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Integrating RME and Geogebra: Transforming mathematics learning to support students' mathematical literacy

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Abstract

The low mathematical literacy of Indonesian students as shown by the PISA results has become an issue in education. This study aims to analyze the effect of the Geogebra-assisted RME approach on students' mathematical literacy skills. This study applied a quantitative method with a One-Group Pretest-Posttest Design, which was carried out on 30 ninth grade students of SMP Negeri 2 Kapetakan, Cirebon Regency. The instruments used include a mathematical literacy test and student response questionnaires. Data were collected through test and questionnaire, then analyzed using N-gain and simple linear regression. The results showed that the average N-gain score of 0.85 was in the high category, which indicates a significant increase in mathematical literacy skills. In addition, the results of a simple linear regression test showed that the implementation of Geogebra-assisted RME had a positive and significant effect on students' mathematical literacy skills, with an R^2 value of 0.337. These findings show that a contextual learning approach supported by interactive technology is effective in improving students' ability to understand, apply, and interpret mathematical concepts in real life. This research makes an empirical contribution to the integration of RME approaches and technology in geometry learning and mathematical literacy at the secondary level.

Keywords: Geogebra, mathematical literacy, Realistic Mathematics Education

INTRODUCTION

Education is a process of interaction between educators and students that aims to achieve optimal learning outcomes in a supportive environment (Pidria et al., 2023). However, the challenges in the world of education today are increasingly complex, especially in the face of a global era that demands students to have 21st century skills, one of which is mathematical literacy (Janah et al, 2019). Based on the International Student Assessment Program (PISA) international survey, Indonesia is consistently ranked at the bottom in terms of mathematical literacy, in the last cycle, the average mathematics literacy score of Indonesian students was recorded far below the OECD country average (Setyaningsih & Munawaroh, 2022). This issue

shows that there is a gap in the mastery of mathematical concepts and their application in real life by Indonesian students.

This situation is exacerbated by the learning conditions in the field, where the approach used still tends to be conventional and teacher-centered (Oktavia & Qudsiyah, 2023). Many teachers still use the lecture method without actively involving students, thus making the learning process monotonous and limiting the development of students' critical and creative thinking skills (Hidayat et al., 2020). This problem is even more complex when it is associated with mathematics subjects, especially the field of geometry which is often considered difficult by students (Siregar & Restati, 2017). Many students are not able to distinguish between two and three dimensional shapes and have difficulties in applying geometric concepts in real-life contexts (Rezky et al., 2022).

Previous research has extensively discussed the effectiveness of the approach *Realistic Mathematics Education* (RME) in improving math skills. For example Susanti (2025) found that RME can improve mathematical problem solving and student engagement in learning. Azis et al. (2021) stated that student learning outcomes improved significantly with the RME approach compared to the expository method. A'la et al. (2025) also showed that the RME approach contributes to the development of students' mathematical literacy. However, most of these studies have not combined the RME approach with technology-based learning media, especially Geogebra, in the context of geometry learning.

In fact, the RME approach and educational technology such as Geogebra have great synergistic potential. RME is based on the idea that mathematics is a human activity that must be taught by relating concepts to real contexts (Rahmatunisa, 2020). Meanwhile, Geogebra is a dynamic mathematics software that allows the visualization of geometric concepts in an interactive and concrete way (Nesta et al., 2024). Geogebra provides opportunities for students to build their own geometric concepts through visual exploration, so that learning becomes more meaningful (Muliyana & Roza, 2022). The combination of RME and Geogebra has the potential to provide a fun learning experience, encourage active interaction, and support students' thinking processes in understanding mathematical concepts in depth.

This research focuses on the application of the Geogebra-assisted *Realistic Mathematics Education* approach to improve students' mathematical literacy skills. This approach is expected to be able to answer the challenges of low mathematical literacy and difficulties in learning geometry faced by students. With a student-centered, contextual, and interactive technology-supported learning approach, this study aims to analyze how Geogebra-assisted RMEs can improve students' understanding of concepts and abilities to formulate, apply, and interpret mathematical concepts in real-life contexts more effectively.

RESEARCH METHOD

This study uses a quantitative method with a one-group pretest-posttest design. This design was chosen because it allowed researchers to measure differences in students' mathematical literacy abilities before and after treatment without using a control group. The research was carried out at SMP Negeri 2 Kapetakan, Cirebon Regency. The participants were 30 ninth grade students who were selected through the cluster random sampling technique to get an equal representation of students' abilities (Suriani et al., 2023).

The data were collected by using mathematical literacy test and a student response questionnaire. The literacy test refers to three indicators from the OECD, namely formulating mathematical problems, using mathematical concepts and procedures, interpreting and evaluating mathematical solutions (Dinarti et al., 2023). After being prepared, the test instrument was then pilot tested to find out its validity, reliability, difficulty degree, and distinguishing power as described in Table 1. Meanwhile, the questionnaire is structured based on five indicators, namely contextual problems, the use of Geogebra, classroom interaction, literacy improvement, and interest in RME.

Table 1. The Results of the Pilot Test of the Literacy Test

Validity		**Discriminatory power**		**Difficulty level**	
Score	Category	Score	Category	Score	Category
0.490	Valid	0.375	Low	0.553	Moderate
0.194	Invalid	0.118	Low	0.706	Moderate
0.345	Invalid	0.193	Low	0.596	Moderate
0.835	Valid	0.760	High	0.686	Moderate
0.460	Valid	0.327	Low	0.64	Moderate
0.391	Valid	0.273	Low	0.543	Moderate
0.741	Valid	0.670	Moderate	0.663	Moderate
0.878	Valid	0.800	High	0.673	Moderate
0.847	Valid	0.762	High	0.676	Moderate
0.680	Valid	0.607	Moderate	0.74	Moderate
Reliability r11 = 0.814 Category = High					

The experiment was carried out in eight meetings, with details of two meetings used for the implementation of pretest and posttest and six meetings for learning activities. Of the six learning meetings. Three meetings were used for real exploration activities so that students could find their own definitions and formulas of geometry transformation, and the other three meetings were conducted with the help of Geogebra software to strengthen the conceptual understanding visually and interactively. Data were analyzed using an N-Gain test to determine the improvement of mathematical literacy ability and a simple linear regression test to see the effect of the treatment on student learning outcomes.

FINDINGS & DISCUSSION

To determine the improvement of students' mathematical literacy skills after the implementation *of Realistic Mathematics Education* (RME) learning assisted by Geogebra, the researcher conducted an N-Gain statistical test. This test aims to see the extent of the improvement that occurred by comparing the results of the pretest and posttest students in the experimental class. Pretest scores describe students' initial abilities before learning, while posttest scores show results after learning is given. The results of the N-gain test are described in Table 2.

Table 2. N-gain Test

N-gain Score	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
	28	.67	1.00	.8545	.09997
Percentage	28	66.67	100.00	85.4502	9.99698
Valid N (listwise)	28				

Based on the table, the average N-gain score obtained by students is 0.85 which is in the high category, with a minimum N-gain value of 0.67 and a maximum N-gain value of 1. This shows that there is a significant improvement in students' mathematical literacy abilities after the implementation of the Geogebra-assisted RME approach. These results support that the use of this method is effective in improving students' mathematical literacy skills, especially in geometry transformation materials.

The next analysis is to perform a simple linear regression test. Before conducting the test, prerequisite testing is required which includes a normality test and a homogeneity test. The results of the normality test using the help of SPSS software are presented in Table 3.

Table 3. Normality Test

	Kolmogorof-Smirnov		**Shapiro-Wilk**	
	Df	**Sig**	**Df**	**Sig**
X	28	0.200	28	0.273
Y	28	0.200	28	0.077

Based on Table 3, a significance value greater than 0.05 indicates that the data is normally distributed. After the normality test, the next step is to conduct a homogeneity test. The results of the homogeneity test with the help of SPSS are presented in Table 4.

Table 4. Homogeneity Test

Living Statistic	**df1**	**df2**	**Sig**
2.093	6	14	0.120

Based on the results in Table 4, a significance value greater than 0.05 indicates that the data is homogeneous, so the analysis can be continued using parametric statistical tests.

Table 5. Significance Value

Type	**Df**	**F**	**Sig**
Regression	1	13.241	0.001
Residue	26		
Total	27		

As can be seen in Table 5, the results of the regression analysis showed that the significance value was below 0.05, which indicates a significant influence of the application of RME assisted by Geogebra on students' mathematical literacy skills.

Table 6. R Square

Type	**R**	**R Square**
1	0.581	0.337

Based on Table 6, the correlation value between the variables is 0.581. Meanwhile, the value of the determination coefficient (R Square) was recorded at 0.337, which means that 33.7% of the variation in students' mathematical literacy ability can be explained by the application variable RME with the help of Geogebra.

Table 7. Regression Coefficients

Type	*Unstandardized Coefficients*		*Standardized Coefficients*	t	Sig
	B	*Std.Error*	*Beta*		
(Constant)	25.832	16.810		1.537	0.136
RME	0.696	0.191	0.581	3.639	0.001

The regression results in Table 7 showed that the constant of 25.832 indicated the basic value of mathematical literacy ability. Regression coefficient of application variables RME assisted by Geogebra of 0.696 shows that every 1% increase in the implementation of RME is accompanied by an increase in literacy score of 0.696 points. Thus, the regression equation can be written as:

$$Y = 25.832 + 0.696X$$

The significance value of 0.001 < 0.05 and the t value (3.639) > the t_{table} (2.056) confirm that the influence is significant. However, the value of the constant partially has a significance of 0.136 (> 0.05), which means that it is not significant in explaining the literacy variable independently without the influence of the X variable.

The results of the study show that the application of RME approach combined with the help of Geogebra software has a significant influence on improving students' mathematical literacy skills. This is proven through two types of analysis, namely the increase test using N-gain and the effect test using simple linear regression. Based on the results of the N-gain test, the average score for improving students' mathematical literacy ability was included in the high category. These findings indicate that an RME approach based on real contextual problems, when supported by interactive visual media such as Geogebra, is able to strengthen students' understanding of mathematical concepts. Geogebra allows for dynamic visualization and exploration of mathematical concepts, so that it can stimulate critical thinking and problem-solving skills that are core elements of mathematical literacy.

Furthermore, the results of a simple linear regression test strengthened the findings by showing a positive and significant relationship between the variables of the implementation of Geogebra-assisted RME and students' mathematical literacy skills. A positive regression coefficient value indicates that any improvement in the quality of the implementation of this approach correlates with an increase in students' literacy scores. This means that the more intensive and appropriate the use of RME and Geogebra in learning, the higher the ability of students to understand, analyze, and apply mathematical concepts, both in academic contexts and daily life.

This finding is also supported by the results of observations during the learning process. Students are engaged actively during the realistic mathematics activity as can be seen in Figure 1. They also showed increased participation when solving contextual problems on the board, and were faster to understand concepts when presented with visual simulations by using Geogebra as shown in Figure 2. Moreover, students seem to be more active in group discussions, for example when debating the results of transformation visualization using Geogebra. This meaningful learning is in accordance with the view of Treffers as cited in Hairun et al. (2024) which emphasizes the importance of providing space for students to build their own understanding through relevant and contextual activities.

Figure 1. Realistic activity

Figure 2. Students' activity by using Geogebra

Furthermore, these results are in line with various previous studies. Pertiwi et al. (2021) concludes that Geogebra's RME approach can help students understand mathematical concepts more deeply through visual exploration (Meilindawati et al. (2023). It also emphasizes that the combination of realistic approaches and interactive technology is able to improve students' mathematical application skills. Moreover (Egita & Indriani. 2024) highlighting that the use of technology such as Geogebra not only has an impact on understanding concepts, but also increases students' motivation and confidence in participating in mathematics learning.

Overall, based on the results of statistical analysis and field observation, it can be concluded that RME-based mathematics learning with the help of Geogebra makes a real contribution to improving students' mathematical literacy skills. This strategy is not only effective in improving learning outcomes, but it also creates a more contextual, engaging, and meaningful learning experience for students.

This research makes a new contribution in terms of the application of the RME approach combined with Geogebra in the aspect of mathematical literacy ability, especially in the context of learning in secondary schools. Unlike previous studies that generally only examined understanding concepts or learning motivation, this study specifically examines mathematical literacy skills as an essential 21st century competency. In addition, measurements made through N-gain and regression tests provide a more comprehensive picture of learning effectiveness. For further research, it is recommended that this approach be piloted over a longer period of time, covering a variety of educational levels, and involving a collaborative learning model to see its impact on the more complex dimensions of mathematical literacy. It is important to strengthen the empirical basis of technology integration in the national mathematics curriculum.

CONCLUSION

Based on the results of the research and discussion. it can be concluded that the application *of the Realistic Mathematics Education* (RME) approach assisted by Geogebra has proven to be effective in improving the mathematical literacy skills of grade VIII students. The N-gain test shows that the average increase in students' mathematical literacy ability was 0.8545 in the medium to high category. This shows that learning with Geogebra-assisted RME approach is able to significantly improve student understanding. The results of a simple linear regression test also showed a positive and significant influence between the application of Geogebra-assisted RME on students' mathematical literacy skills. The significance test in the regression model showed a significance value of 0.001 < 0.05 and a t value of 3.639 > a t_{table} of 2.056, which indicates that the effect is statistically significant. Thus. it can be concluded that the Geogebra-assisted RME approach is feasible to be applied as a learning strategy to effectively improve students' mathematical literacy skills.

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