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Model-Eliciting Activities on Students' Mathematical Literacy by Reviewing Differences in Self-Regulated Learning

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Abstract

The mathematical literacy of students is still relatively low. However, it remains a goal and a necessity to develop mathematical literacy as a fundamental skill for solving problems in various contexts, particularly in formulating, employing, and interpreting mathematics. Previous studies have proven that model-eliciting activities effectively enhance mathematical literacy. On the other hand, mathematical literacy is influenced by differences in self-regulated learning. Therefore, this study answers whether implementing model-eliciting activities regarding self-regulated learning differences affects students' mathematical literacy. This study employed a quasi-experimental non-equivalent pretest and posttest design that involved 55 fourth-grade primary students. Data collection used a mathematical literacy test and a self-regulated learning questionnaire. The levels of self-regulated learning were categorised as low, medium, and high. The data analysis was a two-way analysis of variance test followed by the Tukey test. The study showed that implementing model-eliciting activities by considering differences in self-regulated learning affected students' mathematical literacy. Another finding is that students with high self-regulated learning are better at mathematical literacy than those with low self-regulated learning.

Keywords: *model-eliciting activities, mathematical literacy, self-regulated learning.*

Abstrak

Literasi matematika siswa masih tergolong rendah, namun sampai saat ini masih menjadi tujuan dan kebutuhan sebagai keterampilan fundamental untuk menyelesaikan masalah dalam berbagai konteks khususnya dalam hal merumuskan, menggunakan, dan menafsirkan matematika. Peneliti-peneliti sebelumnya telah membuktikan *model-eliciting activities* efektif untuk meningkatkan literasi matematika. Disisi lain, literasi matematika dipengaruhi oleh perbedaan *self-regulated learning*. Oleh karena itu, penelitian menjawab rumusan masalah mengenai apakah implementasi *model-eliciting activities* dengan memperhatikan perbedaan *self-regulated learning* berpengaruh terhadap literasi matematika siswa. Penelitian ini menggunakan quasi eksperimental non-equivalent pretest dan posttest desain dengan melibatkan 55 siswa kelas empat sekolah dasar. Pengumpulan data menggunakan tes literasi matematika dan kuisioner *self-regulated learning*. Perbedaan tingkat *self-regulated learning* dikategorikan sebagai rendah, sedang, dan tinggi. Analisis data yang digunakan adalah uji analisis varians dua arah dan dilanjutkan uji Tukey. Temuan penelitian menunjukkan implementasi *model-eliciting activities* dengan memperhatikan perbedaan *self-regulated learning* berpengaruh terhadap literasi matematika siswa. Temuan lainnya adalah siswa yang memiliki *self-regulated learning* tinggi lebih baik dalam literasi matematika dibanding siswa yang memiliki *self-regulated learning* rendah.

Kata kunci: *model-eliciting activities*, literasi matematika, *self-regulated learning*.

INTRODUCTION

Mathematical literacy is a basic skill that students must have and is the main focus in the curriculum of various countries (Holenstein et al., 2021). According to the Program for International Student Assessment (PISA), mathematical literacy is an individual skill in mathematical forethought, performance, and self-reflection in various contexts (OECD, 2023). This skill not only includes understanding basic concepts but also the skill to apply and relate mathematics to real-world situations, whether involving numbers or not (Sikko, 2023).

In learning mathematics, primary students face difficulties in recognizing numbers, formulas, and mathematical symbols (Monica et al., 2023). Mathematical literacy is needed to solve contextual problems (Nisa & Arliani, 2023). Mastery of mathematical literacy can build positive motivation and students' readiness to face real-world challenges (Mubarokah & Amir, 2024). Therefore, teachers need to pay attention to the process and results of using mathematical literacy in learning (Utami & Amir, 2023).

The Program for International Student Assessment results show Indonesia's position in international rankings is still low. In 2022, Indonesia obtained a score of 377, far below the Organisation for Economic Co-operation and Development average of 489, and ranked 74th (OECD, 2023). This score shows that Indonesia still faces a big challenge in mathematical literacy. This low skill makes it difficult for many students to apply mathematical knowledge in real contexts (Utami & Amir, 2023).

Primary students in Indonesia have low mathematical literacy (Runtu et al., 2023). The low mathematical literacy is because students experience difficulties understanding mathematical concepts as a whole, so students tend only to memorize formulas and work on mathematical problems, not based on understanding the correct process (Rufiana et al., 2024). Most mathematical literacy students' also encounter difficulties relating mathematics to real-world problems (Mubarokah & Amir, 2024; Nisa & Arliani, 2023). In this, students struggled to formulate, employ, and interpret appropriate divergent solutions (Khotimah et al., 2019; Utami & Amir, 2023).

Model-eliciting activities can encourage thinking skills and students' reasoning through the development of mathematical models that represent the conceptual system of mathematical experience (Mei et al., 2022). This process consists of five stages: submitting problems, responding, understanding, creating mathematical models, presenting results (Hartati et al., 2020). By actively engaging students in the process of thinking and modeling, model-eliciting activities aid understanding of concepts and procedures while developing modeling skills and mathematical creativity that are relevant across fields (Chamberlin & Moon, 2005).

Self-regulated learning is the skill of students' managing their learning process independently to enhance the quality of learning (Zimmerman & Schunk, 2011). This skill encourages students to use reason before acting and contribute to better learning outcomes (Mejeh & Held, 2022). This process emphasizes active engagement in managing memory and learning strategies (Wirth et al., 2020), and consists of three phases: forethought, performance, and self-reflection (Zimmerman & Schunk, 2011). Support for self-regulated learning includes meaningful tasks, clear instructions, and students' active participation (Mejeh & Held, 2022).

Self-regulated learning must be considered in the eliciting activities model because both emphasize independence, reflection, and open-ended problem-solving. Huang et al. (2024) showed that support for self-regulation enhances the skill of solving math story problems. Li et al. (2021) and Ansari et al. (2021) confirmed that self-learning strategies strengthen the effectiveness of modeling and solving higher-order thinking problems. In addition, self-regulation reduces math anxiety (Harahap et al., 2025) and needs to be developed early on (Lee et al., 2023). Chimmalee and Anupan (2022) also stated that the success of the modeling activity is highly dependent on the student's skill to regulate their learning process. Thus, integrating self-regulation is a key component in effectively implementing the model-eliciting activities.

Model-eliciting activities have learning characteristics to facilitate students' mathematical literacy (Kehi & Naimnule, 2023). In this, model-eliciting activities provide opportunities for students to apply mathematical concepts in real-world problem solving, which is by students' self-regulated learning levels (Nisa & Arliani, 2023). On the other hand, self-regulated learning is a crucial factor in improving mathematical literacy because students can organize themselves and use their reasoning power in learning (Gabriel et al., 2020). Therefore, it is possible that paying attention to self-regulated learning in the implementation of model-eliciting activities can enhance mathematical literacy students' performance more optimally.

Various studies have discussed how the eliciting activities model can enhance critical thinking skills (Şener & Dede, 2024), mathematical creativity (Sengil-Akar & Yetkin-Ozdemir, 2022), students' participation (Jung & Brady, 2025), problem-solving skills and mathematical disposition (Sari et al., 2020), and reflective thinking (Özbek & Cho, 2022). However, these studies have not examined how differences in students' self-regulated learning affect the effectiveness of the eliciting activities model. Meanwhile, Srikoon et al. (2024)

emphasized the importance of innovative models in enhancing mathematical literacy. Karlen et al. (2024), Bednorz and Bruhn (2023), as well as Zimmerman and Schunk (2011), emphasized the important role of self-regulated learning. Unfortunately, the interaction between the two has rarely been studied. This study fills that void by examining how differences in students' self-regulated learning affect the success of the eliciting activities model in enhancing mathematical literacy.

Hence, Unlike previous studies, this study emphasizes implementing the eliciting activities model to mathematical literacy by considering differences in students' self-regulated learning. This study aims to analyze the increase or decrease in mathematical literacy based on differences in self-regulated learning by implementing the eliciting activities model. The results are expected to contribute to teachers in designing more effective mathematics learning by considering students' self-regulated learning characteristics.

METHODS

This study employed a quantitative approach with a non-equivalent pretest-posttest quasi-experimental design involving both experimental and control groups. The research design is illustrated in Figure 1. The study's primary objective was to analyze the effect of implementing model-eliciting activities on students' mathematical literacy, considering differences in self-regulated learning. Furthermore, the stages of the implemented model-eliciting activities comprised five distinct steps, as visualized in Figure 2.

O_1	➔	E_1	➔	X	➔	O_2
O_1	➔	E_2	➔	-	➔	O_2

Figure 1. Research design

Information :

E1 : Experimental class — O1 : Pretest

E2 : Control class — O2 : Posttest

X : Treatment with model-eliciting activities

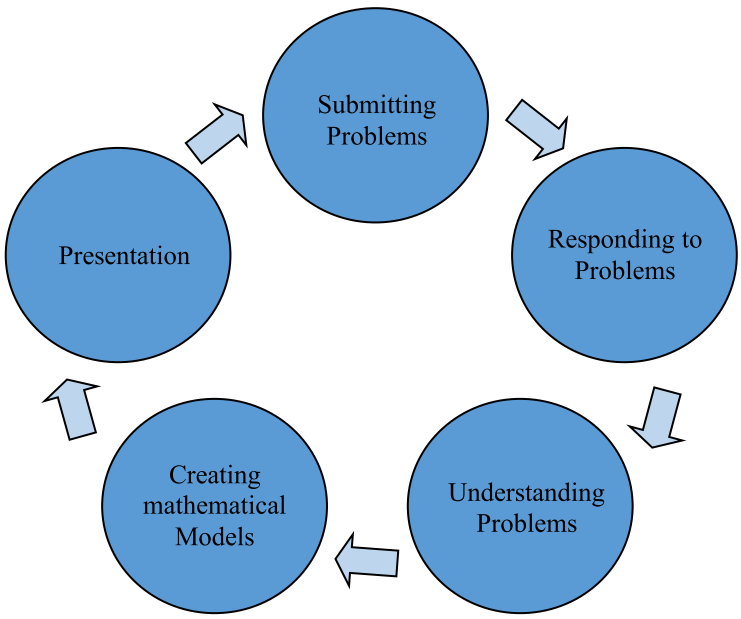

Figure 2. Stages model-eliciting activities (Hartati et al., 2020)

The five stages of model-eliciting activities were adapted from Hartati et al. (2020). First, students read worksheet problems to establish context (submitting problems). Second, they listened to the questions provided (responding to problems). Third, each group ensured a shared understanding of the task (understanding problems). Fourth, students worked collaboratively to solve the problem and develop a solution (creating mathematical models). Fifth, the groups presented their models after discussing and reviewing their solutions (presentation).

A random sampling technique was employed to select the experimental and control classes (Cresswell & Cresswell, 2018). Both classes received different treatments: the experimental class was taught using model-eliciting activities, while the control class received conventional instruction. The population of the study consisted of fourth-grade students, totaling 85 learners. The sample comprised two classes: 27 students from class 4A (experimental group) and 28 students from class 4B (control group).

The instruments used in this study were a questionnaire and a test. The questionnaire measured students’ self-regulated learning skills using a 5-point Likert scale. The indicators of self-regulated learning—forethought, performance, and self-reflection—were adapted from Zimmerman and Schunk (2011). The questionnaire grid is presented in Table 1. Students' self-regulated learning levels were categorized into three levels: low, medium, and high. The test instrument consisted of five open-ended questions designed according to the mathematical literacy indicators of formulating, employing, and interpreting, as adapted from the OECD (2023).

Table 1. Self-regulated learning questionnaire grid

Phase	**Indicator**	**Question numbers**		**Total**
		(+)	(-)	
Forethought	Self-analysis task	1	2	2
	Goal setting	9	32	2
	Strategic planning	33	34	2
	Self-motivation belief	3	4	2
	Self-efficacy	29	35	2
	Outcome expectation	5	36	2
	Internal approach	7	8	2
	Goal orientation	31	10	2
		Total cognitive phase items		16
Performance	Self-control	13	14	2
	Self-instruction	28	6	2
	Imaginary	11	12	2
	Attention focusing	15	16	2
	Task strategy	17	18	2
	Self-observation	19	20	2
	Self-recording	37	38	2
	Self-experimentation	27	22	2
		Total performance phase items		16
Self-reflection	Self-judgement	23	24	2
	Self-evaluation	26	30	2
	Casual attribution	39	40	2
	Self reaction	25	41	2

Self-satisfaction/affect	21	42	2
Adaptive-defensive	43	44	2
	Total self-reflection phase items		12
Total items of self-regulated learning scale			44

Table 1 presents the self-regulated learning questionnaire grid, which consists of three main phases: forethought, performance, and self-reflection. The instrument includes a total of 44 items, each comprising both positive (+) and negative (–) statements. The first phase, forethought (16 items: 8 positive, 8 negative), includes the following components: self-analysis tasks, goal setting, strategic planning, self-motivation belief, self-efficacy, outcome expectation, internal approach, and goal orientation. The second phase, performance (16 items: 8 positive, 8 negative), includes self-control, self-instruction, imaginary, attention focusing, task strategy, self-observation, self-recording, and self-experimentation. The third phase, self-reflection (12 items: 6 positive, 6 negative), comprises self-judgment, self-evaluation, causal attribution, self-reaction, self-satisfaction/affect, and adaptive-defensive.

The data analysis techniques employed in this study involved the use of Statistical Product and Service Solutions (SPSS) version 26. Statistical tests included a normality test and a homogeneity test. The Shapiro–Wilk test was applied to determine whether the data were normally distributed, and the Levene test was used to test the homogeneity of variance, using a significance level of 0.05 as the criterion prior to conducting the two-way analysis of variance (ANOVA). Additionally, Tukey's post hoc test was carried out to examine differences in the mean of the dependent variable between groups.

RESULTS AND DISCUSSION

This study obtained mathematical literacy scores and self-regulated learning differences. Data was collected from the experimental and control classes. Self-regulated learning difference data was collected through a questionnaire, and the results of the difference from the experimental and control classes are shown in Figure 3.

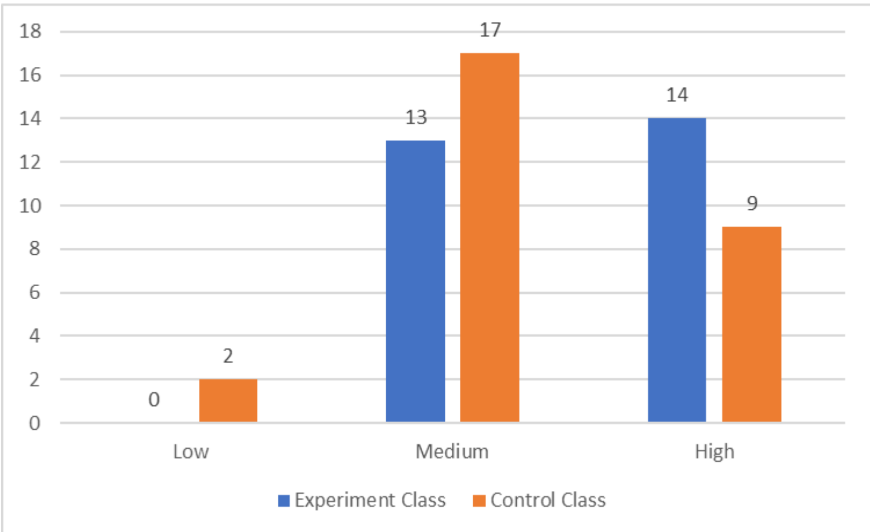

Figure 3. Self-regulated learning difference results in experimental and control classes

Data on the difference in self-regulated learning between the experimental and control classes are shown in Figure 3. In the experimental class, there were no students in the low category, 13 in the medium category, and 14 in the high category. In the control class, were 2 students in the low, 17 medium, and 19 high categories. Thus, students' self-regulated learning was distributed in moderate, high, and low categories. The mathematical literacy scores of each class are presented in Table 2.

Table 2. Descriptive statistics of mathematical literacy scores by class and self-regulated learning

Class	Self-regulated learning	Mean	Std. deviation	N
Experiment	Low	0.00	0.000	0
	Medium	27.38	4.053	13
	High	28.79	4.526	14
Control	Low	18.00	0.000	2
	Medium	23.47	4.259	17
	High	28.00	3.000	9
Total	**Low**	**18.00**	**0.000**	**2**
	Medium	**25.17**	**4.549**	**30**
	High	**28.48**	**3.941**	**23**

Table 2 shows that those with high self-regulated learning had the highest average mathematical literacy scores in the experimental (28.79) and control (28.00) classes, followed by medium and low levels. The standard deviations in the experimental class were greater at the moderate (4.053) and high (4.526) levels than in the control class (4.259 and 3.000), indicating that the implementation of the eliciting activities model resulted in greater variation in learning outcomes. This means that the effect of this learning model is more diverse depending on the differences in students' self-regulation. Meanwhile, standard deviation = 0.000 at the low level indicates no variation in scores, possibly due to the very small number of students in this category. Shapiro-Wilk test results are presented in Table 3 and Levene test results in Table 4.

Table 3. Shapiro-Wilk test

	Shapiro Wilk		
	Statistic	**df**	**Sig.**
Standardized Residual for Mathematical Literacy	0.959	55	0.61

Table 4. Levene test

		Levene statistic	Sig.
Mathematical Literacy	**Based on Mean**	2.333	0.068

The Shapiro-Wilk test results show a significant value of 0.061 (>0.05). This means that all data are normally distributed. Meanwhile, in the Levene test in Table 4, the Levene statistic value was obtained as 2.333 with a significance level of 0.068 (>0.05). Thus, the homogeneity requirement is met. Hypothesis testing procedures can be carried out because the requirements of the two-way statistical test related to the normality and homogeneity tests have been met. Hypothesis results are presented in Table 5.

Table 5. Two-way test results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	401.676[a]	4	100.419	6.081	.000
Intercept	13912.736	1	13912.736	842.513	.000
Class	69.395	1	69.395	4.202	.046
SRL	207.729	2	103.865	6.290	.004
Class * SRL	30.747	1	30.747	1.862	.179
Error	825.669	50	16.513		
Total	39244.000	55			
Corrected Total	1227.345	54			

Several results were obtained from the data analysis in Table 5. First, the significance value is 0.046 (<0.05), so it can be interpreted that there is a difference in students' mathematical literacy based on experimental and control classes. Second, a significance value of 0.004 (<0.05) was obtained, so it can be interpreted that there is a difference in students' mathematical literacy based on students' self-regulated learning skills. Third, the significance of 0.179>0.05 was obtained, so it can be interpreted that there is no interaction between experimental and control classes with students' self-regulated learning skills in determining students' mathematical literacy. Tukey test results are presented in Table 6.

Table 6. Comparison of students' self-regulated learning levels

(I) SRL Level	(J) SRL Level	Mean Difference (I-J)	Std. Error	Sig.
Low	Medium	-7.17	3.108	.064
	High	-10.48*	3.138	.004
Medium	Low	7.17	3.108	.064
	High	-3.31*	1.180	.019
High	Low	10.48*	3.138	.004
	Medium	3.31*	1.180	.019

Tukey's test in Table 6 shows that the difference in mathematical literacy occurs at low and high self-regulated learning levels (significance level of 0.004, which is far below 0.05). Based on the quantitative results described above, the study results are reinforced by the differences in the results of mathematical literacy answers in the two classes.

The findings of this study show that implementing model-eliciting activities about self-regulated learning differences affects students' mathematical literacy. This is in line with previous studies that model-eliciting activities on mathematical literacy students' are classified as obtaining better results, especially those related to the real world (Kehi & Naimnule, 2023; Susanti et al., 2023). Additionally, taking into account the differences in students' levels of self-regulated learning may influence their mathematical literacy (Gabriel et al., 2020; Sari et al., 2022).

Another finding shows that students with high self-regulated learning have better mathematical literacy skills than students with low self-regulated learning. A significant difference was seen between the two. This aligns with previous studies, which state that students with high self-regulated learning can set goals, self-understand, and manage emotions to achieve optimal results (Arianto & Hanif, 2024; Bednorz & Bruhn, 2023).

Conversely, students with low self-regulated learning tend to copy their friends' work because they have difficulty finding solutions (Oudman et al., 2022).

The class with the model-eliciting activities did not have students with low self-regulated learning, while the conventional class did. However, the self-regulated learning category in this study does not fully reflect students' skills in solving complex open-ended problems. Further evidence is needed that the model-eliciting activities can equalize students with different levels of self-regulated learning (Battaglia et al., 2025). This finding indicates the need to refine the instrument and the level of self-regulated learning measurement to be more accurate (Bednorz & Bruhn, 2023; Karlen et al., 2024). Therefore, further studies are needed related to the measurement of self-regulated learning as a whole so that the results are more accurate and meet the needs of students.

The study results showed no direct interaction between the eliciting activities model and students' self-regulated learning. This means that the different levels of self-regulated learning (low, medium, high) in the class with the eliciting activities model and conventional learning produce similar patterns (Bednorz & Bruhn, 2023). The characteristics of the two learning models did not show significant differences in each level of self-regulated learning, either individually or on average. This finding is consistent with Yuni et al. (2021), who found that the learning model enhances reflective thinking skills but does not impact self-regulated learning, as well as Putri et al. (2020), which also did not find significant effectiveness between models in improving students' self-regulated learning.

Model-eliciting activities can enhance mathematical literacy by considering differences in students' self-regulated learning levels. In general, the class that applied the eliciting activities model showed better results than the class with conventional learning (De Ruig et al., 2023). This activity requires students to develop solutions, evaluate their limitations, and assess their decisions in a real context (Huffman & Mentzer, 2021). Thus, students with high self-regulated learning who follow the eliciting activities model tend to have higher mathematical literacy than those who follow conventional learning.

Based on the review of several previous researchers and the results of this study, it can be interpreted that the results of this study are in line in general but have novelty in examining the implementation of the model-eliciting activities based on different levels of self-regulated learning that have not been widely studied before (Arianto & Hanif, 2024; Bednorz & Bruhn, 2023). This study shows that the model-eliciting activities can be used as a learning approach that provides real mathematical experience while being responsive to students' self-regulation differences. This work is in line with the idea that open contextual learning encourages a deeper understanding of mathematics (Battaglia et al., 2025; Chamberlin & Moon, 2005). Therefore, teachers can consider the results of this study as a basis for choosing a learning model that develops mathematical literacy and adapts to students' self-regulation needs in the classroom.

CONCLUSION

The results showed that students who received model-eliciting activities had higher mathematical literacy than students who only received the conventional learning model. Furthermore, students with a high self-regulated learning level have a higher mathematical literacy than those with a low one. The results of this study have limitations, namely the short time required for data collection. This study discussed model-eliciting activities on mathematical literacy based on self-regulated learning differences, so studies on other differences in student skills need to be explored. Suggestions for future studies: It is necessary to conduct additional studies on how far the implementation of model-eliciting activities will overcome the insignificance of students with low self-regulated learning levels. Another suggestion is that further study is needed to maintain model-eliciting activities as a learning model by considering differences in students' self-regulated learning levels to achieve mathematical competence, especially in mathematical literacy.

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