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Effect of Differences in Learning Treatments on the Mathematical Representation Ability of Elementary School Students

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ABSTRACT

Selecting an appropriate learning approach is important for developing students' mathematical representation ability. This study aimed to examine and compare the effectiveness of three instructional treatments, namely the Realistic Mathematics Education (RME) approach integrated with the DASAFA (Dadu Sarapan Favorit) media, the RME approach without additional media, and the use of DASAFA media without the RME approach, in improving the mathematical representation ability of third-grade elementary school students on data presentation material. This study employed a quasi-experimental method with a nonequivalent pretest-posttest comparison-group design. The research subjects consisted of 115 students from four public elementary schools in North Sumedang District, divided into three experimental groups. The instruments used included a test measuring mathematical representation ability with a reliability of 0.923, as well as a learning interest questionnaire using a four-point Likert scale. Data analysis was conducted using the Kruskal-Walli's test, N-Gain, and the coefficient of determination. The results showed significant differences in improvement among the three groups. The RME approach integrated with DASAFA media produced the greatest improvement, contributing 48.3% to students' mathematical representation ability. The RME group contributed 38%, while the DASAFA media group contributed 15.4%. However, the DASAFA group achieved the highest visual representation score and the highest learning interest score of 87.03%. The findings suggest that integrating RME with contextual concrete media can support more meaningful mathematics learning, although students' symbolic and verbal representation abilities still require further development.

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Introduction

Mathematical representation ability was one of the fundamental competencies that students needed to master in the process of learning mathematics at all levels of education, including elementary school. This ability constituted a basic need for students, as it played an important role in helping them understand mathematical concepts and solve the various mathematical problems they encountered (Atikasuri & Al-Kusaeri, 2024). Mathematical representation ability was not merely the ability to re-present a problem in another form, but encompassed a more comprehensive ability, namely the ability to generate, select, use, and connect various forms of representation—visual, symbolic, and verbal—in order to understand and solve mathematical problems. Globally, the importance of mastering mathematical representation had been emphasized by the National Council of Teachers of Mathematics (NCTM), which regarded representation as one of the main processes in learning mathematics, alongside problem solving, communication, connection, reasoning, and representation (Natonis et al., 2022). This ability held a very important role, as it could help students communicate their understanding of mathematical concepts through various forms of presentation, such as diagrams, tables, graphs, mathematical symbols, mathematical models, and verbal or written explanations, as a means of solving mathematical problems. Mathematical representation ability was the ability to re-present symbolic notations, tables, graphic images, diagrams, equations, or other mathematical expressions into different forms (Lestari & Yudhanegara, 2017).

At the national level, the mathematical ability of Indonesian students remained a major concern. The results of PISA 2023 still placed Indonesia at a low rank, with an average numeracy literacy score of 366 points, 106 points below the global average, with 82% of students still at a low level, below level two (Yuda & Rosmilawati, 2024). Although PISA measured students aged around 15 years, this condition could not be separated from the weak foundation of mathematical ability built from the elementary school level onward. This was reinforced by the results of a preliminary study conducted in North Sumedang District, which showed that third-grade elementary school students experienced difficulties in all three indicators of mathematical representation, namely visual representation (presenting data from one representation to another, such as tables and diagrams, with the use of representation to visually solve problems still being lacking), symbolic representation (weakness in constructing equations or mathematical models from a given representation, forming conjectures from a number, and solving problems involving mathematical expressions), and verbal representation (students showing limited understanding in constructing problem situations based on given data or representations, writing interpretations of a representation, writing the steps of solving mathematical problems in words, and answering questions using words or written text). This situation indicated that the implementation of mathematics learning in Indonesia, particularly at the elementary education level, still faced major challenges in building students' mathematical abilities from an early stage.

Mathematics had often been associated with being a highly complex subject that tended to generate anxiety and fear among students. This negative perception had a significant impact on declining student learning interest, which in turn affected their overall learning outcomes. This condition was consistent with the cognitive development stage of elementary school students based on Piaget's theory, which placed children aged 7 to 11 years at the concrete operational stage, a transitional stage in which children had been taught to think logically, but still with the aid of concrete objects (Rizqiyati et al., 2023). At this stage, children could understand logic with the help of concrete objects (Isrok'atun, 2021, p. 2). Students' cognitive

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structures had not yet fully developed to process abstract information without support from concrete examples or contextual empirical experience. Therefore, when mathematics was taught solely through an approach that did not integrate real-life context as a means of understanding, students faced significant cognitive difficulties in constructing mathematical meaning. Studies conducted by Pohan et al. (2023) and Husaini et al. (2024) stated that students' low mathematical representation ability affected problem solving, problem analysis, difficulty in connecting concepts, and a lack of accuracy in working on problems. This weakness was further exacerbated by the continued dominance of teacher-centered learning, which caused students to be passive and less actively involved (Anjly, 2026).

The implication was that the process of mathematical abstraction, which required formal thinking ability, had not yet been fully achieved. This condition ultimately contributed to students' low mathematical representation ability, particularly in reformulating a problem into visual, symbolic, or verbal form. The weakness in students' mathematical representation ability was influenced by the learning approach applied in the classroom, in which the process was still dominated by the teacher's role as the center of learning. Such a condition caused students to tend to be passive and less actively engaged throughout the teaching and learning process, which ultimately led to a decline in their interest and motivation toward learning mathematics as a whole. In line with this, it was also stated that one of the main factors causing students' low mathematical representation ability was the use of a teaching approach that remained entirely teacher-centered during instruction, with students spending most of their time merely taking notes and listening to the teacher's explanation without active involvement in thinking and problem solving, so that their interest and enthusiasm toward mathematics tended to decline over time (Anjly et al.,; Putri & Musdi, 2025). There was a need for improvement in learning in order to enhance mathematical representation ability (Sari et al., 2023).

Thus, during the process of learning mathematics, students needed to develop their mathematical representation ability by constructing their own knowledge through a student-centered learning approach. The application of the Realistic Mathematics Education (RME) approach was regarded as one relevant alternative for addressing this problem. RME connected abstract mathematical concepts with everyday life, so that students could understand the meaning of the problems they faced and were able to represent those problems in mathematical form. Research conducted by Ridha et al. (2021) showed that the application of the Realistic Mathematics Education approach in the mathematics learning process had proven effective in improving students' conceptual understanding. In this context, the RME approach enabled students to build a deeper understanding of mathematical concepts, develop their ability to interpret contextual problems, and integrate various mathematical concepts in the process of solving those problems (Laia et al., 2025).

This indicated that the approach played an important role in helping students understand mathematical material more deeply and comprehensively, so that learning became more meaningful. Ramadhani et al. (2025) also found that the application of the Realistic Mathematics Education approach in learning had a significant effect on improving students' mathematical representation ability. These findings strengthened the empirical basis that the RME approach was a relevant and effective approach in the learning process that could be implemented more broadly in efforts to improve the quality of mathematics learning.

The effectiveness of implementing the RME approach could be significantly enhanced if supported by the use of concrete media during the learning process. Concrete learning media served as a teaching aid to facilitate the delivery of material in a tangible way, capable of bridging students' understanding from the concrete to the abstract stage of thinking. This had a significant relationship with the developmental characteristics of elementary school students, who were cognitively still at the concrete operational stage, as previously explained, where students still required concrete objects as a foundation for building their mathematical understanding. Through the use of concrete media, students did not merely listen or take notes, but also participated actively in the process of manipulating objects that represented mathematical concepts, so that the learning experience became more meaningful and contextual. Research by Misykah & Panggabean (2022) stated that the use of concrete media affected student learning outcomes, which were classified in the high category with an average score of 85, compared to learning without media. Rizqiyati et al. (2023) also stated that the use of concrete media had a significant effect on student learning outcomes.

Previous studies showed that the application of the RME approach integrated with concrete media was able to significantly improve conceptual understanding, mathematical representation ability, and student learning outcomes. However, most of these studies still had limitations in their scope, and no specific study had yet examined the effectiveness of RME assisted by DASAFA media, RME without media, and DASAFA media without RME in the context of data presentation material for third-grade elementary school students. This research gap served as the main justification for conducting this study. In this study, the RME approach was integrated with concrete media, namely the DASAFA (Dadu Sarapan Favorit/Favorite Breakfast Dice) media. The DASAFA media consisted of a set of dice themed around breakfast menus, used in groups to collect and present data. Operationally, the use of DASAFA media was designed to facilitate the three forms of mathematical representation in stages. Initially, students repeatedly rolled the DASAFA dice in groups and recorded the results of each roll in a tally table, then presented them in the form of a bar chart, thereby producing a visual representation. Next, students translated the data in the tables and diagrams into mathematical symbols, such as identifying the highest and lowest frequencies or calculating the difference and sum of data using addition operations, thereby forming a symbolic representation. In the final stage, students were asked to explain and interpret the processed data using their own sentences, for example, concluding their group's favorite breakfast based on the data obtained, thereby forming a verbal representation. Therefore, the stages of using DASAFA media were explicitly designed to integrate the training of all three indicators of mathematical representation within a single series of activities.

The DASAFA media was selected based on three pedagogical considerations. First, the DASAFA media was able to present real-life contexts closely related to students' everyday factual experiences, in line with the main principle of RME according to Gravemeijer (in Dwirahayu et al., 2020) which emphasized meaningful mathematics learning through realistic situations. The theme of favorite breakfast was an experience familiar and easily recognizable to all students. Second, the use of dice allowed students to directly manipulate concrete objects, in line with the cognitive developmental stage of elementary school students who, based on theoretical review, were still at the concrete operational stage according to Piaget's theory. Third, this media was designed for group use, encouraging students to engage in discussion and collaboration, in line with the principle of interactivity in RME according to Gravemeijer (in Dwirahayu et al., 2020). The operational differences among the three treatment groups were based on two main aspects, namely the use of DASAFA media and the RME learning approach, which connected each stage of learning with the context of students' daily lives. Group 1 (RME and DASAFA) applied both components in full. Learning began with the presentation of a contextual problem related to breakfast, followed by group-based data exploration using DASAFA, discussion of findings, and concluded with a teacher-led summary. This sequence of steps allowed all three mathematical representations to be trained meaningfully and contextually. Group 2 (RME only) followed the same learning steps, but without the manipulation of physical dice. The data used at each stage of learning came from a survey given

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to classmates regarding their favorite breakfast, which included provided pictures. This approach aimed to assess the extent to which RME learning could improve students' representation ability without prior experience in manipulating concrete objects. Group 3 (DASAFA only) still used the DASAFA dice to collect data directly, similar to Group 1, but their learning process followed a conventional approach and did not follow the RME approach. The comparison of these three treatments allowed this study to identify the contribution of concrete media and the RME learning approach, both separately and in an integrated manner, to the improvement of students' mathematical representation ability.

Therefore, the purpose of this study was to identify students' mathematical representation ability through the application of the RME approach integrated with DASAFA media, the RME approach alone, and the use of DASAFA media alone. In addition, this study also focused its examination on a comparative analysis of the effectiveness level of the three treatments in significantly improving students' mathematical representation ability in third-grade elementary school data presentation material. Furthermore, the study was conducted with the aim of examining how effectively the integration of the RME approach with DASAFA media could provide a more optimal contribution compared to the application of each treatment separately.

Method

Type of Research

This study employed a quantitative approach as the basis for its implementation, focusing on the collection and processing of data in numerical form through statistical calculation procedures in order to obtain objective answers to the questions that had been formulated in the study. Experimental research was one approach within research methodology designed to examine whether a treatment had an effect on another variable, by controlling and regulating the conditions present during the research process (Sugiyono, 2016). In its implementation, the method selected was a quasi-experimental design, also known as a quasi-experiment. This research method had been equipped with a control group as a reference; however, the control group could not yet function optimally in controlling all external variables that had the potential to affect the validity of the experiment's implementation (Sugiyono, 2016). The research design used was the nonequivalent pretest-posttest comparison-group design, in which the experimental and control groups were not determined randomly; the use of this design required the administration of a pretest to determine students' initial ability (Lestari & Yudhanegara, 2017).

This study was designed to involve three different treatment groups. The first group applied the RME approach integrated with DASAFA media, the second group used the RME approach without additional media, and the third group received learning based entirely on DASAFA media. The main objective of this study was to examine the extent to which students' mathematical representation ability had improved in the data presentation material for third-grade elementary school students. By systematically testing and comparing the results of the three different treatment groups, this study was intended to build a comprehensive and structured understanding of the contribution of each treatment, both when used individually and in combination, to the development of students' mathematical representation ability. The research design could be visualized as follows: all three treatment groups underwent an initial measurement (pretest), then each group received a different treatment for a predetermined period of time, and concluded with a final measurement (posttest). The comparison between the pretest and posttest results was used to measure the magnitude of improvement (N-Gain) in each group.

Table 1. Nonequivalent Pretest-Posttest Comparison-Group Design

Class	Pretest	Intervention	Posttest
1	O_1	X_1	O_2
2	O_3	X_2	O_4
3	O_5	X_3	O_6

A, B, and C each represented experimental group 1, experimental group 2, and experimental group 3, respectively. In experimental group 1, O1 referred to the data collected from the pretest results, which was used to identify students' initial ability prior to the learning treatment. X1 represented the learning treatment applied using the RME approach integrated with DASAFA media. O2 referred to the data obtained from the posttest results, which served as an evaluation after the intervention was implemented. Meanwhile, in experimental group 2, O3 referred to the pretest data used to identify students' initial ability before the treatment was applied. X2 represented the learning treatment implemented using the RME approach without any additional media. O4 referred to the posttest data obtained after the treatment was implemented. In group 3 of the experimental groups, O5 referred to the pretest data used to identify students' initial ability before the treatment was implemented. X3 represented the learning treatment applied using DASAFA learning media without incorporating the RME approach. O6 indicated the posttest data obtained as a final evaluation after the learning treatment was implemented.

Population and Sample

Population referred to the entire set of research subjects or objects, whether individuals, groups, institutions, or documents, possessing certain characteristics relevant to the research focus and serving as the basis for determining the scope of the research analysis (Ramadani et al., 2025). The population established in this study included all third-grade students enrolled in public elementary schools located in North Sumedang District, Sumedang Regency, in the 2025/2026 academic year. Based on data collected by the Ministry of Primary and Secondary Education (Kemendikdasmen), there were 34 public elementary schools spread throughout that district. All members of the population shared similar characteristics, including the availability of learning facilities such as projectors, status as public schools, the elementary education level, third-grade level, and geographic location within North Sumedang District. The sample determination process was carried out through purposive sampling, a sampling technique based on specific considerations and criteria formulated by the researcher. The selected sample consisted of 115 third-grade students from four public elementary schools, namely SDN Panyingkiran I, SDN Panyingkiran II, SDN Panyingkiran III, and SDN Sindang IV. All four schools were located within North Sumedang District, Sumedang Regency.

In this study, group division was determined based on the teaching treatment applied to each class. Third-grade students at SDN Panyingkiran I and SDN Panyingkiran II were designated as experimental group 1 (N = 48). Both classes received mathematics learning through the application of Realistic Mathematics Education integrated with the use of DASAFA media. Meanwhile, third-grade students at SDN Sindang IV (N = 31) were placed in experimental group 2, in which the intervention involved the application of the Realistic Mathematics Education approach without the use of additional media. Third-grade students at SDN Panyingkiran III (N = 36) were designated as group 3 in this experiment, receiving a treatment that focused on the use of DASAFA media in the learning process without specifically applying the Realistic Mathematics Education approach.

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The combining of SDN Panyingkiran I and SDN Panyingkiran II into a single treatment group (Group 1, N = 48) was carried out because the number of third-grade students at each school was fewer than 30 (26 and 22 students, respectively), which did not meet the minimum sample size requirement for a quasi-experimental study. This combination was considered valid because both schools were part of the same supervisory cluster, had relatively similar student characteristics, and were treated in the same manner, namely using the RME approach integrated with DASAFA media, with equivalent procedures and instructional duration. This approach of combining intact groups was commonly used in quasi-experimental research in education, since randomization at the individual student level could not be administratively implemented. The researchers took note of the imbalance in sample sizes among the groups (N = 48, N = 31, and N = 36) and took steps to address it by using statistical analysis methods that were robust to differences in sample size. They also reported effect sizes as additional information to complement the statistical significance values.

Instruments

This study used two types of data collection instruments, namely a test instrument and a non-test instrument. The test instrument consisted of items specifically designed to measure students' mathematical representation ability in accordance with the predetermined written indicators. The indicators measured were: visual representation, symbolic representation, and verbal representation. The non-test instrument took the form of an interest measurement questionnaire, which was filled out by students by checking the available options. The test items were designed in essay form, comprising 11 items for the pretest and 11 items for the posttest, each constructed based on a blueprint referring to the three representation indicators, with the aim of assessing the extent to which students could communicate mathematical ideas through various types of representation, including visual, symbolic, and verbal forms. Each item was equipped with a tiered scoring rubric corresponding to the level of accuracy and completeness of the representation presented by the students. The assessment of mathematical representation ability in this study was conducted in two stages, namely before (pretest) and after (posttest) the learning process took place. The first stage was carried out at the beginning of the learning activity to obtain an initial picture of students' understanding of the material to be delivered. The second stage was carried out at the end of the learning process to assess the extent of students' cognitive development and to measure the extent to which the learning objectives had been achieved.

Before being used for data collection, the test instrument was first validated by experts using a prepared validation sheet. This validation process involved three validators who were third-grade elementary school teachers. Based on the evaluation given by the three validators, the instrument was judged suitable for use as a data collection tool, with a validation score of 97.2, indicating that the instrument met the feasibility criteria and was appropriate for use in this study. Based on the validity test using Pearson's Product Moment correlation, all items of the mathematical representation ability test, both for the pretest and posttest, were found to be valid. A reliability test of the instrument was also conducted to ensure measurement consistency. The reliability of the test instrument obtained was 0.923, which fell into the very high category. The items applied in this study are presented in Table 2.

Table 2. Mathematical Representation Ability Test Items

<table>
<tr><th>Representation Ability Indicator</th><th>Pretest</th><th>Posttest</th></tr>
<tr><td>Visual Representation</td>
<td>
1. There is data on students who like various types of fruit, as follows:
• Apples liked by 12 students
• Bananas liked by 15 students
• Oranges liked by 9 students
• Mangoes liked by 7 students
• Grapes liked by 11 students
• Papayas liked by 6 students
Create a complete and neat table based on the data above!
2. Data on the number of third-grade students who bring a hat to school:
• Monday: 4 students
• Tuesday: 6 students
• Wednesday: 5 students
Create a neat and correct bar chart from the data!
3. Look at the table of the number of students who go to school using the following methods!
<table>
<tr><th>Method of Going to School</th><th>Number of Students</th></tr>
<tr><td>Walking</td><td>8</td></tr>
<tr><td>Bicycle</td><td>5</td></tr>
<tr><td>Dropped off by parents on a motorbike</td><td>7</td></tr>
<tr><td>Dropped off by parents by car</td><td>5</td></tr>
<tr><td>Public minivan</td><td>9</td></tr>
</table>
Which method of going to school is used by the fewest students?
</td>
<td>
1. On Friday, third-grade students took part in the following sports activities:
• Football joined by 18 students
• Badminton joined by 14 students
• Running joined by 16 students
• Gymnastics joined by 10 students
• Swimming joined by 12 students
• Basketball joined by 9 students
Present the data in a complete and systematic table!
2. Data on the number of third-grade students by breakfast menu:
• Rice: 6 students
• Bread: 4 students
• Fruit: 5 students
• Milk: 3 students
Convert the data into a neat and correct bar chart!
3. Look at the table of the results of third-grade waste collection!
<table>
<tr><th>Type of Waste</th><th>Total</th></tr>
<tr><td>Plastic</td><td>9</td></tr>
<tr><td>Paper</td><td>6</td></tr>
<tr><td>Cans</td><td>5</td></tr>
<tr><td>Rubber</td><td>7</td></tr>
<tr><td>Food waste</td><td>9</td></tr>
</table>
Which type of waste was collected the most?
</td></tr>
</table>

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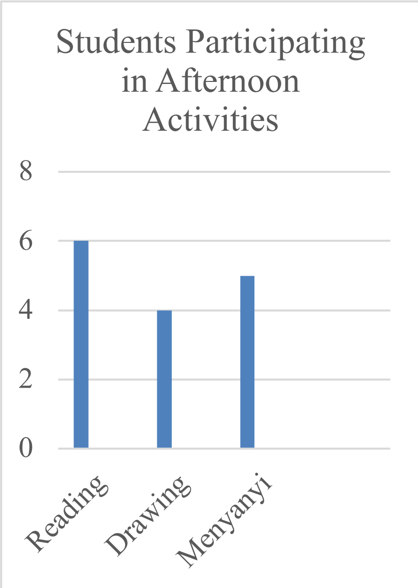
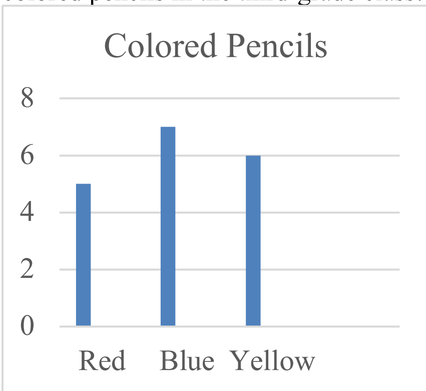
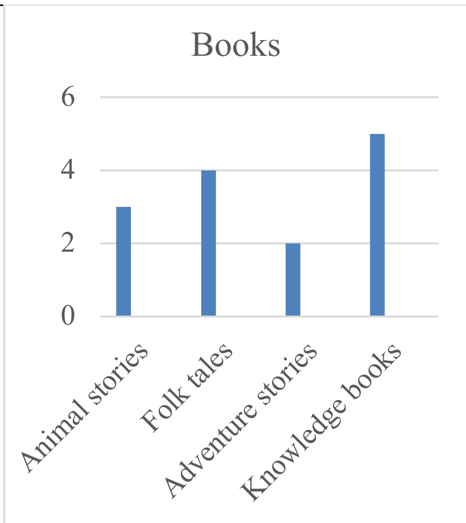
<table>
<tr><th>Representation Ability Indicator</th><th>Pretest</th><th>Posttest</th></tr>
<tr><td></td><td>4. Look at the bar chart of the number of students taking part in afternoon activities!


How many students took part in reading and singing activities?</td><td>4. Look at the bar chart of the number of colored pencils in the third-grade class!


Is the number of blue colored pencils more than 6? How many are there? Explain your answer based on the chart!</td></tr>
<tr><td>Symbolic Representation</td><td>5. Look at the following breakfast menu table!
<table>
<tr><th>Breakfast Menu</th><th>Number of Students</th></tr>
<tr><td>Fried rice</td><td>6</td></tr>
<tr><td>Egg</td><td>5</td></tr>
<tr><td>Bread</td><td>4</td></tr>
<tr><td>Cereal</td><td>3</td></tr>
</table>
How many students had breakfast with fried rice and bread?</td><td>5. Look at the breakfast menu table of third-grade students!
<table>
<tr><th>Breakfast Menu</th><th>Number of Students</th></tr>
<tr><td>Rice</td><td>7</td></tr>
<tr><td>Egg</td><td>5</td></tr>
<tr><td>Fried fish</td><td>4</td></tr>
<tr><td>Milk</td><td>5</td></tr>
<tr><td>Fruit</td><td>6</td></tr>
</table>
ow many students had breakfast with rice, egg, and fruit?</td></tr>
<tr><td></td><td>6. Look at the bar chart of the number of books in the third-grade reading corner!</td><td>6. Look at the bar chart of stationery in the class!</td></tr>
</table>

Representation Ability Indicator	Pretest	Posttest

Pretest



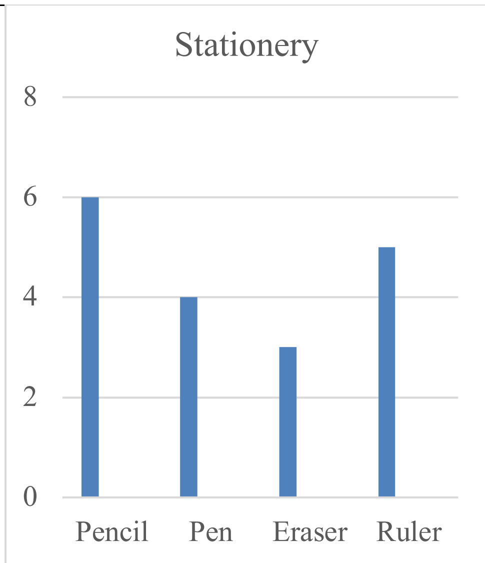
Add up all the data in the bar chart, then write down the result!

7. Look at the table of the number of Andi's pets!

Type of Animal	Total
Rabbits	22
Fish	6
Birds	14
Chickens	8

What is the difference between the number of rabbits and chickens?

Posttest



How many stationery items are there in total in the bar chart?

7. Look at the table of the number of students participating in art activities!

Art Activity	Number of Students
Dancing	26
Singing	9
Playing music	11
Painting	17

Calculate the difference between the number of students participating in painting and singing?

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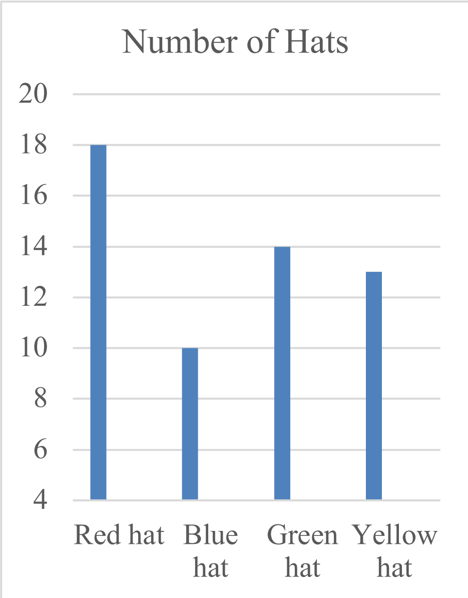
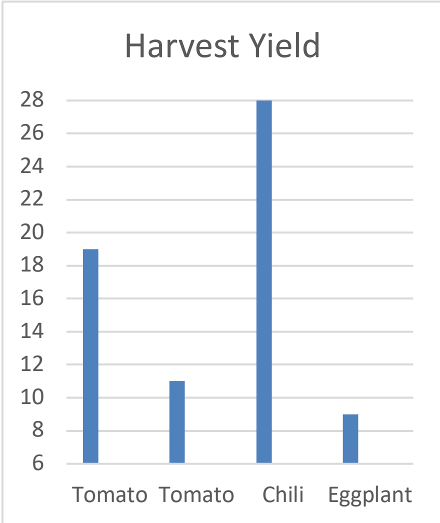
Representation Ability Indicator	Pretest	Posttest
	8. Look at the bar chart of the number of colored hats in the third-grade class!	8. Look at the bar chart of the harvest results in the school garden!

Pretest 8:



What is the difference between the number of yellow hats and blue hats?

Posttest 8:



What is the difference between the number of chilies and carrots**?**

Verbal Representation

Pretest 9. Look at the table of types of snacks purchased by third-grade students!

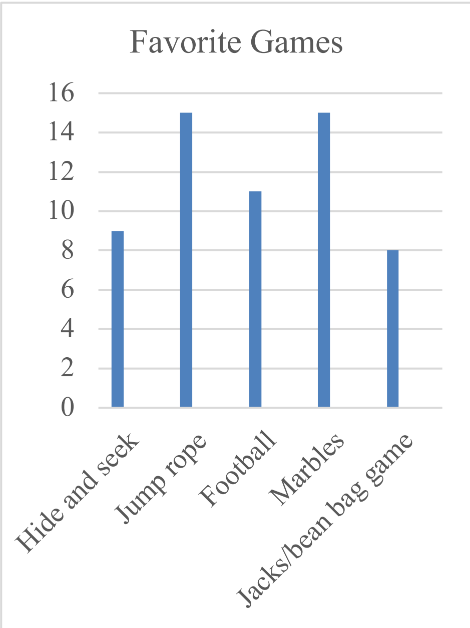
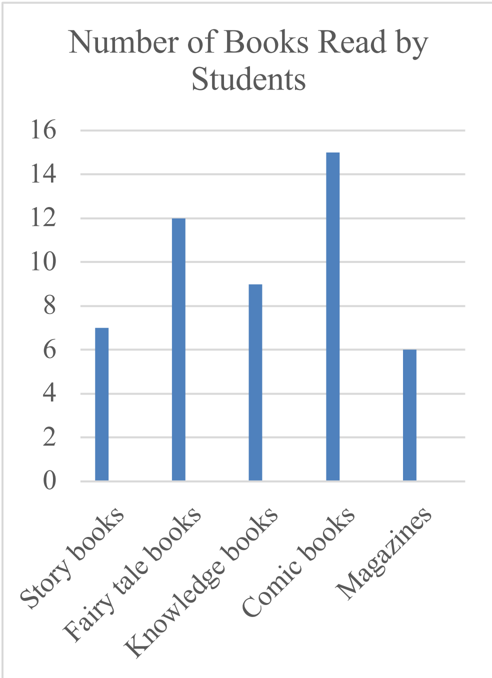
Type of Snack	**Number of Students**
Chiki	7
Batagor	12
Pentol	5
Rolled egg	9
Sempol	8

Write 2 sentences about the snacks that were purchased the most based on the table!

Posttest 9. Look at the table of third-grade students' habits on holidays!

Kebiasaan	**Number of Students**
Watching TV	6
Helping parents	11
Playing	14
Reading books	5
Exercising	9

Write 2 simple sentences explaining students' habits based on the table!

<table>
<tr><th>Representation Ability Indicator</th><th>Pretest</th><th>Posttest</th></tr>
<tr><td></td>
<td>10. Look at the bar chart of the number of third-grade students' favorite games!

Write 2 simple sentences explaining the games most liked by students based on the bar chart, and mention the numbers!</td>
<td>10. Look at the bar chart of the number of books read by students over one week!

Write 2 simple sentences explaining students' reading habits based on the bar chart!</td></tr>
<tr><td></td>
<td>11. Look at the mathematics test scores of five students below!
<table><tr><th>Name</th><th>Score</th></tr><tr><td>Ani</td><td>85</td></tr><tr><td>Budi</td><td>78</td></tr><tr><td>Citra</td><td>90</td></tr><tr><td>Dedi</td><td>80</td></tr><tr><td>Evi</td><td>88</td></tr></table>
Write 3 sentences clearly explaining who got the highest score!</td>
<td>11. Look at the science test scores of five students below!
<table><tr><th>Name</th><th>Score</th></tr><tr><td>Fajar</td><td>75</td></tr><tr><td>Gita</td><td>88</td></tr><tr><td>Hendra</td><td>92</td></tr><tr><td>Indah</td><td>85</td></tr><tr><td>Joko</td><td>80</td></tr></table>
Write 3 sentences explaining the order of scores from highest to lowest, and who got the highest score!</td></tr>
</table>

An attitude scale questionnaire was used as a tool to gain an understanding of students' responses and opinions regarding the learning treatments applied during the research activities. The questionnaire in this study was used to determine students' interest in the three learning treatments, namely the application of the RME approach integrated with DASAFA media, the RME approach alone without any media, and learning supported only by DASAFA media. The questionnaire instrument was designed using a Likert scale with four response options, namely Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). The neutral option was deliberately omitted from the scale to encourage students to provide more definite assessments, thereby ensuring that the data collected were more valid and scientifically

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accountable. The neutral option was deliberately omitted to encourage students to give more decisive assessments. The questionnaire consisted of 20 statement items (14 positive statements and 6 negative statements with reverse scoring), covering the following aspects: (1) feelings of enjoyment toward learning, (2) courage and self-confidence, (3) active engagement, and (4) diligence in learning. The questionnaire on students' interest in mathematics learning through the application of the Realistic Mathematics Education approach integrated with DASAFA media, as implemented in this study, is presented in Table 3.

Table 3. Likert Scale Questionnaire on the Application of the Realistic Mathematics Education Approach Integrated with DASAFA Media

Learning Interest Indicator	Statement Type	Statement
Feeling of enjoyment	Positive	I enjoy learning mathematics by relating it to daily life and DASAFA media
Interest		I am interested in learning using DASAFA media
Courage		I dare to ask the teacher when I do not understand
		I dare to ask friends during discussions
		I dare to express my opinion in front of the class
Engagement		I enjoy working together with friends
Feeling of enjoyment		I feel that learning becomes more enjoyable
Interest		I am interested in reading tables or diagrams
Diligence		I do not give up easily when working on problems
Interest		I want to get good grades in mathematics
Attention		I focus when the teacher explains
Feeling of enjoyment		I feel that learning time passes quickly because it is enjoyable
Courage		I am confident in answering questions
Low interest (negative indicator)	Negative	I feel bored when learning mathematics by relating it to daily life and DASAFA media
		I am not interested in participating in discussion activities
		I am lazy about using DASAFA media
		I do not dare to ask even when I do not understand
		I find the lesson difficult to understand
		I want the lesson to end soon

Figure 1. DASAFA Media

Procedure and Data Collection

Data collection in this study was carried out through written tests consisting of a pretest and a posttest to measure the level of students' mathematical representation ability. The pretest was administered before the learning treatment was applied as an effort to obtain an initial picture of students' baseline ability, while the posttest was administered after all treatments had been completed to provide final data reflecting the development of students' ability. The data collected were quantitative in nature and came from three experimental groups, each of which received a different treatment, thereby enabling a systematic comparison among the groups.

The implementation of the study consisted of three main stages. In the first stage, an initial test (pretest) was administered to all groups to obtain an initial understanding of students' mathematical representation ability. In the second stage, all three groups received the learning treatment over three meetings (each lasting 2 × 35 minutes) covering the data presentation material. Group 1 (RME + DASAFA) underwent five phases of RME learning, namely orientation to the contextual problem, exploration using DASAFA media, group discussion, presentation of representations, and reflection. DASAFA media was used to collect real data, which was then presented in the form of tables and bar charts, analyzed for the highest and lowest values, summed, compared for the difference between two data points, and used to construct sentences about the data obtained. Group 2 (RME without DASAFA) followed the same five RME phases, but used data that had to be obtained by surveying classmates about their favorite breakfast, which had been presented on a worksheet, without physically manipulating dice. Group 3 (DASAFA without RME) used DASAFA to collect data and present it in the requested format, without following the structured pedagogical guidance of RME. In the third stage, a final ability test (posttest) was administered to all groups to measure the final achievement of mathematical representation ability, and all students completed the learning interest questionnaire regarding the treatment they had received.

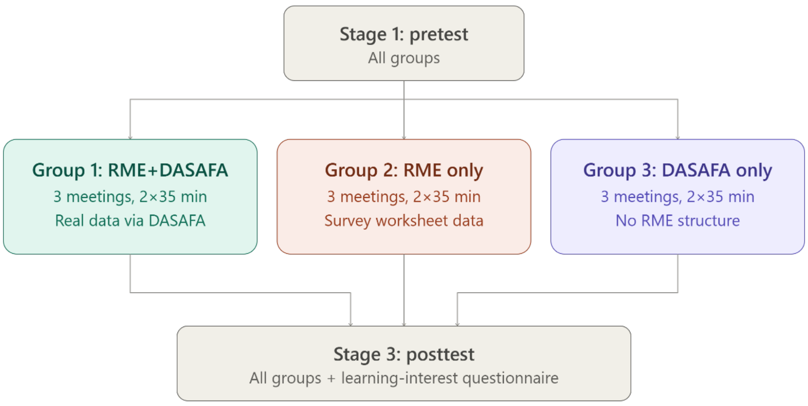

Figure 2. Research Procedure Flowchart

Data Analysis

Data analysis was carried out in several stages. First, descriptive statistics were used to describe the characteristics of the data for each group, including the mean, highest score, and lowest score. Second, prerequisite tests were conducted, including a normality test using the Shapiro-Wilk test and a homogeneity test using Levene's test, to determine the appropriate type of inferential statistics. Third, because the data did not simultaneously meet the assumptions of normality and homogeneity, hypothesis testing was carried out using the H-Test (Kruskal-Wallis), a nonparametric test used to compare differences among three independent groups. Fourth, N-Gain was calculated to measure the magnitude of improvement in mathematical representation ability for each group. Fifth, the coefficient of determination (R^2) was calculated through simple regression between pretest and posttest scores within each group to measure the proportion of the increase in posttest scores that could be explained by the initial condition and

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the treatment given within that group. This R^2 value was used as a relative measure of each treatment's contribution to the improvement of mathematical representation ability, not as a measure of causality between different variables.

Research Findings

Implementation of DASAFA Media

DASAFA (Dadu Sarapan Favorit / Favorite Breakfast Dice) media was a learning aid in the form of a die, each side of which was covered with a different picture of a breakfast menu, such as chicken porridge, bread, vegetable lontong, fried rice, uduk rice, and cereal. This media was designed so that students could collect real and concrete data on their favorite breakfast choices before the data was processed into a mathematical representation.

The implementation of DASAFA media in this study was carried out through the following steps:

1. Equipment preparation. Each small group consisting of 3-4 students was given one DASAFA die, which had six sides, each displaying a different breakfast menu picture.
2. Data collection through dice rolling. The die was rolled in turn by group members for a predetermined number of rolls, and each time the die stopped, the breakfast menu shown on the top face was recorded as one data point.
3. Data recording. The results of each roll were recorded by students on a provided worksheet, producing a set of real data from their own group experiment.
4. Data presentation. The data from the dice rolls were then presented by the students in the form of visual representations such as frequency tables and bar charts, with the horizontal axis showing the type of breakfast menu and the vertical axis showing the frequency of occurrence.
5. Data analysis. Students analyzed the presented data into symbolic and verbal representations, which included identifying the most and least frequently consumed breakfast menus, calculating totals, finding the difference between two sets of data, and composing narrative sentences explaining the meaning of the data obtained.

In Group 1 (RME + DASAFA), the use of this media was integrated into the exploration phase of the RME learning process. Students first received orientation to a contextual problem, such as a question about their favorite breakfast menu. They then rolled the DASAFA dice to collect data directly, discussed the results in groups, presented the data representations they had created, and concluded with reflection. In Group 3 (DASAFA without RME), the same dice media was used along with similar technical steps for data collection and presentation, but it was not guided by the stages of the RME approach—there was no contextual problem orientation, structured group discussion, presentation, or reflection—so the activity tended to be more instructional/procedural in nature, following the instructions on the worksheet. As a distinguishing factor, Group 2 (RME without DASAFA) did not use DASAFA. Data on favorite breakfast menus in this group was obtained through a direct survey given to classmates, and the results were then written on a worksheet without involving a physical manipulative activity such as rolling dice.

Pretest of the Three Experimental Groups

This section presents a comparative analysis of students' mathematical representation ability before treatment (pretest) across the three different treatment groups. This analysis aimed to describe students' initial mathematical representation ability before the learning treatment was applied. A comparison of students' initial ability across the three groups needed to be conducted before the treatment was implemented. This step ensured that any differences observed in the pre-treatment results could be attributed with certainty to the treatment itself, rather than to pre-existing differences in initial ability. A summary of the pretest results for the three experimental groups is presented in Table 4.

Table 4. Pretest Scores of the Three Experimental Groups

Experimental Group	N	Max. Score	Max. Score	Mean
RME + Media DASAFA	48	94	17	52,50
RME (Without Media)	31	87	15	41,87
Media DASAFA (Without RME)	36	62	19	37,31

Based on the table presented above, there was a difference in the mean initial mathematical representation ability scores among the three groups before the treatment was given, in which the first experimental group applying RME integrated with DASAFA media obtained a mean score of 52.50 with a highest score of 94 and a lowest score of 17, the second experimental group using the RME approach without additional media obtained a mean score of 41.87 with a highest score of 87 and a lowest score of 15, and the third experimental group using only DASAFA media obtained a mean score of 37.31 with a highest score of 62 and a lowest score of 19. These findings indicated that the RME class assisted by DASAFA media had a superior initial ability compared to the other two classes; in order to prove whether this difference was statistically significant, further in-depth statistical analysis testing was required.

Normality Test of the Pretest for the Three Experimental Groups

The first step before carrying out further statistical procedures was the normality test, which aimed to determine whether the subsequent analysis should use a parametric or nonparametric statistical approach. Data were declared normally distributed if the Sig. value was ≥ 0.05 (H_0 accepted), whereas a Sig. value < 0.05 indicated a non-normal distribution (H_1 accepted). The results of the normality test are presented in Table 5.

Table 5. Normality Test of Pretest Scores for the Three Experimental Groups

Experimental Group	N	Statistics	Sig.	Description
RME + Media DASAFA	48	0,972	0,307	Normal
RME (Without Media)	31	0,957	0,248	Normal
Media DASAFA (Without RME)	36	0,949	0,100	Normal

The results of the normality test for the pretest scores of the three experimental groups are presented in Table 5 above. All three classes obtained significance values exceeding 0.05 (0.307, 0.248, and 0.100, respectively), so that H_0 was accepted in all groups. Thus, the pretest data from the three experimental classes were concluded to be normally distributed.

Homogeneity Test of the Pretest for the Three Experimental Groups

The homogeneity test was conducted to identify whether the variance of the data among the groups was homogeneous or not. Data were considered homogeneous if the Sig. value was ≥ 0.05 (H_0 accepted), and not homogeneous if the Sig. value was < 0.05 (H_1 accepted). The results of this test are presented in Table 6.

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Table 6. Homogeneity Test of Pretest Scores for the Three Experimental Groups

Pretest Results of the Three Experimental Groups	Levene Statistic	df1	df2	Sig.
Based on Mean	9.070	2	112	0,000
Based on Median	8.625	2	112	0,000
Based on Median and with adjusted df	8.625	2	99.887	0,000
Based on trimmed mean	9.084	2	112	0,000

As shown in Table 6, all variants of Levene's test obtained a significance value of 0.000, which was below the 0.05 threshold, so that H_0 was rejected. This indicated that the variance of the pretest scores among the three experimental groups was not equal, or not homogeneous. Therefore, a nonparametric statistical approach was used for the subsequent mean difference testing.

H-Test (Kruskal-Wallis) of the Pretest for the Three Experimental Groups

The test of mean differences among the three experimental groups was conducted using the H-Test (Kruskal-Wallis), given that the data did not meet the assumption of homogeneity. The results are presented in Table 7.

Table 7. H-Test (Kruskal-Wallis) of Pretest Scores for the Three Experimental Groups

	Pretest Results
Chi-Square	59,721
df	2
Asymp Sig.	,000

The Asymp. Sig. value of $0.000 < 0.05$ indicated that H_0 was rejected, which meant that a significant gap was found among the pretest scores of the three experimental groups.

Posttest of the Three Experimental Groups

This section presents a comparative analysis of students' final mathematical representation ability (posttest) across the three experimental groups. This analysis aimed to identify the treatment that was most successful in optimally improving students' mathematical representation ability.

Table 8. Posttest Scores of the Three Experimental Groups

Experimental Group	N	Max. Score.	Min. Score	Mean
RME + Media DASAFA	48	100	26	80,29
RME (Without Media)	31	100	42	74,32
Media DASAFA (Without RME)	36	100	60	83,25

Based on the recapitulation of posttest scores presented in Table 8, the group using the RME approach integrated with DASAFA media obtained a mean score of 80.29, with a minimum score of 26 and a maximum of 100. The RME group recorded a mean of 74.32, while the DASAFA media class achieved the highest mean among the three, namely 83.25, with a minimum score of 60 and a maximum of 100. The difference in mean scores indicated variation in students' mathematical representation ability across all experimental groups after the treatment stage had been implemented, with the DASAFA media group showing the highest posttest achievement. Nevertheless, further statistical testing was needed to confirm its significance.

Normality Test of the Posttest for the Three Experimental Groups

The normality test was applied with the aim of identifying whether the subsequent analysis should use a parametric or nonparametric statistical approach. The results of the normality test are presented in Table 9.

Table 9. Normality Test of Posttest Scores for the Three Experimental Groups

Experimental Group	N	Statistics	Sig.	Description
RME + Media DASAFA	48	0,847	0,000	Unnormal
RME (Without Media)	31	0,972	0,566	Normal
Media DASAFA (Without RME)	36	0,949	0,100	Normal

Based on Table 9, the RME group integrated with DASAFA media obtained a Sig. value of 0.000 < 0.05 (not normal), while the RME group (Sig. 0.566) and the DASAFA media group (Sig. 0.100) both produced values ≥ 0.05 (normal). Because one of the classes did not meet the assumption of normality, the data as a whole were declared not to meet the requirement of a normal distribution, thus requiring nonparametric statistical testing.

Homogeneity Test of the Posttest for the Three Experimental Groups

Following the normality test, a homogeneity test was conducted to examine whether the variance of the data among the groups was equal, which served as a prerequisite before hypothesis testing.

Table 10. Homogeneity Test of Posttest Scores for the Three Experimental Groups

Posttest Results of the Three Experimental Groups	Levene Statistic	df1	df2	Sig.
Based on Mean	4.631	2	112	.012
Based on Median	2.240	2	112	.111
Based on Median and with adjusted df	2.240	2	82.645	.113
Based on trimmed mean	3.611	2	112	.030

As presented in Table 10, Levene's test based on the mean produced a Sig. value of 0.012 < 0.05, so that H_0 was rejected. This condition indicated that the posttest scores across the three experimental groups had unequal, or non-homogeneous, variances.

H-Test (Kruskal-Wallis) of the Posttest for the Three Experimental Groups

Given that the data were not normally distributed and were not homogeneous, the test of mean differences among the three independent experimental groups was conducted using the Kruskal-Wallis test (H-test) at a significance level of $\alpha = 0{,}05$.

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Table 11. H-Test (Kruskal-Wallis) of Posttest Scores for the Three Experimental Groups

	Posttest Results
Chi-Square	7.267
df	2
Asymp Sig.	.026

As presented in Table 11, the test produced an Asymp. Sig. value of 0.026 < 0.05, so that H_0 was rejected. This confirmed that a significant gap was found in the posttest scores among the RME group integrated with DASAFA media, the RME group, and the DASAFA media group.

N-Gain of the Three Experimental Groups

N-gain was calculated to determine the difference in the level of improvement among the three experimental classes. Given the non-normal distribution of the data, the Kruskal-Wallis test (H-test) was applied at $\alpha = 0{,}05$.

Table 12. N-Gain of the Three Experimental Groups

	N-Gain
Chi-Square	9.898
df	2
Asymp Sig.	.007

As presented in Table 12, the N-Gain scores produced an Asymp. Sig. value of 0.007 < 0.05, so that H_0 was rejected. This finding reflected a significant gap in the development of mathematical representation ability among the three experimental groups. Given that the results of the Kruskal-Wallis test showed a significant difference in n-gain scores among the three experimental groups, a partial post-hoc test was conducted to identify which pairs of groups exhibited that difference. The comparison between the RME group integrated with DASAFA media and the RME group using the Mann-Whitney test produced an Asymp. Sig. (2-tailed) value of 0.222 (> 0.05), indicating that there was no significant difference between the two. A similar comparison between the RME group integrated with DASAFA media and the DASAFA media group also produced an Asymp. Sig. (2-tailed) value of 0.075 (> 0.05), meaning that no significant difference was found. In contrast, the comparison between the RME group and the DASAFA media group using the Independent Sample T-Test (assuming unequal variances, given that Levene's Test result showed Sig. 0.043 < 0.05) produced a Sig. (2-tailed) value of 0.001 (< 0.05), indicating a significant difference, with the mean n-gain of the DASAFA media group (0.7358) being higher than that of the RME group (0.5610). Thus, the significant difference detected in the overall Kruskal-Wallis test originated from the difference between the RME group and the DASAFA media group, while the RME group integrated with DASAFA media did not show a significant difference from either of the other two comparison groups.

Coefficient of Determination of the Three Experimental Groups

To determine the extent to which each treatment contributed to the improvement of students' mathematical representation ability, the coefficient of determination (R^2) was utilized. The coefficient of determination was obtained from a regression analysis between the N-gain score as the dependent variable and the treatment group as the independent variable, which was coded using dummy variables. The R^2 value indicated the proportion of variance in the improvement of mathematical representation ability that could be explained by the applied treatment. Based on the results of the analysis, the group that received the Realistic Mathematics Education (RME) approach integrated with DASAFA media contributed 48.3% to the improvement of students' mathematical representation ability. The group using the RME approach alone contributed 38%, whereas the group using only DASAFA media contributed 15.4%. A higher coefficient of determination for each group signified a larger proportion of the improvement in students' mathematical representation ability that could be explained by the applied treatment.

Student Interest Questionnaire of the Three Experimental Groups

An analysis of the mathematics learning interest questionnaire was conducted across three experimental groups to identify differences in student interest levels based on the respective treatments applied. In the group utilizing the Realistic Mathematics Education (RME) approach integrated with DASAFA media, the questionnaire results from 48 students revealed an overall percentage of 79.06% (high category), with the response distribution as follows: 37.5% strongly agreed, 60.42% agreed, and 2.08% disagreed. In the RME group, the questionnaire results from 31 students showed a percentage of 77.65% (high category), with 32.26% of students strongly agreeing and 67.74% agreeing; no negative responses were recorded. In the DASAFA Media group, the questionnaire results from 36 students demonstrated the highest overall percentage at 87.03% (very high category), with the majority of students strongly agreeing (80.56%) and the remainder agreeing (19.44%). Overall, all three experimental groups exhibited positive interest toward mathematics learning. The class receiving the standalone DASAFA media treatment achieved the highest interest score, indicating that the instructional media possessed a strong appeal among students and effectively stimulated their engagement in the mathematics learning process.

Research Implementation

This study was conducted in three main stages: the preparation stage, the treatment implementation stage, and the final measurement stage. During the preparation stage, all experimental groups took a pretest to measure students' initial mathematical representation ability prior to the implementation of the learning treatments. The three experimental groups comprised: (1) the RME group integrated with DASAFA media (n = 48), (2) the RME group without any additional media (n = 31), and (3) the DASAFA media group without the RME approach (n = 36). During the treatment implementation phase, each group received a different learning treatment in accordance with the established experimental design. The first group applied the RME approach integrated with DASAFA instructional media, in which students were guided to develop mathematical concepts through real-life contexts facilitated by concrete media. The second group applied the RME approach independently without utilizing any supplementary media, whereas the third group solely used DASAFA as an instructional medium without integrating RME principles. All treatments were administered over a duration of three sessions across all groups to ensure comparable results.

The administration of the interest questionnaire was carried out during the third treatment session. After all treatment sessions were completed, the final measurement stage was conducted by administering a posttest to all students in the three experimental groups. The collected data were then statistically analyzed to assess the improvement in students' mathematical representation ability as well as differences in their learning interest among the three groups. A comparison of the pretest and posttest mean values, along with the student interest scores across the three experimental groups, is presented in Figures 3 and Figures 4.

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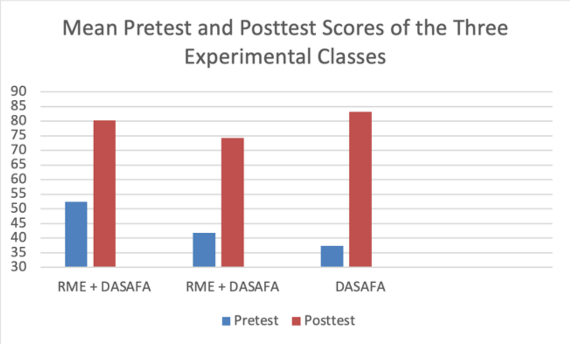

Figure 3. Mean Pretest and Posttest Scores of the Three Experimental Classes

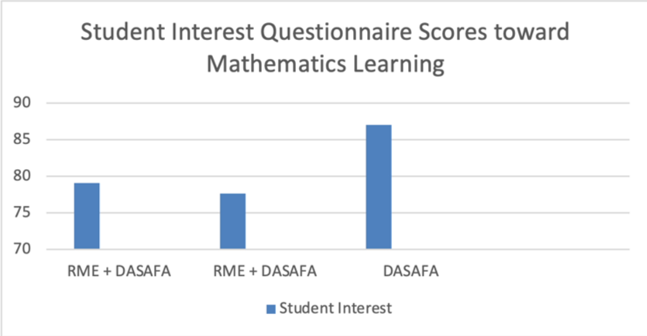

Figure 4. Student Interest Questionnaire Scores toward Mathematics Learning

Discussion

Based on the results of the data analysis conducted, students' mathematical representation ability in the group using the RME approach integrated with DASAFA media showed improvement across all three indicators measured, with all three falling into the moderate category. The highest achievement was observed in the visual representation indicator, which could be understood as the result of a synergy between the real-problem context in the RME approach and the direct visualization facilitated by DASAFA media. However, it should be noted that the DASAFA media group actually achieved the highest visual result among all groups, indicating that concrete media played a more dominant role in shaping students' visual understanding compared to the contextual approach alone. Meanwhile, symbolic representation obtained the lowest score (44.75%) because students still experienced difficulty translating mathematical concepts into formal symbols. This situation was further reinforced by the results of the learning interest questionnaire, which fell into the high category (79.06%), indicating that learning supported by concrete media proved effective in fostering students' motivation and enthusiasm for learning mathematics. This finding was consistent with the study by Kusumaningrum & Nuriadin (2022) which emphasized that students' mathematical representation ability improved more effectively when the RME approach was applied together with concrete media, because the combination of the two supported the development of mathematical representation more comprehensively. Nur Aliffia et al. (2025) also stated that the implementation of the RME approach assisted by concrete media contributed significantly to improving mathematics learning outcomes; in addition, students also participated during the ongoing learning process, were active in learning, and showed improved understanding of the material.

In the group using only the RME approach, all three mathematical representation indicators also fell into the moderate category. Visual representation remained the indicator with the highest achievement, although its achievement was not as high as that of the DASAFA media group, which again supported the assumption that the presence of concrete media directly contributed to the development of students' visual representation. The verbal and symbolic representation indicators showed lower achievement, with symbolic representation reaching only 40%, reflecting students' limitations in expressing mathematical ideas both in writing and through formal symbols, which was closely related to their not-yet-fully-developed mathematical literacy skills. Nevertheless, the results of the learning interest questionnaire in this class remained in the high category (77.65%), indicating that the RME approach without additional media was still able to foster students' interest in learning mathematics. This finding was consistent with Apriyanti et al. (2023) who stated that the application of RME could make students more active in class, foster a sense of enthusiasm, develop problem-solving ability, and enable students to understand mathematical concepts connected to real situations in daily life. Ramadhani et al. (2025) explained that the RME approach could improve mathematical representation ability and contribute to each of its indicators, namely visual, symbolic, and verbal representation. Ulfa & Liesdiani, (2025) also stated that the use of RME had been shown to encourage improvement in student learning outcomes, particularly in problem-solving ability.

In the group using DASAFA media, the visual representation indicator reached the high category with a score of 76.75%, making it the highest achievement among all experimental groups. This finding indicated that the concrete and directly manipulable nature of DASAFA media played an important role in shaping students' visual representation, even without a structured pedagogical framework such as RME. Students were able to engage deeply and repeatedly with the learning media, enabling a faster and more consistent visual understanding of mathematical concepts across all students, regardless of their initial ability. The verbal and symbolic representation indicators in this group showed better development compared to the other two groups, although challenges in expressing mathematical ideas in a structured written form still remained, indicating that without a systematic pedagogical approach, the development of verbal and symbolic representation had not yet reached its optimal level. This group also achieved the highest interest score among the three groups, with 87.03% falling into the "very high" category, indicating that DASAFA media had a significant appeal in creating an enjoyable and motivating learning experience. This finding was consistent with the study by Septiati et al. (2022) which explained that concrete media could improve and train students' mathematical representation ability to solve problems and represent solutions to a problem. Nurul Laily et al. (2023) also suggested that in learning with concrete media, students' interest in learning mathematics began to increase, and students were very active and enthusiastic in the ongoing learning process.

Overall, the results of the partial post-hoc test showed that the significant difference detected in the Kruskal-Wallis test for the n-gain data actually originated only from the comparison between the RME group and the DASAFA media group, with the DASAFA media group obtaining a higher mean n-gain (0.7358) than the RME group (0.5610). Meanwhile, the RME group integrated with DASAFA media did not show a significant difference compared to either the pure RME group or the pure DASAFA media group. This finding indicated that, statistically, the three treatments produced relatively equivalent improvements in mathematical representation ability at a significance level of 0.05, so that conclusions regarding which treatment was "most superior" needed to be viewed from different perspectives, rather than drawn as a single conclusion.

When viewed in terms of the magnitude of the mean improvement (n-gain), the DASAFA media group was numerically superior across all mathematical representation indicators, indicating that concrete media alone was able to drive rapid and substantial improvement. However, when viewed in terms of the consistency of the treatment's effect on the improvement of students' ability, as reflected in the coefficient of determination values, the RME group integrated with DASAFA media actually showed the highest contribution (48.3%), compared to the RME group (38%) and the DASAFA media group (15.4%). This meant that the integration of RME and DASAFA media produced an effect that was more predictable and more closely related to students' initial ability, even though its mean improvement was not as high as that of the DASAFA media group. Thus, the advantage of each treatment depended on the evaluation criteria used: DASAFA media was superior in terms of the magnitude and evenness of improvement (n-gain), while RME assisted by DASAFA media was superior in

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terms of the consistency and predictability of its effect (coefficient of determination). The high level of learning interest across all groups also indicated that both the contextual approach and concrete media were equally capable of creating a positive learning atmosphere, so that the selection of a learning treatment in the field should be adjusted to the learning objectives, student characteristics, and available time, rather than being based solely on a single measure of statistical superiority.

Conclusion

This study examined the effectiveness of three learning treatments on the mathematical representation ability of third-grade elementary school students on data presentation material. In general, all three approaches used, namely the RME approach integrated with DASAFA media, the RME approach without additional media, and the use of DASAFA media without the RME approach, were each proven effective in improving students' mathematical representation ability. However, the pattern and level of improvement varied significantly among the three groups. The group using DASAFA media without the RME approach achieved the highest score on the visual representation indicator among all experimental groups. This indicated that concrete media, which could be manipulated directly, had an advantage in helping students develop a quick and consistent visual understanding. Nevertheless, this advantage in the visual aspect was not accompanied by a consistent improvement across all mathematical representation indicators as a whole, as shown by that group's coefficient of determination, which amounted to only 15.4%. The RME group without additional media showed a more structured improvement compared to the DASAFA media group, with a coefficient of determination of 38%, although its achievement on the symbolic and verbal representation indicators remained relatively low due to students' limitations in expressing mathematical ideas formally and in writing.

The results of the partial post-hoc test showed that the significant difference in the n-gain among the three experimental groups specifically originated only from the comparison between the RME group and the DASAFA media group, with the DASAFA media group achieving a higher mean n-gain (0.7358) than the RME group (0.5610). In contrast, the RME group integrated with DASAFA media did not show a significant difference from either the RME group or the DASAFA media group, which meant that, statistically, the three treatments produced relatively equivalent improvements in mathematical representation ability. Therefore, conclusions regarding which treatment was most effective needed to be reviewed based on the criteria used. When viewed in terms of the magnitude of the mean improvement (n-gain), DASAFA media showed the highest results across all mathematical representation indicators. However, when viewed in terms of the consistency and predictability of the treatment's effect on the improvement of students' ability, as indicated by the coefficient of determination, the RME approach integrated with DASAFA media provided the highest contribution (48.3%) compared to the RME approach (38%) and DASAFA media (15.4%). Thus, DASAFA media was superior in terms of the magnitude and evenness of the improvement in mathematical representation ability, while the integration of RME with DASAFA media was superior in terms of the consistency of the treatment's effect on students with varying initial abilities. Beyond the cognitive aspect, all experimental groups showed a high level of learning interest, with the DASAFA media group achieving the highest interest score, confirming that the use of concrete media was consistently able to create an enjoyable learning experience and increase students' active participation in learning mathematics.

Theoretically, this study contributed by presenting empirical evidence that combining the RME approach with concrete media grounded in the context of students' daily lives could improve mathematical representation ability more comprehensively than the use of either component separately. In practice, this study offered an alternative approach to learning that was contextual, interactive, and could be applied by elementary school teachers, with the aim of improving students' mathematical representation ability, particularly in data presentation material. However, there were a number of limitations in this study that needed attention, namely the absence of a control group for comparison, which meant that the effectiveness of the treatments could not be directly compared with a learning condition without any intervention at all. In addition, there remained room to further improve students' verbal and symbolic representation abilities, as these aspects showed a tendency toward smaller gains compared to visual representation, indicating that future research could explore more targeted strategies to support the development of these specific abilities. Therefore, teachers were encouraged to integrate the Realistic Mathematics Education approach integrated with DASAFA media as an alternative learning approach while simultaneously increasing attention to the development of students' symbolic and verbal representation abilities. For future researchers, it was recommended to refine the research design by including a control group, developing more comprehensive instruments, and expanding the study to other mathematics topics so that the findings could be generalized more broadly.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Auhor Contributions

V.S.N.S. conceived the research idea, collected the data, and was actively involved in the organization and analysis of the data. M and I actively participated in the development of the theory, methodology, data organization and analysis, and discussion of the research results. All authors declared that the final version of this article had been read and approved. The total percentage of contributions to the conceptualization, drafting, and correction of this paper was as follows: V.S.N.S.: 40%, M.: 30%, and I.: 30%.

Data Availability Statement

The authors stated that data sharing was not applicable, as no new data were created or analyzed in this study.

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