solution strategies before the teacher facilitated students in drawing conclusions about data presentation concepts. Through these series of activities, PADAPI media not only functioned as a visual aid but also as a concrete model bridging students' real experiences toward formal mathematical representations. The

integration of the RME approach with PADAPI media is expected to form a more meaningful understanding of data presentation concepts through students' active involvement in every learning process. The application of this learning media is supported by Piaget's cognitive development theory, which explains that elementary school students are at the concrete operational stage. At this stage, understanding of a concept is more easily formed when students obtain learning experiences involving real objects or concrete representations so that abstract concepts become easier to understand.

The effectiveness of the RME approach in mathematics learning has been widely discussed in previous research. [Setiyawan et al. \(2025\)](#) showed that the application of the RME approach to data presentation material resulted in a learning mastery percentage of 92.6%. [Putri & Ariani \(2020\)](#) also reported that the RME approach helped students build understanding of data presentation through activities of observing, grouping, and representing data in tabular form. In addition, [Febriana \(2022\)](#) and [Marlina & Fuziawati \(2021\)](#) concluded that the RME approach was able to improve elementary school students' understanding of mathematical concepts. Research by [Umami, Utaminingsih, & Riswari \(2024\)](#) showed that the integration of the RME approach with concrete media provided a significant improvement in students' understanding of mathematical concepts.

Nevertheless, these studies still leave several research gaps. Most studies have focused more on improving learning outcomes or general mathematical conceptual understanding, while studies specifically discussing conceptual understanding of data presentation in tabular form among third-grade elementary school students remain limited. This condition indicates that this topic still requires further research to enrich the empirical evidence regarding the effectiveness of RME implementation in data presentation material. Previous studies have also generally only tested the effectiveness of the RME approach or the use of concrete media separately. In addition, there is still limited research that directly compares the improvement of conceptual understanding through learning using the RME approach assisted by media, the RME approach without media, and conventional instruction within a single research design on data presentation material. The media used in previous studies have also not been specifically designed to facilitate activities of collecting data, grouping data, determining frequencies, and compiling tables according to the characteristics of data presentation material for third-grade elementary school students.

Based on these research gaps, this study offers novelty in the form of the integration of the RME approach with PADAPI media specifically designed to facilitate activities of collecting data, grouping data, determining frequencies using tally marks, and presenting data in tabular form according to the characteristics of data presentation material in elementary school. In addition, this study compares the improvement of conceptual understanding of data presentation in learning using the RME approach assisted by PADAPI media, the RME approach without media, and conventional instruction within a single research design.

This study is expected to enrich studies on the application of mathematics learning strategies, particularly in data presentation material in elementary school. In addition to providing empirical evidence regarding the effectiveness of the applied approaches, the results of this study are expected to serve as a reference for teachers in selecting learning strategies capable of improving students' conceptual understanding. On this basis, this study aims to examine the improvement of conceptual understanding of data presentation among students who participated in learning using the Realistic Mathematics Education (RME) approach assisted by Smart Data Board (PADAPI) media, the RME approach without media, and

conventional instruction. This study also aims to compare the improvement of conceptual understanding of data presentation among the three learning groups.

Method

Settings

This study applied a quantitative approach with a quasi-experimental research method. The selection of this method was based on the research conditions carried out in classes that had been determined by the school, so the researcher could not randomly assign students to groups. Nevertheless, the quasi-experimental design still provided the opportunity to evaluate changes in conceptual understanding experienced by students through comparison of results before and after learning in groups that received treatment as well as comparison groups. In this way, the effectiveness of the treatment could be analyzed based on the changes that occurred in each group. The research design used was a nonequivalent pretest-posttest control group design. In this design, there were three research groups, namely two experimental groups and one control group. Before the learning activities began, all groups were given a pretest to determine students' initial abilities. After each group received treatment according to the planned learning, all students were given a posttest as a basis for determining changes in conceptual understanding that had occurred. Experimental Group I participated in learning using the RME approach assisted by Smart Data Board (PADAPI) media, Experimental Group II received learning with the RME approach only, while the control group participated in learning using the conventional approach.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experimental I	O ₁	X ₁	O ₂
Experimental II	O ₁	X ₂	O ₂
Control	O ₁	–	O ₂

Description:

O₁ = pretest

O₂ = posttest

X₁ = learning using the RME approach assisted by PADAPI media

X₂ = learning using RME approach

Participants

The research population was all third-grade students of an accredited B elementary school in South Sumedang District that had implemented the Merdeka Curriculum and had third-grade study groups. The selection of accredited B schools was carried out to obtain relatively homogeneous school characteristics so as to minimize the influence of external factors on the research results. The sampling technique used purposive sampling, namely sample selection based on certain considerations adjusted to the research objectives. These considerations included: (1) the school had B accreditation status, (2) had implemented the Merdeka Curriculum, and (3) was willing to be the research location. The total research sample consisted of 92 students divided into three learning groups.

Table 2. Characteristics of the Research Sample

Group	Number of Students	Treatment
Experimental I	30	RME approach assisted by PADAPI media
Experimental II	32	
Control	30	RME approach
Total	92	Conventional instruction

Instruments

The research instrument used in this study was a test instrument. The test instrument consisted of essay questions used to measure students' conceptual understanding of data presentation. Essay tests were chosen because they allowed students to express their understanding more deeply, not only through final answers but also through the thinking processes demonstrated in solving the questions. The instrument development referred to indicators of mathematical conceptual understanding based on the Decree of the Director General of the Ministry of National Education No. 506/C/Kep/PP/2004 (in Nurkhodijah & Abadi, 2023), namely: (1) restating concepts; (2) classifying objects according to certain characteristics; (3) providing examples and non-examples; (4) presenting concepts in various mathematical representations; (5) developing necessary and sufficient conditions of a concept; (6) using certain procedures appropriately; and (7) applying concepts in problem-solving.

The test instrument consisted of 20 essay items that had undergone content validity testing through expert judgment as well as empirical validity testing. In addition, reliability analysis, difficulty level, and discriminating power analysis were conducted before the instrument was used in the study. These stages were carried out to ensure that the instrument had adequate quality so that it could measure conceptual understanding of data presentation accurately and consistently. The results of the instrument validity test are presented in Table 3.

Table 3. Results of the Test Instrument Validity Test

Item Number	Sig. Value	Conclusion	Correlation Coefficient	Interpretation
1	0,003	Valid	0,477	Moderate
2	0,001	Valid	0,527	Moderate
3a	0,002	Valid	0,492	Moderate
3b	0,000	Valid	0,641	High
4a	0,000	Valid	0,571	Moderate
4b	0,002	Valid	0,490	Moderate
5a	0,000	Valid	0,803	Very High
5b	0,000	Valid	0,758	High
6	0,000	Valid	0,627	High
7a	0,000	Valid	0,558	Moderate
7b	0,000	Valid	0,682	High
7c	0,000	Valid	0,653	High
8	0,000	Valid	0,593	Moderate
9a	0,000	Valid	0,710	High
9b	0,000	Valid	0,622	High
10	0,000	Valid	0,573	Moderate
11	0,001	Valid	0,534	Moderate
12	0,000	Valid	0,800	High
13	0,000	Valid	0,586	Moderate
14	0,000	Valid	0,535	Moderate

Based on Table 3, all items obtained significance values less than 0.05, so all items were declared valid. The correlation coefficient of each item ranged from 0.477 to 0.803 with moderate, high, and very high categories. Most items were in the moderate and high categories, indicating that the instrument had good ability to measure students' conceptual understanding of data presentation. Thus, all items were suitable for use in the research. Furthermore, the reliability of the instrument was tested using the Cronbach's Alpha technique. The test results are presented in Table 4.

Table 4. Results of the Reliability Test

<i>Reliability Statistic</i>	
<i>Cronbach's Alpha</i>	<i>N of Items</i>
0,829	20

Based on the reliability test results, the Cronbach's Alpha value was 0.829 for 20 items. This value was in the range of $0.80 \leq r < 1.00$, indicating that the instrument had very high reliability. In addition to being reliable, the instrument also had an appropriate difficulty level and good discriminating power. Thus, the instrument met the criteria as a data collection tool suitable for use in the research. Examples of items used to measure conceptual understanding of data presentation are presented in Table 5.

Table 5. Sample Items of the Test Instrument for Conceptual Understanding of Data Presentation

Test Item	Task Characteristics
The following is data on animals at Sayangsatwa Zoo:  What animals are in the data? Mention the types of animals and their frequency of appearance!	Students must identify all types of animals in the data, group the same animals into one category, count the frequency of each type of animal, and present the grouping results in the form of frequencies for each type of animal.
The following is data on animals at Sayangsatwa Zoo:  Present the data in tabular form!	Students represent raw data into a simple frequency table with the correct structure.

Data Collection

The research was conducted over five meetings on data presentation material in tabular form. The material taught in all research groups was data presentation in tabular form according to the Phase B Mathematics Learning Outcomes of the Merdeka Curriculum. The first meeting was used to administer the pretest to determine students' initial ability to understand data presentation concepts. The second to fourth meetings were the treatment stages according to the learning group. In Experimental Group I, the learning process was carried out by applying the Realistic Mathematics Education (RME) approach supported by Smart Data Board (PADAPI) media. The learning activities began by presenting a contextual situation derived from experiences or activities familiar to students as a starting point for understanding data presentation material. Subsequently, students attached pictures (data cards) to the PADAPI media according to the data obtained, grouped the pictures (data cards) by category, determined the frequency using tally marks, and then presented the results in the table available on the PADAPI media. The work results of each group were discussed to compare solution strategies before the teacher facilitated students in concluding data presentation concepts.

In Experimental Group II, learning was carried out by applying the RME approach without using Smart Data Board (PADAPI) media. The learning process began by inviting students to understand the problems presented in a real context. Subsequently, students sought alternative solutions according to their understanding, presented and discussed their work with peers, then compared various emerging strategies before finally formulating the concepts learned based on the discussion results. Different from the two experimental groups, students in the control group participated in learning using the conventional approach. The learning process was more teacher-centered through material delivery, provision of examples of problem solving, followed by independent exercise completion by students. The fifth meeting was used to administer the posttest to determine students' conceptual understanding of data presentation after all treatments had been given. Subsequently, the data were analyzed to answer the research objectives. Based on these stages, the research was conducted through sample determination, pretest administration, treatment provision according to research groups, posttest administration, data analysis, and conclusion drawing. To provide a clearer picture of the research implementation stages, the research procedure was visualized in the form of a flowchart as presented in Figure 1. Research Procedure Flowchart.

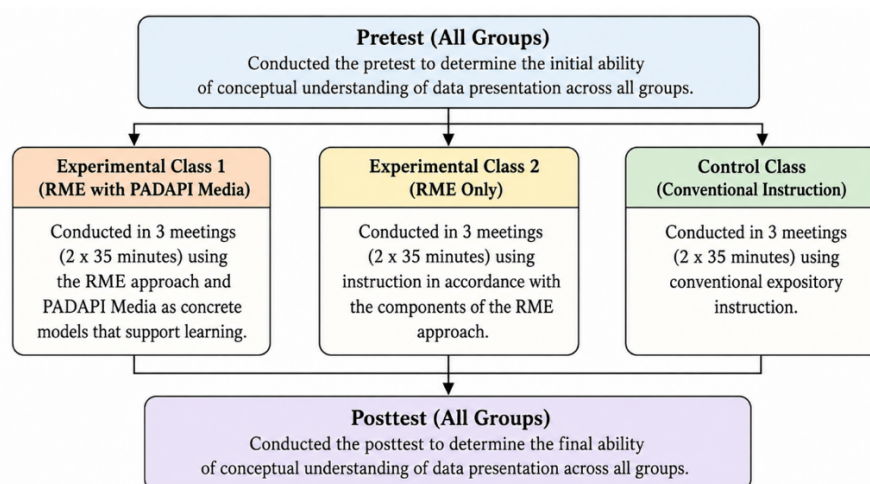


Figure 1. Research Procedure Flowchart

Analysis

The research data were processed through two stages of analysis: descriptive analysis and inferential analysis. Descriptive analysis was used to describe the profile of students' conceptual understanding of data presentation before and after receiving the treatment. The presentation of analysis results included mean scores, minimum scores, maximum scores, score range, and Normalized Gain (N-Gain) used to indicate the magnitude of learning improvement after the learning process took place. Before hypothesis testing was conducted, the characteristics of the data were first examined to determine the most appropriate analysis technique. This examination included the normality test using Shapiro–Wilk and the homogeneity of variance test using Levene's Test with a significance level of 0.05. The results of these two tests served as the basis for determining the use of parametric analysis if statistical assumptions were met or non-parametric analysis if these assumptions were not met.

The effectiveness of learning in each group was determined through comparison of pretest and posttest results. Analysis was conducted using the Paired Sample t-Test for groups with normally distributed data, while groups that did not meet the normality assumption were analyzed using the Wilcoxon Signed Rank Test. To determine whether the improvement in ability differed among the three research groups, N-Gain scores were compared using the Kruskal–Wallis test. All data processing was conducted using IBM SPSS Statistics software. Hypothesis testing in this study was directed to answer two main formulations, including: (1) there was an improvement in conceptual understanding of data presentation among students after participating in learning in each group; and (2) there were differences in the improvement of conceptual understanding of data presentation between students who received learning using the RME approach assisted by Smart Data Board (PADAPI) media, the RME approach, and conventional instruction.

Results

The focus of this study was to examine changes in conceptual understanding of data presentation among third-grade elementary school students after receiving three different learning treatments, namely the RME approach assisted by Smart Data Board (PADAPI) media, the RME approach without media, and conventional instruction. As an initial step, the test results obtained before and after the treatment were analyzed descriptively to describe the condition of students' abilities in each group. This analysis provided information on the tendency of score changes as a basis for evaluating the effectiveness of each treatment before inferential statistical analysis was conducted.

Learning Implementation

The material used in this study was data presentation in tabular form. The treatment in Experimental Group I was carried out through the application of the RME approach combined with Smart Data Board (PADAPI) media. During the learning process, PADAPI media was utilized to facilitate students in every stage of data presentation, starting from identifying and collecting data, grouping data based on their characteristics, calculating the frequency of each category, compiling data into tabular form, to interpreting the information presented. The series of learning implementations using PADAPI media at each meeting are summarized in

Table 6.

Table 6. Implementation of PADAPI Media in Experimental Group I

Meeting	Material	PADAPI Implementation
2	Collecting and grouping data	Students collected data on classmates' favorite foods, then attached picture cards of foods to the PADAPI media according to categories so that data groups were formed.
3	Determining frequency and compiling tables	Students counted the number of picture cards in each category using tally marks, then presented the results in the table available on the PADAPI media.
4	Comparing data and drawing conclusions	Students used the table on the PADAPI media to compare the frequency of each category, determine the most and least chosen foods, and draw conclusions based on the data through class discussion.

As a complement to the description of learning implementation, visualizations of the PADAPI media and documentation of its application in the learning process are presented in Figure 2. Visualization of PADAPI Media and Figure Figure 3. Documentation of PADAPI Media Implementation. These visualizations provide an overview of the characteristics of the media used as well as student activities during learning using the RME approach assisted by PADAPI media.

**Figure 2. Visualization of PADAPI Media****Figure 3. Documentation of PADAPI Media Implementation**

Statistik Deskriptif Descriptive Statistics

Before inferential analysis was conducted, descriptive statistical analysis was first performed to provide a general overview of the ability to understand data presentation concepts in each research group. This analysis included the number of subjects, score range, minimum

score, maximum score, and mean pretest and posttest scores. The results of the descriptive statistical analysis are presented in Table 7.

Table 7. Results of Descriptive Analysis

Group	Tes	N	Range	Minimum Score	Maximum Score	Mean
Experimental I	Pretest	30	0-100	10	75	49,67
	Posttest	30	0-100	15	96	67,03
Experimental II	Pretest	32	0-100	9	75	43,88
	Posttest	32	0-100	31	93	69,84
Control	Pretest	30	0-100	2	85	44.90
	Posttest	30	0-100	10	91	54.43

Based on the data in Table 7, the initial ability to understand data presentation concepts in the three groups showed relatively comparable conditions. The mean pretest score in Experimental Group I was 49.67, while Experimental Group II and the control group obtained means of 43.88 and 44.90, respectively. The closeness of these means indicated that before the treatment was given, the three groups had relatively equal initial abilities.

After all learning sessions were completed, score improvements were observed in each research group. The mean posttest score of Experimental Group I increased to 67.03 from the initial score of 49.67. In Experimental Group II, the mean score changed from 43.88 to 69.84, while the control group increased from 44.90 to 54.43. When viewed based on the magnitude of score improvement, Experimental Group II obtained an increase of 25.96 points, followed by Experimental Group I with 17.36 points, while the control group only increased by 9.53 points.

Changes in students' abilities were also seen from the development of the highest scores achieved after treatment. In Experimental Group I, the maximum score increased from 75 to 96. Experimental Group II showed an increase in the maximum score from 75 to 93, while the control group increased from 85 to 91. These results showed that after participating in the learning process, there were students who were able to achieve higher levels of concept mastery compared to conditions before treatment.

In general, the descriptive analysis results showed that the greatest improvement in ability was obtained by students in Experimental Group II, followed by Experimental Group I, while the control group showed relatively lower improvement. These findings provided an initial indication that the application of the RME approach, both with the use of Smart Data Board (PADAPI) media and without media, had the potential to produce better improvements in conceptual understanding of data presentation compared to conventional instruction. Nevertheless, this tendency still needed to be proven through inferential statistical analysis to determine whether the differences in improvement that occurred were statistically significant.

Equality of Initial Ability

Before the treatment was given, an analysis of the initial ability to understand data presentation concepts through pretest results was conducted. The results of the testing are presented in the following Table 8.

Table 8. Normality Test and Mean Difference Test of Pretest Scores for Conceptual Understanding of Data Presentation

Group	Mean	Normality Test (<i>Shapiro-Wilk</i>)		Mean Difference (<i>Kruskal-Wallis</i>)	
		Sig.	Description	Sig.	Description
Experimental I	49.67	0,014	Not Normal	0,327	There was no difference in initial ability (Pretest) among students in Experimental Group I, Experimental Group II, and the control group.
Experimental II	43.88	0,630	Normal		
Control	44.90	0,944	Normal		

Comparison of pretest scores in the three groups showed that students' initial abilities were relatively balanced. Experimental Group I obtained a mean score of 49.67, while Experimental Group II and the control group obtained means of 43.88 and 44.90, respectively. These mean differences were relatively small, so descriptively they did not yet indicate a significant gap in initial abilities among groups.

Furthermore, the data distribution was examined as a basis for determining the appropriate analysis technique. The normality test results showed that the data in Experimental Group I did not meet the normality assumption because it had a significance value of 0.014 (< 0.05). In contrast, Experimental Group II and the control group met this assumption with significance values of 0.630 and 0.944, respectively. Since there was one group that was not normally distributed, the analysis of initial ability differences was conducted using the Kruskal–Wallis test.

The Kruskal–Wallis test produced a significance value of 0.327, which was greater than the significance level of 0.05. This result indicated that there was no statistically significant difference in the initial ability to understand data presentation concepts among the three research groups. In other words, students in Experimental Group I, Experimental Group II, and the control group started the research with relatively equal levels of concept mastery.

This equality of initial abilities provided an adequate basis for comparing results after treatment was given. Since the initial conditions among groups did not differ significantly, the changes observed in the posttest results could subsequently be interpreted as the impact of the different learning treatments applied to each group.

Final Ability

To determine differences in the final ability to understand data presentation concepts after treatment was given, a mean difference test was conducted on posttest scores in the three research groups. The results of the normality test and posttest mean difference test for the three groups are presented in Table 9.

Table 9. Normality Test and Mean Difference Test of Posttest Scores for Conceptual Understanding of Data Presentation

Group	Mean	Normality Test (<i>Shapiro-Wilk</i>)		Mean Difference (<i>Kruskal-Wallis</i>)	
		Sig.	Description	Sig.	Description
Experimental I	67,03	0,004	Not Normal	0,011	There were differences in final ability (Posttest) among students in Experimental Group I, Experimental Group II, and the control group.
Experimental II	69,84	0,014	Not Normal		
Control	54,43	0,521	Normal		

Comparison of posttest results showed variations in the final ability to understand data presentation concepts in the three groups after each received the learning treatment. Experimental Group II obtained the highest mean score of 69.84, followed by Experimental Group I with a mean of 67.03, while the control group obtained a mean of 54.43. Descriptively, these results showed that both groups that participated in learning with the RME approach achieved higher final outcomes compared to the group that participated in conventional instruction.

Before conducting the inter-group difference analysis, the distribution of posttest data was examined through the normality test. The test results showed that the data in Experimental Group I and Experimental Group II did not meet the normality assumption with significance values of 0.004 and 0.014, respectively. In contrast, the data in the control group met the normality assumption because it had a significance value of 0.521. The presence of groups that were not normally distributed caused the comparative analysis to be conducted using the Kruskal–Wallis test.

The Kruskal–Wallis test produced a significance value of 0.011, which was smaller than the significance level of 0.05. This finding indicated that there were statistically significant differences in the final ability to understand data presentation concepts among the three research groups. Thus, students' posttest achievement was influenced by the different learning treatments applied to each group.

Improvement of Conceptual Understanding in Each Group

The improvement of conceptual understanding in each group was analyzed using the paired two-sample difference test. If the data met the normality assumption, the Paired Sample t-Test was used; if the data did not meet the normality assumption, the Wilcoxon Signed Rank Test was used. The test results are presented in Table 10.

Table 10. Results of the Conceptual Understanding Improvement Test

Group	Test	Sig.	Decision
Experimental I	<i>Wilcoxon Signed Rank Test</i>	0,000	There was a significant improvement
Experimental II	<i>Wilcoxon Signed Rank Test</i>	0,000	There was a significant improvement
Control	<i>Paired Sample t-Test</i>	0,000	There was a significant improvement

Analysis of changes in conceptual understanding of data presentation in each group showed an improvement in ability after the learning process. The selection of analysis techniques was adjusted to the characteristics of the data distribution in each group. Experimental Group I and Experimental Group II were analyzed using the Wilcoxon Signed Rank Test because the data did not meet the normality assumption, while the control group was analyzed using the Paired Sample t-Test because the data were normally distributed.

The test results showed that all groups obtained a significance value of 0.000 ($p < 0.05$). These values indicated that there were significant differences between pretest and posttest scores in each group. Thus, the learning applied in Experimental Group I, Experimental Group II, and the control group all provided significant improvements to students' conceptual understanding of data presentation.

Improvement of Conceptual Understanding (N-Gain)

To determine the level of improvement in conceptual understanding of data presentation after learning, a Normalized Gain (N-Gain) analysis was conducted for each research group.

The results of the N-Gain calculation for conceptual understanding of data presentation are presented in [Table 11](#).

[Table 11. N-Gain of Conceptual Understanding of Data Presentation](#)

Group	Mean Score		N-Gain	N-Gain Category
	Pretest	Posttest		
Experimental I	49,67	67,03	0,41	Moderate
Experimental II	43,88	69,84	0,48	Moderate
Kontrol	44,90	54,43	0,19	Low

The Normalized Gain (N-Gain) values showed that all groups experienced improvements in conceptual understanding of data presentation after participating in the learning process. Nevertheless, the magnitude of the improvement achieved was not the same for each group. Experimental Group II, which participated in learning using the RME approach, obtained an N-Gain value of 0.48 in the moderate category. Experimental Group I, which learned using the RME approach assisted by Smart Data Board (PADAPI) media, was also in the moderate category with an N-Gain value of 0.41. In contrast, the control group only obtained an N-Gain value of 0.19, which was included in the low category.

These differences indicated that learning applying the RME approach tended to produce better improvements in conceptual understanding compared to conventional instruction. During the learning process, students in both experimental groups were actively involved in solving contextual problems, exchanging ideas through discussion, and building concepts gradually based on exploration results. This condition was different from the control group, whose learning process was more teacher-centered through material delivery, sample problem discussions, and individual exercises, so that students' opportunities to construct their own understanding independently were more limited.

When viewed in terms of the magnitude of score changes, Experimental Group II showed a mean improvement of 25.96 points, followed by Experimental Group I with 17.36 points, while the control group only increased by 9.53 points. Although both experimental groups were in the moderate improvement category based on N-Gain values, the magnitude of these score improvements indicated that the application of the RME approach contributed more to improving conceptual understanding of data presentation compared to conventional instruction. To confirm whether these differences in improvement were statistically meaningful, further analysis was conducted using inferential tests.

Data Differences in Improvement of Conceptual Understanding of Data Presentation

To determine differences in the improvement of students' conceptual understanding of data presentation after receiving different learning treatments, an analysis was conducted on Normalized Gain (N-Gain) scores in the three research groups. The test results are presented in [Table 12](#).

Table 12. Results of the N-Gain Difference Test for Conceptual Understanding of Data Presentation

Group	N	Mean N-Gain	Test		Mean Difference Test (Kruskal- Wallis)	Description
			Normality	Homogeneity		
Expeerimental I	30	0,41	0,262 (Normal)	0,020 (not homogeneous)	0,011	There were differences in the improvement of conceptual understanding of data presentation between Experimental Group I, Experimental Group II, and the control group.
Experimental II	32	0,48	0,101 (Normal)			
Control	30	0,19	0,092 (Normal)			

Comparison of Normalized Gain (N-Gain) values showed variations in the improvement of conceptual understanding of data presentation in the three research groups. Experimental Group II achieved the highest mean N-Gain of 0.48, which was included in the moderate category. This value was followed by Experimental Group I with a mean N-Gain of 0.41, also in the moderate category. Meanwhile, the control group only obtained a mean N-Gain of 0.19, thus falling into the low category.

Before comparing improvements among groups, the characteristics of the N-Gain data were first analyzed. The normality test results showed that the data distribution in all groups met the normality assumption with significance values of 0.262, 0.101, and 0.092, respectively ($p > 0.05$). However, the homogeneity test results produced a significance value of 0.020 ($p < 0.05$), indicating that the variances among groups were not homogeneous. This condition caused the analysis of improvement differences to be conducted using the non-parametric Kruskal–Wallis test.

The Kruskal–Wallis test produced a significance value of 0.011, which was smaller than the significance level of 0.05. This finding indicated that the improvement in conceptual understanding of data presentation differed significantly among the three research groups. When viewed from the mean N-Gain values, the group that participated in learning using the RME approach obtained the highest improvement, followed by the group that learned using the RME approach assisted by Smart Data Board (PADAPI) media, while the group that participated in conventional instruction showed the lowest improvement.

Discussion

The results showed that learning applying the Realistic Mathematics Education (RME) approach provided better improvement in conceptual understanding of data presentation compared to conventional instruction. Interestingly, the group that received learning using the RME approach without the assistance of Smart Data Board (PADAPI) media showed higher improvement than the group using the RME approach assisted by the media. This finding indicated that the effectiveness of learning was not only determined by the presence of media but was also influenced by how the learning approach was implemented, the level of student participation during the learning process, and the opportunities given to them to develop concepts through mathematical activities.

Conceptual understanding is a fundamental component in mathematics learning because it serves as the foundation for the development of various other mathematical abilities. Muchtar,

Hendriani, and Fitriani (in Meidianti et al., 2022) explained that concept mastery plays an important role in supporting problem-solving abilities, reasoning, and mathematical communication. Thus, mathematics learning in elementary school should not only emphasize mastery of problem-solving procedures but also need to encourage students to understand the meaning behind the concepts studied so that they can apply them in various situations. This view is in line with the indicators of conceptual understanding proposed by the Ministry of National Education (in Prasasti, Awalina, & Hasana, 2020), namely the ability to restate concepts, classify objects based on certain characteristics, provide examples and non-examples, present concepts in various representations, and use concepts to solve problems.

The improvement in conceptual understanding in the group that participated in learning with the RME approach showed that students' active involvement during the learning process contributed to the formation of better understanding. In this study, students did not directly receive explanations about data presentation forms but obtained opportunities to process information through a series of activities, starting from collecting data, grouping data according to certain categories, determining frequencies, compiling data into tabular form, to interpreting the information obtained. This series of activities helped students understand the relationship between the data collected and its presentation in tabular form, so that the concepts learned were not only memorized but understood based on the learning experiences they had experienced.

These findings are in line with Freudenthal's view (in Fakhrany et al., 2024), which views mathematics as a human activity. Based on this view, mathematical concepts should be built through meaningful experiences and start from situations familiar to students. Learning activities that begin with real contexts allow students to undergo a gradual mathematization process before reaching more formal concept forms. Therefore, the improvement in conceptual understanding obtained in the RME group can be understood as the result of a learning process that provides space for students to construct their own knowledge through learning experiences, not just receiving information directly from the teacher.

This understanding is consistent with the Phase B Mathematics learning outcomes in the Merdeka Curriculum, which emphasize students' ability to collect, group, sort, and present simple data in tabular form (Susanto et al., 2022). Thus, the application of RME in this study not only supported the improvement of student learning outcomes but was also in accordance with the competency demands that need to be developed in data presentation material in elementary school.

The advantages of the RME approach are related to the characteristics of RME proposed by Treffers (in Asmaarobiyah, Rosmilawati, & Juansah, 2025), namely the use of real-world contexts, progressive mathematization, knowledge construction, interaction, and interconnectedness among concepts. These characteristics allow students to experience the process of change from contextual problems toward formal mathematical concepts gradually. This is in line with Julie, Suwarsono, & Juniati (2014), who explained that RME helps students build mathematical understanding through a mathematization process that begins from real situations toward formal representations. In this study, students not only knew how to create tables but also understood the relationship between data, categories, frequencies, and the information that could be obtained from data presentation.

The results of this study can also be explained through the constructivist perspective, which views students as subjects who actively construct their knowledge during the learning process. Piaget and Vygotsky (in Hukom, 2025) explained that understanding develops through student involvement in learning experiences, interaction with the environment, and

communication with others. These characteristics were evident during the application of the Realistic Mathematics Education (RME) approach, when students were given opportunities to develop solution strategies based on their understanding, discuss their work with peers, provide reasons for the answers obtained, and evaluate various alternative solutions that emerged during learning. Through these activities, students not only received feedback from the teacher but also from the process of interaction with peers. This condition is in line with Vygotsky's view that scaffolding and social interaction play a role in helping students achieve better levels of understanding.

The results of this study reinforce the findings of [Febriana \(2022\)](#), who reported that the application of the RME approach contributed to improving mathematical conceptual understanding through the use of contexts close to students' lives and a gradual mathematization process. Similar findings were also reported by [Marlina & Fuziawati \(2021\)](#), who showed that the RME approach was effective in improving mathematical conceptual understanding. The suitability of these results is thought to be related to the characteristics of learning applied in the three studies, namely making contextual problems the starting point for students to build concepts through thinking activities, exploration, and discussion. Thus, mathematical concepts are not understood merely as a sequence of procedural completion, but as knowledge formed through learning experiences that can be used to understand various situations relevant to students' lives.

Different from previous studies that generally only examined the effectiveness of RME, this study provided additional findings through the comparison of the application of RME with and without PADAPI media assistance and conventional instruction. The results showed that the addition of PADAPI media had not yet produced higher improvement compared to the application of RME without media assistance. This finding differs from the research of [Umami et al. \(2024\)](#), which showed that the combination of the RME approach with concrete media was able to significantly improve mathematical conceptual understanding. The difference in results may be influenced by several factors, such as media characteristics, media suitability with learning materials, duration of media use, and the student adaptation process to media use.

In this study, PADAPI media required an introduction stage so that students understood how to use the media in data presentation activities. Although PADAPI helped students carry out concrete activities such as collecting data, grouping categories, determining frequencies, and compiling tables, the use of media also potentially required its own learning time because students needed to understand how to utilize the media in data presentation activities. This condition might allow part of the learning time to be used for understanding media use so that the mathematization process, concept discussion, and material deepening did not take place optimally. Therefore, the improvement in conceptual understanding in the RME group without PADAPI could occur because students focused more directly on mathematical thinking processes, finding solution strategies, and building concepts through discussion.

Although the group using the RME approach without PADAPI media showed higher improvement, the presence of PADAPI media still provided support for the data presentation learning process. In this study, the media helped students visualize the relationship between the data obtained, the grouping process, frequency determination, and its presentation in tabular form. With representations that could be observed directly, students more easily understood the relationship between each stage of data presentation compared to if they only received verbal explanations.

This finding can be explained through Piaget's cognitive development theory ([in Isrok'atun, Hanifah, Maulana, & Suhaebar, 2020](#)), which states that elementary school students

are at the concrete operational stage. At this stage, the concept formation process is more effective when supported by learning experiences involving objects or representations that can be observed and manipulated directly. Therefore, the use of PADAPI provided more concrete learning experiences, thus helping students understand the abstract concept of data presentation.

The role of PADAPI in this study is inseparable from the characteristics of the RME approach that emphasizes the relationship between mathematical concepts and real situations. The media was utilized as a means to bridge students' experiences with the data presentation concepts being studied. This finding supports the opinion of [Unaenah et al. \(2023\)](#) that the use of relevant media can strengthen the application of the RME approach because it helps students connect real experiences with mathematical concepts. This opinion is reinforced by [Kristanto \(2016\)](#), who explained that learning media functions to transform abstract concepts into more concrete ones so that they are easier for students to understand.

Nevertheless, the results of this study show that PADAPI media is not the main factor determining the improvement of conceptual understanding. Media plays a role as a facilitator that supports students in building understanding through learning activities designed based on RME principles. During this process, students not only learned to compile data into tabular form but also understood that data could be used to describe a condition, obtain information, and serve as a basis for making decisions or solving problems. This finding is in line with [Maulana \(2016\)](#) that data is not just a collection of information but can be used to explain a situation or solve problems.

The low improvement in conceptual understanding in the control group can be explained through the characteristics of conventional learning that rely more on direct information delivery from the teacher. In this learning, students tended to receive concepts that had been explained and follow the sample solutions provided without many opportunities to discover concepts through their own experiences. [Asnanda et al. \(2024\)](#) and [Najwa et al. \(2025\)](#) explained that expository learning can cause students to be less active in the knowledge construction process because learning activities are more teacher-centered. This condition can cause students' understanding to be more procedural, thus less developed when facing problems that require conceptual understanding.

Overall, this study reinforces previous research findings that the RME approach is an effective learning alternative for improving conceptual understanding of data presentation in elementary school students. This study also contributes that the use of learning media needs to be considered based on function, suitability, and integration with learning activities. The RME approach, both with and without PADAPI media assistance, is able to help students understand data presentation concepts more meaningfully through real contexts, mathematization processes, interaction, and direct learning experiences.

Research Implications

The results showed that the RME approach, both assisted by PADAPI media and without media assistance, was more effective than conventional instruction in improving students' conceptual understanding of data presentation. This finding implies the importance of implementing student-centered learning through the use of real contexts, mathematization activities, and students' active involvement in constructing their own knowledge. This is in line with the principle of RME, which views mathematics as a human activity, so that learning needs to start from situations that are meaningful to students ([Fakhrany et al., 2024](#)). Furthermore, the results of this study also reinforce the findings of [Febriana \(2023\)](#) and [Marlina & Fuziawati \(2021\)](#), which showed that the application of RME was able to improve students' mathematical

conceptual understanding. Therefore, teachers need to develop more contextual and meaningful learning to help students understand mathematical concepts more deeply.

In addition, this study showed that the use of learning media serves as a supporting tool that helps concretize concepts, but the effectiveness of learning is more determined by the quality of learning approach implementation and student involvement during the learning process. This finding is in line with the opinion of [Kristanto \(2016\)](#), who stated that learning media functions as an intermediary to make it easier for students to obtain meaningful learning experiences, so that learning success is not only determined by the media used but also by the suitability of the media with learning objectives and the strategies applied. Thus, teachers need to consider the suitability between approaches, media, and student characteristics in designing mathematics learning. This finding can also serve as a basis for developing RME-based learning innovations by utilizing various concrete media to improve conceptual understanding of mathematics in elementary school.

Conclusion

This study showed that the application of the Realistic Mathematics Education (RME) approach was more effective than conventional instruction in improving conceptual understanding of data presentation among third-grade elementary school students. The learning process that began with contextual problems, involved mathematization activities, encouraged student discussions, and provided opportunities for students to construct their own knowledge proved to be able to support the formation of deeper conceptual understanding. The results also showed that both learning using the RME approach assisted by Smart Data Board (PADAPI) media and the RME approach without media produced better improvement in conceptual understanding compared to conventional instruction. These findings indicated differences in the level of improvement in conceptual understanding of data presentation in the three groups studied. The added value of this study lies in the development of Smart Data Board (PADAPI) media as a learning tool designed to help students learn data presentation in tabular form through a series of activities, starting from collecting data, grouping data, calculating frequencies, to compiling data into tabular form. In addition to producing learning media, this study also provided empirical evidence regarding the application of the RME approach to data presentation material and presented a comparison of effectiveness between RME learning assisted by PADAPI, RME without media, and conventional instruction in third-grade elementary school students.

Although it provided positive results, this study still had several limitations. The scope of the study only covered data presentation material in tabular form and involved samples from several classes in one research area. In addition, the aspect analyzed in this study was limited to conceptual understanding, so it had not yet provided a comprehensive picture of the influence of the RME approach on other mathematical abilities. Based on these limitations, further research is suggested to apply the RME approach assisted by PADAPI media at different grade levels, with more diverse student characteristics, and in varied school environments with a larger sample size. Subsequent research can also expand the focus of the study by investigating the influence of this approach on other mathematical abilities, such as problem-solving skills, mathematical reasoning, mathematical communication, and student learning motivation, so that a more comprehensive understanding of its effectiveness in mathematics learning can be obtained.

Declarations

- Conflict of Interest** : The authors declare that there are no conflicts of interest.
- Auhor Contributions** : D.N.: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing.
M.: Conceptualization, Methodology, Validation, Supervision, Writing – review & editing.
I.: Conceptualization, Methodology, Validation, Supervision, Writing – review & editing.
All authors have read and agreed to the published version of the manuscript
- Data Availability Statement** : The authors declare that the data supporting the findings of this study will be made available by the corresponding author, [D.N.], upon reasonable request.

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