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The Effect of RME Approach Assisted by Mathigon on Students' Mathematical Literacy and Mathematical Resilience

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Abstract

The objectives of this study are to test and describe whether there is an effect of the RME approach assisted by Mathigon on students' mathematical literacy and mathematical resilience; to test and describe whether there is an effect of the RME approach assisted by Mathigon on students' mathematical literacy; to test and describe whether there is an effect of the RME approach assisted by Mathigon on students' mathematical resilience. The research used a quasi-experimental design and was conducted in one of the public junior high schools in Kupang City, involving two classes, namely the experimental class (n = 29) and the control class (n = 28). The research instruments were a mathematical literacy test and a mathematical resilience questionnaire that had been validated and reliable ($\alpha = 0.742$ and 0.723). The results showed that the RME approach assisted by Mathigon had a significant effect simultaneously and partially on students' mathematical literacy and mathematical resilience ($p < 0.05$). This finding indicates that the integration of a contextual approach with interactive digital media is effective in supporting mathematics learning.

Keywords: *Mathematical literacy; Mathigon; Mathematical Resilience; RME*

Introduction

Mathematics is one of the disciplines that plays a strategic role in education because it is essential in helping individuals solve various problems in everyday life. Mathematical literacy is one of the important components in building 21st-century skills, given its close relationship with real-world contexts. Mathematical literacy itself is the ability to apply and develop students' mathematical knowledge learned at school into everyday life (Fauzana et al, 2020).

One of the assessments that measures mathematical literacy is PISA (Programme for International Student Assessment), conducted by the Organisation for Economic Co-operation and Development (OECD). However, from the PISA results, the mathematical literacy skills of students in Indonesia are still relatively low and below the PISA average. The factors that cause this are due to the lack of access and understanding of teachers of mathematical literacy in the PISA survey, due to a lack of information, low awareness of the importance of PISA, and a lack of initiative to track the results of the survey, so that learning evaluation has not been aligned with PISA standards (Umbara & Suryadi, 2019).

In addition to cognitive aspects, affective aspects are factors that influence student learning outcomes Students. One of the effective aspects that can affect student learning outcomes is mathematical resilience. Resilience is the ability to respond positively when facing challenges (Yohannes & Juandi, 2020). In the context of mathematics, mathematical resilience reflects students' positive and confident attitude when facing learning difficulties (Zanthy, 2018; Kooken et al., 2016).

Facts in the field show that students' mathematical resilience skills are still relatively low. Kurnia's research (2018) shows that students' mathematical resilience is still low, which has an impact on weak mathematical communication skills and mathematical literacy. This is in line with the findings of Ruqoyyah et al. (2020), who attributed low resilience to uninteresting learning, unsupportive teaching materials, and student character. Therefore, the role of teachers is very important in improving mathematical resilience through the selection of appropriate learning methods. Xenofontos and Mouroutsou (2022) asserted that collaborative and non-teacher-centred learning contributes positively to improving students' mathematical resilience.

One important step in improving students' mathematical literacy and mathematical resilience is to use the right learning approach. One of the contextual approaches that can be applied in learning is the Realistic Mathematics Education (RME) approach. Realistic Mathematics Education (RME) is a learning approach that emphasizes mathematics as a human activity, not starting from formal concepts, but from real contexts that are close to students' lives (Nuraida & Aman, 2019). Through the selection of appropriate contextual problems, RME encourages students to develop strategies, discuss, collaborate, and find their own mathematical concepts in the problem-solving process (Gravemeijer, 1997; Nuraida & Aman, 2019).

Some previous research results show the effect of RME on students' cognitive abilities, one of which is students' literacy skills, such as research by Fauzana et al. (2020) and Sumirattana et al. (2017), who found that the RME approach had a positive effect on mathematical literacy skills. In addition, research conducted by Umbara & Nuraeni (2019) found that the RME approach assisted by learning media can improve mathematical literacy skills. Realistic Mathematics Education (RME) not only improves students' mathematical literacy skills but can also improve students' mathematical resilience as the results of research by Thornton et al. (2012) and Astuti et al. (2024) who found that the realistic approach with media assistance has an effect on students' mathematical resilience skills.

Based on the results of previous research, the Realistic Mathematics Education (RME) approach assisted by technological media has been proven to have an effect on students' mathematical literacy skills. Umbara & Nuraeni (2019) proved that RME assisted by Adobe Flash can create active, fun, and effective learning in improving concept understanding. Fitriani et al. (2018) also found that RME assisted by VBA Excel helped the transition process from horizontal to vertical mathematization. As a development, this research combines RME with Mathigon media, an interactive math learning site that provides various visual tools in the fields of geometry, number, and probability, to present material and support active student involvement in learning.

Based on the previous description, it can be concluded that the RME approach has great potential in improving students' mathematical literacy and mathematical resilience. Therefore, researchers are interested in examining the effect of integrating the RME approach with Mathigon media on the quality of mathematical literacy and mathematical resilience. Most of the previous studies focused more on the effect of RME with conventional media. However, there are still limited studies that link RME with interactive digital media such as Mathigon, especially in improving students' conceptual understanding and positive attitude toward learning mathematics. The purpose of this study is to test and describe the effect of the RME approach assisted by Mathigon on students' mathematical literacy and mathematical resilience, both multivariate and univariate.

Methods

This study used a quasi-experimental design with a nonequivalent control group design model. In this study, two classes were used, namely the experimental class, which is a class that gets mathematics learning using the RME approach assisted by Mathigon, and the control class, which gets mathematics learning using the Scientific approach. Operational stages include: preparation of devices and instruments, expert validation, instrument trials, learning implementation, data collection and analysis.

The research was conducted in public junior high schools in Kupang City in February 2025. The sample consisted of class VII F as the experimental class (n = 29) and class VII G as the control class (n= 28), which were purposively selected based on equal initial ability. The material used was Flat Buildings in grade VII. Learning in the experimental class applied the Realistic Mathematics Education (RME) approach, assisted by Mathigon, while the control class used the scientific approach.

The instruments consisted of a mathematical literacy test and a mathematical resilience questionnaire. Content validation was carried out by two experts and reliability was calculated with Cronbach's Alpha, with the results of 0.742 on mathematical literacy test data and 0.723 on mathematical resilience test data. Indicators of mathematical literacy instruments based on the PISA mathematical literacy process (OECD, 2023)

Table 1. Indicators of Mathematical Literacy

Aspects	**Indicator**
Formulate	Identify mathematical information/aspects of a problem located in a real-world context.
Employ	Apply mathematical concepts, facts, and procedures to solve mathematical problems.
Interpret	Interpret and evaluate results in accordance with real-life problems/contexts.

Meanwhile, the mathematical resilience ability instrument is based on aspects according to Kooken et al. (2016). Indicators of mathematical resilience are presented in Table 2.

Table 2. Indicators of mathematical resilience

Aspects	**Indicator**
Formulate	Having motivation to learn and solve math problems.
	Have a belief that math is important and necessary to master/learn.
Struggle	Having perseverance in learning despite facing problems, obstacles, or hurdles.
	Having the confidence to master math
Growth	Adaptability is shown through the willingness to try new strategies or start over
	Shows curiosity, likes to research mathematics, and is willing to utilize various sources (books, internet, teachers, and peers) to fulfil his curiosity.

To answer the research hypothesis, the data were analyzed using Hotelling's T^2 MANOVA test for simultaneous effect and independent sample t-test for the effect of each variable. Prerequisite tests included a multivariate normality test using Hanze-Zirkler and an univariate normality test using Shapiro-Wilk and multivariate homogeneity using Box's M and univariate homogeneity using Levene's Test. Furthermore, the effect size was analyzed using Cohen's d:

$$d = \frac{M_2 - M_1}{\sqrt{\frac{SD_2^2 - SD_1^2}{2}}} \quad ...(1)$$

Results and Discussion

Results

1. Description of Research Data

The research data are the results of the pretest and posttest of mathematical literacy skills and mathematical resilience of students in experimental and control classes. Data from the pretest and posttest results of the mathematical literacy skills of both classes are presented in Table 3.

Table 3. Pretest and Posttest Results of Mathematical Literacy Skills

Description	**Experimental Class**		**Control Class**	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Formulate	35.63 (36%)	65.52 (66%)	25.6 (26%)	58.93 (59%)
Employ	45.69 (46%)	81.9 (82%)	42.86 (43%)	68.75 (69%)
Interpret	21.84 (22%)	55.74 (55%)	32.59 (33%)	49.11 (49%)
Average	32.9	64.45	32,43	56.79
Standard Deviation	11.27	10.96	11.5	11,22
Minimum Score	11	44	11	39
Maximum Score	50	89	56	83

Based on Table 3, there was an increase in each aspect of mathematical literacy in both classes, but the increase in the Employ and Interpret aspects was higher in the experimental class using the RME approach assisted by Mathigon, while the Formulate aspect was higher in the control class with a scientific approach. The average pretest scores of the experimental and control classes were 32.9 and 32.43, respectively, and after treatment increased to 64.45 for the experimental class and 56.79 for the control class. This shows that the RME approach assisted by Mathigon is more effective in improving students' mathematical literacy skills. Furthermore, the pretest and posttest data of the mathematical literacy skills of both classes are presented in Table 4.

Table 4. Pretest and Posttest Results of Mathematical Literacy Skills

Description	**Experiment Class**		**Control Class**	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Value	21.65 (60%)	27.68 (76%)	22.86 (65%)	25.64 (73%)
Struggle	25.96 (63%)	30.62 (74%)	26.54 (66%)	28.21 (71%)
Growth	25.62 (62%)	30.93 (74%)	26.14 (65%)	29.18 (73%)
Average	73,24	89.69	75,54	83,04
Standard Deviation	9,03	8.61	8,61	8.86
Minimum Score	60	78	59	65
Maximum Score	96	110	98	101

Based on Table 4, all aspects of mathematical resilience increased in both classes, but the increase in the Value, Struggle, and Growth aspects was higher in the experimental class using the RME approach assisted by Mathigon. The average pretest scores of the experimental and control

classes were 73.24 and 75.54, respectively, then increased to 89.69 and 83.04 after treatment. This shows that the RME approach assisted by Mathigon is more effective in improving students' mathematical resilience than the scientific approach.

2. Analysis of Research Data

Before conducting hypothesis testing, prerequisite tests will first be carried out. The prerequisite tests used in this study are multivariate and univariate normality tests and multivariate and univariate homogeneity tests. The results of the prerequisite test of mathematical literacy and mathematical resilience test data show multivariate normal and univariate normal data, and multivariate homogeneous and univariate homogeneous. After the prerequisite tests of normality and homogeneity are met, then hypothesis testing can be carried out on the data of students' mathematical literacy and mathematical resilience.

The initial condition mean difference test was conducted to determine whether there were differences in mathematical literacy and mathematical resilience between the experimental class (RME assisted by Mathigon) and the control class (scientific approach) before treatment. Using Hotelling's Trace analysis at a significance level of 0.05 with the help of R software. Table 5 below presents the results of the Hoteling's test$T2$based on the pretest scores of students' mathematical literacy and mathematical resilience skills in the experimental and control classes.

Table 5. Multivariate Test Results of Pretest Datat

Effect	$\mathbf{T^2}$	***p-value***
Hotelling's Trace	1.095	0.578

Based on Table 5, the p-value is 0.578 > 0.05, so H0 is accepted. That is, there is no significant difference between the average initial ability of the two classes. Thus, both classes have equal initial abilities before the treatment is given.

The mean difference test after treatment was conducted to test the first hypothesis related to the effect of the RME approach assisted by Mathigon on students' mathematical literacy and mathematical resilience. Using posttest data and Hotelling's Trace analysis at a significance level of 0.05 with the help of the R software. Table 6 below presents the results of the Hotelling's test Based on the posttest scores of students' mathematical literacy and mathematical resilience in the experimental and control classes.

Table 6. Multivariate Test Results of Posttest Data

Effect	$\mathbf{T^2}$	***p-value***
Hotelling's Trace	11.108	0.0039

Based on Table 6, the p-value is 0.0039 <0.05, so H0 is rejected. That is, there is an average difference between the experimental and control classes after treatment, which shows that the RME approach assisted by Mathigon has an effect on students' mathematical literacy and mathematical resilience.

If the multivariate test shows significant results, then a univariate test is conducted using an independent sample t-test to determine the effect of each approach on the variables of mathematical literacy and mathematical resilience. Posttest data were analyzed with R software, and the results are shown in Table 7.

Table 7. Independent Sample t-Test Results

Variabel	t	p-value
Math Literacy	2.609	0.0117
Mathematical Resilience	2.876	0.0057

Based on Table 7, the p-value for mathematical literacy is 0.0117 and for mathematical resilience is 0.0057, both <0.05, so H0 is rejected. This shows that the RME approach assisted by Mathigon has a greater effect than the scientific approach on both variables.

Effect size is used to determine the effect of treatment and differences between groups. It was found that the RME approach assisted by Mathigon had an effect size of 0.328 for mathematical literacy and 0.392 for mathematical resilience, both of which were in the medium category.

Discussion

1. There is an Influence on the RME Approach Assisted by Mathigon on Students' Mathematical Literacy and Mathematical Resilience

At the beginning of learning, a pretest was given to measure the initial ability of mathematical literacy and mathematical resilience. The results showed that the average mathematical literacy was still low, namely 32.9 in the experimental class and 32.43 in the control class. Mathematical resilience was in the medium category, with a value of 73.24 in the experimental class and 75.54 in the control class. The multivariate test showed no significant difference between the two classes before treatment (p-value 0.578), so both were considered equal in the initial condition.

After the application of the learning approach, the posttest results showed an increase in both classes, but higher in the experimental class with the RME approach assisted by Mathigon. The average posttest of mathematical literacy and mathematical resilience of the experimental class was 64.45 and 89.69, respectively, while the control class was 56.79 and 83.04. The multivariate test showed a p-value of 0.0039 <0.05, which means there is a significant effect of the RME approach assisted by Mathigon on both abilities.

This finding is in line with the research of Fauzana et al. (2020) and Umbara & Nuraeni (2019), which showed that the RME approach can improve mathematical literacy. In addition, Thornton et al. (2012) also stated that real context-based learning through a realistic approach can strengthen resilience.

2. There is an Influence of the RME Approach Assisted by Mathigon on Students' Mathematical Literacy

Univariate hypothesis testing with a t-test shows that the RME approach assisted by Mathigon has a significant effect on students' mathematical literacy, with a p-value of 0.0117 <0.05. This shows that the approach is effective in improving students' mathematical literacy. The increase can be seen from the average pretest to posttest scores, especially in the Employ aspect, which is the most dominant component, reaching 82% in the experimental class compared to 69% in the control class. Meanwhile, the Interpret aspect was the lowest aspect, but still higher in the experimental class (55%) than in the control class (49%). The following presents some of the results of student work in answering questions about mathematical literacy instruments.

The results of student work show that students in the experimental class are better able to solve problems based on the three aspects of mathematical literacy: Formulate, Employ, and Interpret.

The effectiveness of the RME approach assisted by Mathigon lies in the five stages of learning that are integrated with the development of mathematical literacy. The first stage, understanding contextual problems, leads students to relate real situations with appropriate mathematical models, thus strengthening the Formulate aspect. The second stage, explaining contextual problems, develops students' ability to organize important information and arrange it into mathematical representations, which strengthens the Formulate aspect and begins to develop the Employ aspect because students begin to choose a solution strategy.

The third stage, solving contextual problems, focuses on applying mathematical concepts and procedures to solve problems, which directly develops the Employ aspect. Furthermore, the fourth stage, comparing and discussing answers, encourages students to critically assess and interpret results, thus developing the Interpret aspect. Finally, the fifth stage, concluding, provides an opportunity for students to reflect on the process and results of the solution in relation to the initial context, which also strengthens the Interpret aspect.

With contextualized learning design and the use of interactive media such as Mathigon, the RME approach not only encourages concept understanding but also improves higher-order mathematical thinking skills. This allows students to be more skilful in formulating problems, applying solution strategies, and interpreting and evaluating results logically and meaningfully in real-life contexts.

3. There Is an Influence of the RME Approach Assisted by Mathigon on Students' Mathematical Resilience

The univariate t-test showed that the RME approach assisted by Mathigon had a significant effect on students' mathematical resilience, with a p-value of 0.0059 <0.05. The average pretest score was in the moderate category (73.24 in the experimental class and 75.54 in the control class), but after treatment, there was an increase in almost all aspects of resilience, with the experimental class showing higher results, even though the average difference between classes was less than 5%. The Value aspect in the RME-Mathigon class reached 76%, higher than the scientific class (73%). The initial stages of RME learning, which emphasize understanding contextual problems and inference, help students form a positive attitude towards the value of mathematics. While the scientific approach facilitates curiosity and understanding through the observing and questioning stages.

The Struggle aspect was also higher in the RME-Mathigon class (74%) than in the scientific class (71%). Through the stages of explaining, solving, and discussing problems, as well as the support of Mathigon media, students are encouraged to be more diligent, dare to try, and not be afraid to fail. This is also achieved in the scientific approach through the trial and reasoning stages, which require perseverance. The Growth aspect of the experimental class reached 74%, slightly higher than the control class (73%). In RME, students show adaptability, try new strategies, and learn from group discussions. The comparing and inferring stages also encourage increased understanding, as does the communicating stage in science. Overall, although both approaches were able to improve mathematical resilience, the RME approach assisted by Mathigon gave better results in each aspect.

Summary

Based on the results of data analysis and discussion, it is concluded that the Realistic Mathematics Education (RME) approach assisted by Mathigon has a positive effect on the mathematical literacy and mathematical resilience of grade 7 junior high school students on flat building material. And based on further tests, it shows that there is an effect of learning with the RME approach assisted by Mathigon on students' mathematical literacy skills. Students who learn with this approach show higher improvement compared to students who use the Scientific approach. In the

aspect of mathematical literacy, the RME approach assisted by Mathigon was able to improve students' ability to formulate, apply mathematical strategies (employ), and interpret the results of problem solving (interpret). Meanwhile, it was also found that there was an effect of learning with the RME approach assisted by Mathigon on students' mathematical resilience. In the aspect of mathematical resilience, the increase occurred in the three main aspects, namely value (belief in the importance of mathematics), struggle (hard work and perseverance), and growth (willingness to continue learning and developing).

Advice

Based on the conclusions and implications of the research, it is recommended that teachers consider using the RME approach assisted by Mathigon in learning mathematics, especially to improve the mathematical literacy and mathematical resilience of seventh-grade students on flat shapes. This approach can also be further explored by researchers as an innovative alternative that can be combined with other learning strategies. In addition, for its effective implementation, teachers should first introduce how to use Mathigon to students who are not familiar with the media.

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