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The Effectiveness of RME Based Learning on Junior High School Students' Mathematical Procedural Fluency and Mathematical Disposition

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Abstract
This study aimed to examine the differences in mathematical procedural fluency and mathematical disposition between students who received instruction using the RME approach and those taught using the expository approach. The type of research employed was a quasi-experimental study with a posttest-only control group design. The subjects consisted of two seventh-grade classes at SMP Negeri 13 Pekalongan. The instruments used included an essay test and a Likert-scale questionnaire. Data analysis was carried out using the R software. The assumption tests applied were the Shapiro–Wilk test for univariate normality, the Henze–Zirkler test for multivariate normality, the F-test for univariate homogeneity, and Box's M test for multivariate homogeneity. Hypothesis testing was conducted using Hotelling's T^2 *test for multivariate analysis. The result showed a p-value of 8.02e-06 < 0.05, indicating a significant difference between the two groups. Follow-up analysis using the Mann–Whitney U test revealed a significant difference in procedural fluency (p = 3.21e-05), while the independent t-test showed no significant difference in mathematical disposition (p = 0.3207). The mean score for procedural fluency in the RME class was higher than that of the expository class. These findings suggest that the RME approach is more effective in improving students' procedural fluency, although it has not yet shown a significant effect on mathematical disposition.*

Kata Kunci:
Disposisi matematika
Kelancaran prosedural
RME

Abstrak
Penelitian ini bertujuan untuk mengetahui perbedaan kelancaran prosedural matematis dan disposisi matematis antara siswa yang memperoleh pembelajaran menggunakan pendekatan RME dan pendekatan ekspositori. Jenis penelitian yang digunakan adalah kuasi eksperimen dengan desain posttest-only control group. Subjek penelitian terdiri dari dua kelas VII di SMP Negeri 13 Pekalongan. Instrumen yang digunakan meliputi tes uraian dan angket skala

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*Likert. Analisis data dilakukan menggunakan program R. Uji asumsi yang digunakan meliputi Shapiro-Wilk untuk normalitas univariat, Henze-Zirkler untuk normalitas multivariat, uji F untuk homogenitas univariat, dan Box's M untuk homogenitas multivariat. Uji hipotesis dilakukan menggunakan Hotelling's T^2 untuk analisis multivariat. Hasil uji menunjukkan nilai p sebesar 8.02e-06 < 0,05, sehingga terdapat perbedaan signifikan antara kedua kelompok. Analisis lanjutan menggunakan Mann-Whitney U menunjukkan terdapat perbedaan signifikan pada kelancaran prosedural (*p *=3.21e-05), sedangkan independent t-test menunjukkan tidak terdapat perbedaan signifikan pada disposisi matematis (*p *= 0,3207). Rata-rata nilai kelancaran prosedural pada kelas RME lebih tinggi dibandingkan ekspositori. Temuan ini menunjukkan bahwa pendekatan RME lebih efektif dalam meningkatkan kelancaran prosedural siswa, meskipun belum menunjukkan perbedaan signifikan terhadap disposisi matematis.*

INTRODUCTION

The success of learning is influenced by many factors, including the quality of teachers, learning approaches, and student conditions. In the current Indonesian education context, the Merdeka Curriculum was introduced to support learning recovery by emphasizing essential content, differentiated learning, and implementation flexibility (Rahmadayani & Hartoyo, 2022). This curriculum promotes contextual, enjoyable, and meaningful learning based on students' characteristics. According to the Ministry of Education and Culture Decree No. 56/M/2022, mathematics learning should be designed to foster both competence and character through meaningful learning activities.

In practice, however, mathematics learning still faces many challenges, especially in building conceptual understanding and procedural mastery. Many students tend to memorize formulas without understanding the reasoning behind the procedures. As a result, when faced with unfamiliar problems, they struggle to determine appropriate solution steps. This highlights a significant weakness in students' mathematical procedural fluency. Learning mathematics requires not only conceptual understanding but also the ability to apply procedures logically and contextually (Alan & Edi, 2023). Procedural fluency includes the ability to use procedures effectively, flexibly, and efficiently. Effectiveness refers to the accuracy and correctness of the procedure; flexibility implies the ability to choose and shift strategies depending on the context; and efficiency relates to solving problems in a simple and time-saving way (Kilpatrick et al., 2001).

Students with good procedural fluency tend to understand the underlying concepts, minimize errors, and solve problems with greater confidence (Kilpatrick et al., 2001). This fluency is developed through consistent practice and reflective learning opportunities. Unfortunately, based on observations and interviews with seventh-grade mathematics teachers at SMP Negeri 13 Pekalongan, many students still find it difficult to solve mathematical problems. Teachers reported that students often ask questions whenever they are given descriptive problems derived from examples. Some students even show a lack of confidence and give up before attempting to solve the problems. These findings indicate that students' procedural fluency and mathematical disposition remain low and need to be improved through more meaningful and contextual learning approaches.

In addition to cognitive aspects, mathematics learning must also address affective aspects. One important component of this domain is mathematical disposition, which reflects students' attitudes, habits, and tendencies toward mathematics learning. According to (Rozi & Afriansyah, 2022), students with positive mathematical disposition view mathematics as a useful subject, show curiosity, confidence, and perseverance in problem-solving. Conversely, low disposition results in passive learning behavior, discouragement, and loss of motivation.

Thus, there is a need for a learning approach that can develop both cognitive and affective domains through meaningful and participative learning experiences. One relevant approach to achieve this goal is RME. RME starts the learning process from real-life contexts that are close to students' everyday experiences. It involves two types of mathematization: *horizontal mathematization, where students model real-world problems into mathematical forms, and vertical mathematization, where they further develop those models into more formal mathematical concepts (Johar et al., 2021). Through group exploration and discussion, students are gradually guided to construct conceptual and procedural understanding. (Listiawati et al., 2023) state that RME provides students with opportunities to model problems and expand them into formal mathematical concepts through systematic thinking processes.

Previous studies have shown that RME is effective in improving various aspects of mathematics learning outcomes. Its implementation aligns with the principles of the Merdeka Curriculum, which emphasizes relevant and contextual learning experiences. RME allows students to relate mathematical content to real-life situations, making learning more meaningful. (Agustin & Utami, 2022) found that using the RME approach increases students' motivation and learning independence due to its proximity to daily experiences. Similarly, (Zubaidah Amir et al., 2021) concluded that RME significantly enhances students' mathematical reasoning abilities compared to conventional approaches. (Panjaitan et al., 2022) emphasized that RME helps students develop concepts through real-life contexts, which positively impacts learning outcomes. However, (Sihombing, 2024) emphasized that the effectiveness of this approach also depends on internal student factors such as learning styles and thinking readiness.

Although many studies have confirmed the effectiveness of RME in improving mathematics achievement, research specifically analyzing the effect of RME on both procedural fluency and mathematical disposition simultaneously remains limited. These two aspects are closely related and support students' overall mathematical competence. Therefore, this study aims to determine the effectiveness of the RME approach on junior high school students' mathematical procedural fluency and mathematical disposition simultaneously. This combined analysis of cognitive and affective outcomes in one framework is still underexplored. The findings are expected to contribute to the development of contextual and meaningful learning strategies that encourage students' active engagement both cognitively and affectively.

METHOD

This study employed a quantitative approach with a quasi-experimental design and a posttest-only control group design. This design was used to determine the effectiveness of the RME approach compared to the expository approach on students' mathematical procedural fluency and mathematical disposition. The research design is presented in Table 1.

Table 1. Research Design

Group	Treatment	Posttest
Experiment (E)	X_E	Y
Control (C)	X_C	Y

Based on Table 1, this research design involved two groups, namely an experimental class that received learning with the RME approach and a control class that received learning with the expository approach. A posttest was administered to both groups after the treatment to measure students' procedural fluency and mathematical disposition.

The research was conducted in the even semester of the 2024/2025 academic year at SMP Negeri 13 Pekalongan. The population in this study was all seventh-grade students. The sample consisted of two classes selected using a cluster random sampling technique, namely class VII E as the experimental group and class VII C as the control group. Both classes had relatively similar academic characteristics based on their average Mid-Semester Mathematics Exam scores. The sampling technique was done by cluster because class divisions had been predetermined by the school.

The instruments used in this study consisted of two types, namely an essay test and a Likert-scale questionnaire. The test was used to measure students' mathematical procedural fluency, while the questionnaire was used to measure students' mathematical disposition. The instruments were validated by two mathematics education lecturers using Aiken's V technique, and then tried out on a different class to obtain empirical validity, reliability, item discrimination, and item difficulty levels.

The research procedure was carried out through several stages. After determining the subjects and samples, the researcher prepared the learning tools and instruments according to the research objectives. The instruments were validated by experts and then tested to determine the characteristics of the items. The results of the trials were analyzed to obtain feasible items to be used. Learning was carried out according to the approach in each group: the experimental group with the RME approach and the control group with the expository approach. After all the learning sessions were completed, students were given a posttest in the form of an essay test and a mathematical disposition questionnaire. The posttest data were collected and analyzed using R software.

The data analysis technique began with assumption testing, which included a univariate normality test using Shapiro–Wilk, a multivariate normality test using Henze–Zirkler, a univariate homogeneity test using the F-test, and a multivariate homogeneity test using Box's M. The multivariate test used Hotelling's T^2 to determine the simultaneous differences between the experimental and control groups. If a significant difference was found, follow-up univariate tests were conducted using the independent t-test for normally distributed data and the Mann–Whitney U test for non-normally distributed data.

RESULT AND DISCUSSION

Research Results

The data in this study were obtained from students' posttest results in the experimental and control classes. The data were processed using R software. The descriptive analysis of students' mathematical procedural fluency and mathematical disposition is presented in Table 2.

Table 2. Descriptive Statistics of Mathematical Procedural Fluency and Mathematical Disposition

Statistical Data	Experimental Group		Control Group	
	Procedural Fluency	Mathematical Disposition	Procedural Fluency	Mathematical Disposition
Mean	64.5625	88.27	56.25	92.29
Median	64	87.51	56	87.96
Mode	64	85.045	54	79.3
Standard Deviation	8.17919	13.6198	3.32148	18.1447
Variance	66.8992	185.499	11.0323	329.23
Minimum Score	46	63.90	52	57.46
Maximum Score	76	114.97	68	133.36
Range	30	51.07	16	75.89

This difference indicates that the RME approach contributes to students' procedural fluency, although the effect is not statistically significant. Dorner et al., (2025) stated that a lack of understanding of mathematical procedures often leads students to repeatedly make the same mistakes when solving problems. Therefore, instruction that emphasizes procedural understanding through real-life contexts, such as the RME approach, has the potential to help students minimize errors and improve accuracy in problem solving.

a. Normality Test

Henze–Zirkler test showed that both groups were normally distributed at the multivariate level (RME $p = 0.288$; Expository $p = 0.487$). For univariate tests, mathematical disposition was normally distributed (RME $p = 0.716$; Expository $p = 0.554$), while procedural fluency was not (RME $p = 0.016$; Expository $p = 0.0003$).

b. Homogeneity Test

Box's M test indicated non-homogeneous covariance matrices ($p = 1.51e-05$). At the univariate level, variances were homogeneous for mathematical disposition ($p = 0.1155$) but not for procedural fluency ($p = 2.69e-06$).

c. Independent Samples Mean Test (Multivariate dan Univariate)

After conducting normality analysis on procedural fluency and mathematical disposition—both multivariate and univariate—as well as homogeneity tests using Box's M (for multivariate) and the F-test (for univariate homogeneity), the next stage was hypothesis testing. This consisted of: (1) Hotelling's T^2 test to examine the difference in mean vectors between groups, and (2) independent *t*-tests to assess the differences in the means of each variable individually (univariate). The complete results of both tests are presented in Table 3.

Table 3. Hypothesis Test Results

Test	Variable	Statistic	(df)	p-value
Hotelling's T^2	Procedural Fluency and Mathematical Disposition	29.3	2	8.016e-06
Mann–Whitney U Test	Procedural Fluency	464	-	0.5236
Independent T-test	Mathematical Disposition	-1.001	62	0.3207

The decision-making criteria for the mean difference test are as follows: if the *p*-value < 0.05, then H_0 is rejected; conversely, if the *p*-value > 0.05, then H_0 is accepted. Rejecting H_0 indicates a significant difference between the two groups being tested, while accepting H_0 indicates no significant difference. Based on Table 5, the result of the Hotelling's T^2 test shows a *p*-value of 8.016e-06 < 0.05, leading to the rejection of H_0. Thus, it can be concluded that there is a significant difference between the RME and expository groups in terms of procedural fluency and mathematical disposition simultaneously (multivariate). In the univariate tests, the Mann–Whitney U test for procedural fluency produced a *p*-value of 0.5236 > 0.05, indicating that H_0 is accepted. This means there is no significant difference between the two groups in terms of procedural fluency. Furthermore, the independent *t*-test for mathematical disposition yielded a *p*-value of 0.3207 > 0.05, also indicating no significant difference between the two groups on that variable. Overall, although the multivariate test revealed a significant difference between the groups, the univariate tests did not detect significant differences for each variable individually.

Discussions

This study aimed to investigate the effectiveness of the RME approach on students' procedural fluency and mathematical disposition. Based on the descriptive analysis, the experimental group achieved an average procedural fluency score of 64.56, which was higher than the control group's average score of 56.25. This difference indicates that the RME approach contributes to students' procedural fluency, although the effect was not statistically significant.

Inferential analysis was conducted using the R software. The multivariate Hotelling's T^2 test revealed a significant simultaneous difference between the experimental and control groups across the two variables studied ($p = 0.008 < 0.05$). This result indicates that the RME approach had an impact on both cognitive and affective aspects of students simultaneously. However, the univariate tests for each individual variable did not show statistically significant differences. The Mann–Whitney U test for procedural fluency yielded a *p*-value of 0.5236, while the *t*-test for mathematical disposition produced a *p*-value of 0.3207. These findings suggest that the relatively short duration of the intervention was not sufficient to produce a significant impact on each variable independently.

In terms of the learning process, the RME approach implemented in the experimental class provided greater opportunities for students to understand concepts through meaningful learning experiences. RME is grounded in constructivist theory, which positions students as active participants in constructing knowledge through the processes of horizontal and vertical mathematization (Anel et al., 2024). The RME syntax was implemented starting from the use of contextual problems, representation models, student contributions, individual interactions, to reflection and conclusion. These stages have proven effective in helping students develop problem-solving strategies and understand the meaning behind each procedure used (Listiawati et al., 2023).

In the learning process, students were asked to solve problems related to real-life contexts, such as calculating the volume of concrete objects around them. This stage fostered procedural understanding, as students were encouraged to develop solution steps based on real experiences. Through activities such as drawing models or sketches, students began to visualize the procedures in a structured manner. Peer interaction through group discussions provided opportunities to test and refine ideas, while the teacher acted as a facilitator. This process promoted more reflective and flexible procedural fluency (Panjaitan et al., 2022).

From the affective perspective, the RME approach also contributed to students' mathematical disposition. Students in the experimental class appeared more confident, persistent, and actively engaged in asking questions and responding to problems. This is in line with the view of (Rozi & Afriansyah, 2022) who stated that mathematical disposition is shaped through active engagement and a supportive learning environment. Students became more willing to express their ideas, were less likely to give up when facing difficulties, and demonstrated higher learning motivation. In contrast, students in the control group tended to be passive and less involved in the problem-solving process. (Bacatan, 2024) further emphasized that students' disposition is greatly influenced by meaningful learning experiences and contextual learning approaches. In this context, the RME approach provided more contextual and participatory learning experiences, thereby contributing to the development of students' positive attitudes toward mathematics. Similarly, (Noeruddin et al. , 2023) found that students with strong mathematical dispositions tend to design problem-solving strategies in a systematic and logical manner.

The findings of this study support previous research by (Zubaidah Amir et al., 2021) and (Agustin & Utami, 2022) which concluded that the RME approach is effective in enhancing conceptual understanding, learning interest, and promoting more independent learning. In addition, the RME approach also provides learning experiences that encourage students to think actively, communicate their ideas, and reflect on their learning outcomes (Gusteti & Neviyarni, 2022). Thus, the RME approach impacts not only cognitive learning outcomes but also students' attitudes, self-confidence, and independence in the mathematics learning process.

Although the univariate effects were not statistically significant, the findings of this study reinforce the potential of RME as a learning strategy that simultaneously integrates cognitive and affective aspects. The implications of these results may serve as valuable input for the development of instructional models in schools, particularly in fostering students' procedural understanding and positive attitudes toward mathematics.

CLOSING

Conclusion

Based on the results of data analysis and discussion, it can be concluded that the RME approach is effective in supporting mathematics learning simultaneously in terms of procedural fluency and mathematical disposition. The multivariate test showed a significant difference between the experimental and control groups (*p* < 0.001); however, the univariate tests for each individual variable did not show statistically significant differences. Descriptively, the group taught using the RME approach demonstrated better outcomes, particularly in procedural fluency. The learning process involving contextual problems, interactivity, and active student participation in the RME approach contributed to the development of procedural understanding and positive attitudes toward mathematics. Therefore, the RME approach can serve as a relevant alternative to align with the principles of the Kurikulum Merdeka, which emphasizes active, contextual, and student-centered learning.

Recommendations

Based on the findings of this study, it is recommended that mathematics teachers consider using the RME approach as an alternative instructional strategy aimed at developing students' procedural fluency while also fostering their mathematical disposition. This approach can be implemented by adapting problem contexts to students' environments and experiences, thereby making learning more meaningful. For future researchers, it is suggested to conduct studies with a longer treatment duration, broader material coverage, and a larger number of classes in order to obtain more comprehensive results and stronger generalizability.

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