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Analysis of interaction between RME-based blended learning and self-regulated learning in improving mathematical literacy

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Abstract

Most of prior studies on mathematical literacy (ML), self-regulated learning (SRL), and RME-based blended learning were carried out qualitatively. Therefore, it is necessary to test them with statistical inference. This study aims to analyze interaction between RME-based blended learning, conventional learning, and SRL in improving students' ML. The research method used is quasi-experimental with a 2x2 factorial design. The population are students grade 7 of SMP Negeri 40 Palembang with 38 students as samples. RME-based blended learning was conducted in the experiment class while the conventional learning was in the control class. SRL data were obtained from the questionnaire and ML data were obtained from tests. Data are analyzed using the Adjusted Rank Transform Test with Two-Way ANOVA and Mann-Whitney U test. The results shows that there is an interaction between RME-based blended learning, conventional learning, and SRL towards students' ML improvement. Students' ML improvement who receives RME-based blended learning is higher than students who received conventional learning in terms of the high level of SRL and vice versa at the low level. Furthermore, students' ML improvement with high SRL is slightly higher than students with low SRL after getting RME-based blended learning and vice versa after getting conventional learning.

Keywords: blended learning; mathematical literacy; Realistic Mathematics Education; self-regulated learning

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Introduction

Nowadays, the Indonesian education system is undergoing adjustments to the industrial revolution 4.0 era where technology and information are developing massively and rapidly. It provides fundamental changes to human life. There are changes in the way of human activities that affect the world of work. Today, routine work can be replaced with computer systems and production machines. When technology in the 21st century can take over repetitive work, human skills in solving complex problems, thinking critically, arguing, communicating, and collaborating in the future work, cannot be replaced (Sari et al., 2021). These human skills become employee skills demanded in the 21st century (Levin-Goldberg, 2012). One of the fundamental skills to be developed for preparing generations in the 21st century so that they can compete is mathematical literacy (Habibi & Suparman, 2020; Indrawati, 2020; Rizki & Priatna, 2019; Widjaja, 2011).

Mathematical literacy are an individual's ability to reason mathematically, formulate, use, and interpret mathematics to solve problems in various real-world contexts (OECD, 2019). Mathematical literacy consist of seven essential mathematical skills, such as (1) communication; (2) mathematizing; (3) representations; (4) reasoning and arguments; (5) devising strategies for solving problems; (6) using symbolic, formal, and technical language and operations; and (7) using mathematical tools (OECD, 2019). These skills help individuals recognize the role of mathematics in the world and make the judgments and reasoned decisions that 21st-century societies need. For this reason, students need to be equipped with mathematical literacy so that they can solve problems and survive in the future. However, the international assessment conducted by PISA (Program for International Student Assessment) shows that students' mathematical literacy scores are very low. From 78 countries, Indonesia was on rank 73 and the score is 379 of an average score (489) (Aziz & Amidi, 2021; Schleicher, 2019). One of the causes was students still being accustomed to solving problems with procedural and concrete answers (Muzaki & Masjudin, 2019). In addition, another skill is needed to support the achievement of mathematical literacy, namely self-regulated learning, especially during the current pandemic (Hidayat et al., 2018).

Self-regulated learning is defined as learning that is primarily influenced by students' thoughts, feelings, techniques, and behaviours, all of which are geared toward reaching goals. (Hidayat et al., 2018). Self-regulated learning demonstrates a student's ability to choose his or her own learning technique (Kholifasari et al., 2020). Students who have a desire to learn, solve problems, and are responsible for fulfilling their obligations as students possess that they have self-regulated learning. (Fitriasari et al., 2018). Nevertheless, the low self-regulated learning is due to a lack of confidence in abilities, low motivation for self-study, and a less conducive learning environment (Arifin & Herman, 2018).

The low mathematical literacy of students is affected by the lack of self-regulated learning and teacher-centered learning, so students become passive and only receive information from the teacher (Babys, 2016; Kholifasari et al., 2020). Some researches on mathematical literacy by reviewing the aspects of student learning independence have been conducted. However, most of the researches, related to mathematical literacy and self-regulated learning, were carried out in qualitative or descriptive research. According to the findings of the qualitative study, students who have high self-regulated learning have almost all aspects of mathematical literacy, while students who have low self-regulated learning do not have mathematical literacy in problem solving. (F et al., 2019; Kholifasari et al., 2020; Yanuarto et al., 2020). Therefore, innovations in learning are needed to accommodate students in developing self-regulated learning and students' mathematical literacy. Learning models that can be applied is blended learning (Angreanisita et al., 2021; Dianawati et al., 2018; Fitriasari et al., 2018) and Realistic Mathematics Education (RME) (Arisinta et al., 2019; Dianawati et al., 2018; Hilaliyah et al., 2019; Kusumaningrum, 2016).

Blended learning is a type of innovative learning that blends face-to-face classroom learning (offline learning) with online learning (utilising ICT/internet). (Dianawati et al., 2018; Fitriasari et al., 2018; Sari et al., 2020). Blended learning enables students to learn from anywhere and at any time as long as it is connected to the internet. It also has the potential to promote self-regulated learning. Furthermore, technology-based instruction can help students enhance their mathematical literacy. (Indrawati, 2020). Likewise, offline learning in blended learning can complement online learning to provide reinforcement and stabilization, especially in learning mathematics. Besides, an approach that still provides space for students to experience meaningful learning is necessary. In addition to blended learning, RME is the right choice to train mathematical literacy and self-regulated learning (Arisinta et al., 2019; Babys, 2016; Dianawati et al., 2018; Kusumaningrum, 2016).

Wijaya stated that RME is a mathematics learning approach based on Freudenthal's view that mathematics is a human activity (Hilaliyah et al., 2019). Furthermore, Zulkardi & Putri explained that RME is one of the lessons that emphasize context as a starting point for learning in building mathematical models, concepts, and motivations to make the learning process more meaningful (Arisinta et al., 2019). It suits the definition of mathematical literacy, that students can apply mathematics in solving problems related to real-life contexts. In addition, RME can create a conducive learning environment so that students get the opportunity to construct their knowledge (Kusumaningrum, 2016). However, the implementation of RME in mathematics learning today must be adapted to the development of science and technology as a form of innovation. The collaboration between RME and blended learning can be used as a solution to the problem of low learning independence and students' mathematical literacy.

Based on the analysis above, students' self-regulated learning and RME-based learning should be expected to affect students' mathematical literacy. Therefore, the goal to be achieved in this research is to examine the interaction between RME-based learning and conventional learning towards the improvement of students' mathematical literacy.

Methods

This research is experimental research with a Quasi-Experimental design. It is because the sample were not grouped randomly but using existing classes. The research design used is a 2x2 factorial design. The independent variables consist of: (1) learning model, consisting of

RME-based blended learning (B_1) and conventional learning (B_2); and (2) SRL level, consisting of high (A_1) and low (A_2), while the dependent variable is the improvement of ML. Furthermore, the 2x2 factorial design is represented in Table 1.

Table 1. A 2x2 factorial design for RME-based blended learning, self-regulated learning, and mathematical literacy

Self-Regulated Learning (SRL) Levels	Learning Models	
	RME-Based Blended Learning (A_1)	Conventional Learning (A_2)
High (B_1)	A_1B_1	A_2B_1
Low (B_2)	A_1B_2	A_2B_2

Based on Table 1, there are four groups of students, namely A_1B_1, A_1B_2, A_2B_1, and A_2B_2. Group A_1B_1 and A_2B_1 are groups of students with high levels of SRL who received RME-based blended learning and conventional learning, respectively. In addition, groups A_1B_2 and A_2B_2 are groups of students with low levels of SRL who received RME-based blended learning and conventional learning, respectively.

The population of this study was the seventh graders of SMP Negeri 40 Palembang. The sample was 38 students, who were divided into experiment class and control class, each of which was 19 people. Before conducting the research, the classes were first statistically tested for equivalence. The selection of the experiment class and the control class was conducted randomly. The treatment, RME-based blended learning, was in the experiment class, while the conventional learning was in the control class.

The instrument used were questionnaire and test, which are valid and reliable. The SRL data were obtained from the questionnaire before the treatment was given, while the data on ML were obtained from pretest and posttest. The grouping of SRL levels uses the criteria in Table 2 because an ordinal data.

Table 2. The criteria SRL levels

Interval	Levels
$x \geq$ Median	High
$x <$ Median	Low

The test is in the form of 2 essay problems about ML. The assessment rubric follows PISA standards, namely full credit, partial credit, and no credit. The improvement of students' ML is calculated by the normalized gain (N-gain) according to Hake (Nani & Kusumah, 2015) as follows.

$$Ngain = \frac{postest\ score - pretest\ score}{maximum\ possible\ score - pretest\ score}$$

Data were analyzed using the Adjusted Rank Transform Test with Two-Way ANOVA to determine the interaction between RME-based blended learning, conventional learning, and SRL in improving students' ML. In addition, the Mann-Whitney U test was used to do further tests for the simple effect of the learning models and SRL levels toward the improvement of ML.

Results

RME-based blended learning is implemented in the experimental class and conventional learning in the control class. This study begins with the distribution of a questionnaire to measure the level of student SRL as a research factor followed by the ML pre-test. Furthermore, the treatment was conducted in two meetings and continued with post-test. The data from this study were processed using SPSS 22.0.

The first step is to analyse the pre-test data to see the ML equivalence of students in each class through testing the difference between two means. The normality and homogeneity tests on the pre-test data need to be carried out first. The normality test used the Kolmogorov-Smirnov (K-S) test. The test criteria are that if the value of sig. (2-tailed) is more than the significance level α=0.05, so H_0 is accepted, and vice versa. The normality test on ML data from the experiment class and the control class are presented in Table 3.

Table 3. Normality test on ML pre-test using one-sample Kolmogorov-Smirnov test

Learning Model	N	Min	Max	Mean	Std. Deviation	Asymp. Sig. (2-tailed)
RME-based blended learning	19	.00	25.00	2.6316	6.69129	.000[c]
Conventional learning	19	.00	25.00	2.6316	6.69129	.000[c]

Based on Table 3, the means and standard deviations of the students' ML on pre-test data in both classes are the same, namely 2.6316 and 6.69129, respectively. In addition, it can be seen that the value of asymp. sig. (2-tailed) for the experiment and the control classes are equal to 0.000 and less than the significance level α=0.05, so H_0 is rejected. It means that each of the data is non-normal distribution. Furthermore, to determine the equivalence of the initial ML, the experiment class and the control class used non-parametric statistics, namely the Mann-Whitney U test since the data are a non-normal distribution. The null hypothesis is that there is no difference in the means of initial ML between students who receive PMR-based Blended Learning and students who receive conventional learning. The test criteria are to accept H_0 if the value of sig. (2-tailed) is more than the significance level α= 0,05, otherwise, H_0 is rejected. The results of the Mann-Whitney U test are presented in Table 4.

Table 4. Mann-Whitney U test on ML pre-test

	ML Pre-test
Mann-Whitney U	180.500
Asymp. Sig. (2-tailed)	1.000

In Table 4, the value of sig. (2 tailed) is 1.00 and more than the significance level of α = 0.05 so that H_0 is accepted. It means that there is no significant difference between means of the initial ML between students who receive PMR-based Blended Learning and those who receive conventional learning. It shows that this research begins with the condition of students' ML that are relatively the same.

Result about the interaction between RME-based blended learning, conventional learning, and SRL in improving students' ML

To find out the interaction between RME-based blended learning, conventional learning, and SRL in improving students' ML, N-gain of ML data are analyzed using two-way ANOVA utilizing SPSS 22.0. Descriptive statistics of N-gain of students' ML, such as means, standard deviations, minimums, and maximums scores from experiment class and control class, are presented in Table 5.

Table 5. Descriptive statistics of N-gain of students' ML

Self-Regulated Learning Levels	Learning	N	Mean	Category	Std. Deviation
High (B_1)	RME-based blended learning (A_1)	10	.3940	Middle	.39705
	Conventional (A_2)	8	.0175	Low	.04950
Low (B_2)	RME-based blended learning (A_1)	9	.1400	Low	.32738
	Conventional (A_2)	11	.0573	Low	.13070

Based on Table 5, only the mean of students' ML improvement of group A_1B_1 is medium categorized, while other three groups are low. Furthermore, the normality test was carried out as a prerequisite for two-way ANOVA. Table 6 shows the normality test results on the N-gain of ML in the experiment class and those in the control class.

Table 6. Normality tests on the N-gain of ML using one-sample Kolmogorov-Smirnov test

	A_1B_1	A_1B_2	A_2B_1	A_2B_2
N	10	9	8	11
Asymp. Sig. (2-tailed)	.200[c,d]	.000[c]	.000[c]	.000[c]

Table 6 shows that the asymp value. sig. (2-tailed) group A_1B_1 is 0.200 and more than the significance level α=0,05 , so H0 is not rejected. It means that the N-gain of ML, in group A_1B_1, is a normal distribution. However, those in groups A_1B_2, A_2B_1, and A_2B_2 are the same, namely 0.000, and less than the significance level α=0.05, so that H0 is rejected. It means that the N-gain of ML in groups A_1B_2, A_2B_1, and A_2B_2 are non-normal distributions. Since not all the N-gain of ML in groups are normally distributed, N-gain data is transformed using the Adjusted Rank Transform test followed by two-way ANOVA (Leys & Schumann, 2010). The analysis of the adjusted rank data using a two-way ANOVA with a significance level of α=0,05 can be seen in Table 7.

Table 7. Summary of two-way ANOVA

Source	Corrected Model	Intercept	A	B	A * B
F	3.924	139.692	2.432	.909	7.617
Sig.	.017	.000	.128	.347	.009

Based on table 7, there are the values of F and sig. in each A, B, and interaction between A and B. First, the value of F(A) = 2.432 and sig.=0.128 > 0.05 so that H0 is not rejected. It means that there is no difference in the improvement of students' ML between students who received RME-based blended learning and conventional learning. Second, the value of F(B) = 0.909 and sig.=0.347 > 0.05 so that H0 is not rejected. It means that there is no difference in the improvement of students' ML between high and low levels of SRL. Finally, the value of

F(A*B) = 7.617 and sig. =0.009 < 0.05 so that H0 is rejected. It means that there is a significant interaction between RME-based blended learning, conventional learning, and self-regulated learning towards students' ML improvement. Since there is a significant interaction, further analyses are performed to know the simple effect of RME-based blended learning and self-regulated learning towards the improvement of students' mathematical literacy separately.

Result about analysis of simple effect

A simple effect analysis must be carried out to examine the effect of differences between means of the improvement of students' ML from the four groups. From the corrected model row in Table 7, the value of F = 3.924 and sig. = 0.017 < 0.05 so H0 is rejected. It can be said that there is a significant difference between means of the improvement of students' ML among the four groups. For this reason, the difference between RME-based blended learning and conventional learning, in terms of SLR levels, are tested and the difference between high SRL and low SRL, in terms of learning models, are also tested. The criteria of a one-tailed test are to reject H0 if the value of sig. (2-tailed)/2 is less than the significance level α= 0.05, and vice versa. The results of the Mann-Whitney U test are presented in Table 8 and Table 9 below.

Table 8. Mann-Whitney U test in terms of SRL

Self-Regulated Learning Levels	Learning Models	N	Mean	Mann-Whitney U	sig.(2-tailed)
High (B_1)	RME-based blended learning (A_1)	10	19.350	14,5	0,013/2=0,0065
	Conventional (A_2)	8	15.500		
Low (B_2)	RME-based blended learning (A_1)	9	13.556	43	0,519/2=0,258
	Conventional (A_2)	11	27.409		

Table 9. Mann-Whitney U test for N-gain ML in terms of learning models

Learning Models	Self-Regulated Learning Level	N	Mean	Mann-Whitney U	sig.(2-tailed)
RME-based blended learning (A_1)	High (B_1)	10	19.350	25	0,083/2=0,0415
	Low (B_2)	9	13.556		
Conventional (A_2)	High (B_1)	8	15.500	40,5	0,649/2=0,3245
	Low (B_2)	11	27.409		

In the Table 8, for the high level of SRL, the average of A_1B_1 is more than those of A_2B_1 and sig.(2-tailed)/2 = 0,013/2=0,0065 is less than 0.05 that means reject H_0. Therefore, the ML of students who received RME-based blended learning was significantly higher than students who received conventional learning, in terms of the high level of SRL. However, for the low level of SRL, the average of A_1B_2 is less than those of A_2B_2 and sig.(2-tailed)/2 = 0,519/2=0,258 > 0.05 that means not reject H_0. Therefore, the ML of students who received RME-based blended learning was not significantly higher than students who received conventional learning, in terms of the low level of SRL.

In the Table 9, for RME-based blended learning, the average of A_1B_1 is more than those of A_1B_2. The sig. (2-tailed)/2 = 0.083/2=0.0415 is less than 0.05 that means reject H_0. Therefore, the ML of students with high SRL were slightly higher than students with low SRL after getting RME-based blended learning. However, for conventional learning, the average of A_2B_1 is less than those of A_2B_2. The sig. (2-tailed)/2 = 0.649/2=0.3245 is more than 0.05 that means not reject H_0. Therefore, the ML of students with high SRL was not significantly higher than students with low SRL after getting RME-based conventional learning.

Discussion

The results show that there is a significant interaction between RME-based blended learning, conventional learning, and self-regulated learning in improving students' mathematical literacy. This is in line with conclusion of previous research that there is an interaction between learning models, self-regulated learning on mathematics learning outcomes (Putri & Wardika, 2020). In this study, RME-based blended learning is the learning model used, while mathematical literacy is the learning outcomes. Overall, the learning model factor did not affect the improvement of ML between students who received RME-based blended learning and conventional learning, as well as the self-regulated learning factor. However, in terms of the high level of SRL, the ML of students who received RME-based blended learning was significantly higher than students who received conventional learning. In terms of the low level of SRL, the ML of students who received RME-based blended learning was not significantly higher than students who received conventional learning. In addition, the ML of students with high SRL were slightly higher than students with low SRL after getting RME-based blended learning. In addition, the ML of students with high SRL was not significantly higher than students with low SRL after getting conventional learning. This is in line with previous research that students with higher self-regulated learning do not always have high mathematical literacy abilities, and vice versa (Angreanisita et al., 2021).

In RME-based blended learning, students are facilitated *through Google Classroom* and *Whatsapp* groups to learn materials related to the material they will learn in synchronous learning and can discuss it first. In addition, the student worksheet used was developed by the five PMR characteristics and the problems were mathematical literacy problems. This can facilitate students to get used to solving mathematical literacy problems. The existence of interactivity in the process of completing students worksheet can help students understand and solve problems so that students get better mathematical literacy. However, only a few students actively discussed in groups at synchronous times due to several factors. Meanwhile, these activities do not occur in conventional learning.

The results of the research that have been stated above occur for several reasons, especially from conventional learning that is carried out. In conventional learning, the teacher provides informative learning through *Whatsapp* groups, giving assignments. At the time of learning, the teacher provides a detailed explanation of the subject matter, provides examples of how to solve problems, and provides exercises. Students pay close attention to the teacher's explanation, then record what the teacher explains and do the exercises. Before students do the exercises, usually the teacher gives time for students to ask questions about things that they have not understood and the teacher returns to explain. This is very different from learning in the experimental class.

Conclusion

Based on the research results and discussions, it can be concluded that: (1) there is a significant interaction between RME-based blended learning, conventional learning, and self-regulated learning towards students' ML improvement; (2) the ML of students who received RME-based blended learning was significantly higher than students who received conventional learning, in terms of the high level of SRL; (3) the MLS of students who received RME-based blended learning was not significantly higher than students who received conventional learning, in terms of the low level of SRL; (4) the MLS of students with high SRL were slightly higher than students with low SRL after getting RME-based blended learning; and (5) the MLS of students with high SRL was not significantly higher than students with low SRL after getting RME-based conventional learning.

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Conflicts of Interest

All authors declare that this manuscript have no conflict of interest.

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