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Math-Self regulated learning assisted by metacognitive support by reviewing sex differences in mathematics anxiety

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ABSTRACT

The main study aims to analyze the effect of mathematics self-regulated learning (MSRL) assisted by metacognitive support (MS) by reviewing sex differences (SD) in mathematics anxiety (MA). The reason is that MA causes students to have difficulty in learning, so good strategies and approaches are needed so that these problems can be resolved and learning can be carried out optimally. Previous research revealed that MA has a negative impact on student achievement. In several studies, there is a relationship between MA with SRL and MS. This research is a quantitative research using Spearman Rho analysis and ordinal regression analysis, with research population is 3rd-grade students of primary schools in Sidoarjo, East Java. The results showed a relationship between SRL and MS to MA. Furthermore, it revealed that the average student had a positive MS and a high MSRL. However, when viewed from the sex differences, the MA showed that female students were more anxious than male students. Thus, the MS-assisted SRL has a good influence when viewed from SD to MA. The recommendation from this research is so that MS and SRL strategies can be implemented optimally. Teachers must prepare and explore the implementation of using strategies and approaches more deeply.

INTRODUCTION

The problem of mathematics anxiety (MA) has attracted the attention of researchers and has become the main focus of research in the fields of psychology and education (Auliya, 2016). Freedman has specifically described MA as an emotional reaction caused by an unpleasant experience and hurts the subsequent learning process (Score, 2006). The researchers revealed that one of the possible causes of MA in students is caused by teaching methods that emphasize memorization methods rather than methods oriented to problem solving, understanding, and reasoning processes (Stodolsky, 1985). Emphasis on memorization methods makes challenging students' affective development barriers (Making, 1992). As a result, students become anxious, nervous, restless, and tense when faced with mathematical questions emphasizing problem-solving and reasoning (Kesici et al., 2011).

Evaluation of MA in the learning and teaching process requires more attention. This is because MA can hinder student learning processes and reduce student learning outcomes. The higher the number of MA students, the lower the learning outcomes (Mayudana, 2020). Apart from this, meta-analysis studies prove that once students have negative attitudes and anxiety, it will be difficult to change and last into adulthood and have severe consequences (Gierl & Bisanz, 1995).

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These consequences include an attitude of always avoiding mathematics, difficulty learning mathematics, and a lack of understanding of concepts (Hembree & College, 2015).

Attempts to find a solution to this problem can be identified from the cause (Katon & Arigiyati, 2018). The main cause of student anxiety is learning that has not been adequately applied in the student's classroom environment (Mansyur, 2020). Thus, an effort is needed to know and evaluate its achievements to find appropriate learning to reduce MA (Eysenk, 1979).

Learning that has the potential to reduce MA is oriented toward problem-solving, reasoning, and deep understanding (Jiang et al., 2021). Metacognitive learning encourages students to understand, reason, solve problems, and grow student awareness (Ayala, 2014). Students also have high performance (Balashov et al., 2021). Untuk menunjang kesadaran metacognitive siswa, pada penelitian ini dilakukan dengan menggunakan pendekatan metacognitive support (MS) yang terdiri dari metacognitive strategy dan juga metacognitive questioning (Kramarski et al., 2010).

Metacognitive strategies are related to efforts to train students in planning, monitoring themselves, and evaluating their learning (Malley et al., 1985). Teachers can find out how students think and students can also find out how information is processed (Blakey & Spence, 2013). Meanwhile, metacognitive questions are related to elaborating and evaluating the depth of students' conceptual understanding to solve problems (Schellings et al., 2013). By supporting this in the form of metacognitive questions, students are expected to be aware of their own thoughts about what they have learned. Smith stated that metacognition could help students hone their ability to understand what they think so that students can control their learning activities (Smith, 2013).

Several previous research results have confirmed that a positive evaluation of MA positively impacts the achievement of mathematics learning outcomes and can be resolved by optimizing students' learning awareness through MSRL. Thus, there is a relationship between MSRL and MA (Kesici et al., 2011). The results of other studies show that self-regulated learning can affect mathematics learning outcomes (Mutawah et al., 2017). According to Rosenthal & Wolters (2000), if students have high self-efficacy, they will have good self-regulated learning in their daily lives. Zimmerman & Martinez-pons (1988) states a positive relationship between self-ability and self-regulated learning, also related to student anxiety.

Another study found that sex differences (SD) also have a relationship with MA experienced by students (Fennema & Sherman, 1976). The notion that women are more anxious than men academically is a social factor that makes a difference today (Ashcraft, 2002). This assumption is also shown by a study that suggests that women have worse spatial processing to manage information than men (Maloney et al., 2012). In addition, the perception of mathematics makes a person have different assumptions about mathematics, so this is the reason for mathematical anxiety in terms of sex differences (Zirk-sadowski et al., 2014). However, some studies state that both women and men can solve mathematical problems using strategies that support and match their abilities (Hyde et al., 2008).

Based on the studies above, it can be assumed that implementing MS and MSRL can reduce MA. However, efforts to evaluate achievements in integrating MS and MSRL in learning by reviewing SD so that they can be optimal in reducing MA still need further evaluation.

METHOD

This research design uses quantitative research. The research was conducted at SDN Kenongo 1 Tulangan, Sidoarjo Regency, East Java. The subjects of this study were 3rd-grade students of primary schools in Sidoarjo with a target population of 91 students. The sampling in terms of sex differences, namely male and female students. Data collection in this study was carried out using tests and questionnaires containing questionnaires. The research was conducted from October-December 2021 for three months. The researcher gave a questionnaire in the form of a questionnaire to measure the students' MSRL and gave an MS test in the form of essay questions and then calculated the scores for each student. In addition, researchers also used a questionnaire

to meas 22 students' anxiety levels because this study was viewed from the SD then the resulting score is divided into two groups, namely the female group and the male group.

The instruments used are in the form of questionnaires derived from modifications and adaptations of previous studies. Research variables are clustered into MSRL, MA, and MS. The research instrument is a questionnaire containing the identity of the respondents and research variables. The questionnaire used as a measuring tool for MA consists of 16 cognitive, affective, and psychomotor anxiety questions with four alternative Likert scale answers. This questionnaire was modified and adapted from research conducted by (Richardson & Suinn, 1972) with a validity coefficient of 0.500 and a reliability coefficient of 0.868 (Suinn & Winston, 2003)

Thus, the MA questionnaire has an outstanding value, and a valid questionnaire is used as an instrument. Indicators of the MA variable consist of cognitive anxiety, affective anxiety, and psychomotor anxiety. Indicators of mental anxiety, such as thoughts that disturb students while studying, consist of 2 statement items. In comparison, indicators of affective anxiety or feelings experienced by students consist of 12 statement items, and students' psychomotor or behavioral indicators when experiencing MA consist of 2 statement items.

The MSRL questionnaire is also an instrument sourced from Purdie et al., (1996), which has been modified according to research needs, including statements in the form of planning, implementation, and evaluation. The statement consists of 10 questions with a reliability coefficient in the previous study of 0.792. Therefore, the MSRL questionnaire has good reliability and is valid for use. There are five indicators from the MSRL, including students' ability to realize their thoughts, make effective study plans, be aware of and use the sources of information they need, be enthusiastic about feedback, and evaluate their actions.

Furthermore, the indicators of the MS variable that use four indicators include understanding the problem, building new knowledge connections with previous knowledge, developing problem-solving strategies, reflecting on processes, and solutions to problem-solving. In this MS, there is metacognitive questioning where according to Making (1992), students can gain control over their learning, feelings, and behavior through metacognitive questions.

This research data has an ordinal measurement scale to determine the relationship between variables. The statistical analysis used is the Spearman analysis technique and ordinal regression. This research is an experimental study where students are subjected to a treatment to determine the effect of treatment on research subjects. The relationship between variables in this study is shown in Figure 1.

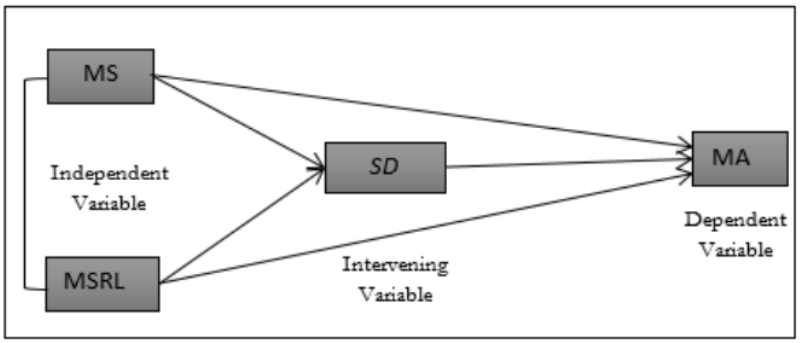

Figure 1. Relationship between variables

The relationship between the implementation of MS and MSRL by reviewing SD to reduce MA in Figure 1 is the basic idea and mapping of research variables to determine the effect of MSRL and MS on students' MA when viewed from SD.

FINDINGS AND DISCUSSION

This study aims to analyze the influence and relationship of variables MSRL, MA, and MS when viewed from SD. Finding the correlation and significance between the variables MSRL, MS, and MA can be done using Spearman Rho correlation analysis.

Table 1. Correlations Spearman

		MSRL	MS	MA
MSRL	Correlation Coefficient	1.000	.091*	-.513**
	Sig. (2-tailed)	.	.390	.000
	N	92	92	92
MS	Correlation Coefficient	.091*	1.000	.273
	Sig. (2-tailed)	.390	.	.009
	N	92	92	92
MA	Correlation Coefficient	-.513**	.273	1.000
	Sig. (2-tailed)	.000	.009	.
	N	92	92	92
*. Correlation is significant at the 0.05 level (2-tailed).				
**. Correlation is significant at the 0.01 level (2-tailed).				

From Table 1, it can be seen that the MSRL variable has a correlation coefficient of -0.513 to MA. This indicates that there is a relationship between MSRL and MA. A negative value in the correlation indicates an opposite relationship between the two. If MSRL has a high value, then MA has a low value and vice versa. It is in line with the findings of Kesici et al., (2011) that students with high MSRL showed common statistical anxiety.

MSRL can provide awareness of student learning and involve metacognitive abilities so that they can apply appropriate learning strategies to achieve explicit and implicit learning goals (Duncan & McKeachie, 2005). Furthermore, the value of sig is known between these two variables is 0.000. As the basis for decision making on the Spearman rank correlation, which is sig < 0.01, it can be concluded that there is a significant relationship between MSRL and MA.

This significant relationship between MSRL and MA supports research conducted by Tobias which states that the cause of MA is influenced by three factors, namely: (1) Students have the perception that teachers are the only source of knowledge, so students' MSRL decreases, this makes an authority that forced; (2) Feelings of fear when they want to express opinions, where the cause is because students are afraid if they answer the questions wrong and are humiliated in front of the class; (3) Some exams cause stress and MA (Smail, 2017).

Developing MSRL can motivate students to continue learning (Feraco et al., 2022, p.14). The curriculum should focus on the content of learning materials and strengthen the importance of self-regulation to reduce students' MA (Gabriel & Buckley, 2020). On the other hand, MS and MA have a correlation coefficient of 0.273 and a sig. of 0.009. This indicates that MS and MA have a correlation coefficient relationship between variables. In addition, there is a significant relationship between the two. These findings are in line with research by Hoorfar & Taleb (2015), who suggested a correlation between MA and metacognitive. If the MA of students is reduced, then students can use their metacognitive abilities even better.

On the other hand, the relationship between MSRL and MS has a low correlation coefficient of 0.091 with a positive value. It indicates that the two variables have a unidirectional relationship. If MSRL has a high value, MS also has a high value. However, both have a sig value of 0.390, which indicates that the variable is less significant. Raković et al. (2022, p.3) found self-regulated learning correlates with students' metacognitive and positively impacts students' learning processes. Having

metacognitive abilities has become a top priority in the 21st century to develop knowledge (Ozturk, 2017). On the other hand, the use of MSRL is also essential because MSRL plays a critical role in choosing learning strategies, identifying learning objectives, and self-regulating during learning (Schraw et al., 2006).

The existence of other factors, such as a pandemic, makes students have to accept online learning which then switches again to face-to-face. Learning during a pandemic can be said to be not running effectively due to limited study time, making students feel less ready to receive lessons properly (Oktawirawan, 2020). As a result, they feel anxious and afraid if they cannot answer the question correctly (Suryaman et al., 2022, p.2). Students' anxiety increases, which causes students' thinking power to not be closely related to their metacognitive. Furthermore, the ordinal regression analysis results with the model fitting test in Table 2 were carried out to determine whether MSRL and MS together have a direct correlation to MA.

Table 2. Model Fitting Information & Goodness-of-Fit

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log-Likelihood	Chi-Square	df	Sig.
Intercept Only	528.022			
Final	491.251	36.771	2	.000
Pearson	-	1696.973	1823	.983
Deviance	-	468.024	1823	1.000

Table 2 shows that the value of sig <5%, meaning that the regression model with MSRL and MA variables is better than the regression model without these two variables. In the table, it is known that there is a decrease in the value of -2 Log-Likelihood from the intercept only of 528,022 to the final of 491,251 with a Chi-Square value of 36,771 and a significant value of 0.000, meaning that the regression model with the presence of the independent variable is able to provide better accuracy results so that a model with independent variables is better than a model without independent variables. It has a Pearson value of 1696,973 with a significance of 0.983 (> 0.05) and Deviance of 468,024 with a significance of 1,000 (> 0.05). This means that the model is by empirical data or the model is feasible to use. From the results of the calculation of the estimated parameters of the ordinal regression model, it can be seen that the negative MSRL variable has a sig <5%, meaning that this variable is suitable for the ordinal regression model.

Thus, the probability of students with a positive MSRL having a high score and an MA is lower than that of a negative MSRL. Furthermore, to determine the percentage of MSRL and MS variables to MA, a statistical analysis of the coefficient of determination is presented in Table 3.

Table 3. Pseudo R-Square

Cox and Snell	.329
Nagelkerke	.330
McFadden	.066

Table 3 explains that the MSRL and MS variables can affect students' MA by 33.0%. Thus, the remaining 67.0% is explained by other factors not discussed in this study. Other factors that can improve students' MSRL include the role of parents, either through giving examples, encouragement, rewarding, facilitating, giving good strategies in punishing, and other processes so

that students' academic achievement can increase (Martinez-pons et al., 1988). Therefore, it is plausible that the 67% change in students' MSRL variables was influenced by other factors not observed in this study. Then to find out the level of MSRL, MA, and MS students, the scores for each questionnaire and test were grouped based on the data obtained

Table 4. Distribution of Student MSC, MSRL, MA Levels

Variable	Interval	Level	%
MS	1.00 < MS< 5.00	Negatif	21%
	5.00 < MS< 10.00	Positif	79%
MSRL	3.00<MSRL<4.00	High	88%
	2.00<MSRL<3.00	Moderate	12%
	1.00<MSRL<2.00	Low	0%
MA	1.00<MA<2.00	Low	20%
	2.00<MA<3.00	Moderate	71%
	3.00<MA<4.00	High	19%

The analysis results from Table 4 found that most respondents had positive MS, which was 79%. In addition, this study showed that 21% of students had negative MS. MS is the deep thinking of students about what they have learned. In this study, students were very enthusiastic when researchers used MS in learning because they could reason freely according to their thoughts. The help of metacognitive questions helps students to stimulate their reasoning and understanding in-depth and not focus on rote methods.

This is also in line with the results of the MSRL variable analysis, which is 88% of students in the high category. The previous analysis's basis for decision-making states that MSRL and MS have a unidirectional relationship. This shows that the MSRL and MS are in the same direction, or if the student's MS is high, then the student's MSRL is also high and vice versa. Other studies confirm the analysis results; research conducted by Çetin (2017) states a correlation between students' MS and MSRL.

MSRL provides opportunities for students to hone their metacognitive in exploring information, increasing knowledge, and increasing their cognitive skills (Winnie, 2011). Respondents with moderate MSRL were only 12%, and there were no students with a low MSRL in this study. This data shows a good influence of the MSRL strategy applied to students. In line with Peña-ayala (2015), who found that the students' MSRL was at a good level.

This study also shows that the score of students who receive independent learning is higher than students who receive knowledge that is dependent on the teacher. This data supports one of the main goals of higher education, namely creating lifelong learners who are independent and have self-regulated learning in seeking, maintaining and processing knowledge (Jado, 2015). In addition, it turns out that MA can impact self-regulation, which directly affects student achievement (Amir et al., 2018). The urgency of MSRL was stated by Huss, who stated that self-regulated learning is essential in the implementation of learning because it can help students form better learning and strengthen their learning abilities (Wolters & Hussain, 2015).

On the other hand, this study found that 20% of students had a low MA level, 71% were in the medium category and 19% were in the high category. This means that the presence of MS and MSRL is very influential on student anxiety. This is in line with research by Kramarski et al., (2010), which states that if you use MS more often during learning, it will reduce anxiety, regardless of high and low achieving students. Thus, the use of MS indirectly affects the MSRL and MS experienced by students. Furthermore, to determine the level of student anxiety when viewed from elementary school, it is necessary to calculate the average score of each student, especially boys and girls.

Table 5. Mathematics anxiety term of sex differences

	MA-Female	MA-Male
N (Valid)	41	51
Mean	34.46	33.84
Std. Error of Mean	1.036	1.089
Median	34.00	34.00
Std. Deviation	6.634	7.775

Table 5 presents the MA variables' mean scores and standard deviation for male and female students. In this case, both were given the same treatment, namely MSRL and MS, but both had different anxiety levels. It is known from the average in the table that the anxiety of female students is higher than that of male students.

This study found that male students were more enthusiastic about receiving mathematics lessons than female students. Male students are more confident, dare to work on questions in front of the class, and are not tense when working on them. On the other hand, female students feel reluctant to come forward and are dominant. They are afraid of being wrong in answering questions. Feelings of tension and anxiety are also found in female students.

The questionnaires and tests are given also showed the same results: female students were more anxious than male students. This study is in line with research conducted by Devine, which states that the MA level of female students is higher than that of male students (Devine et al., 2012, p7). Research conducted by Indiyani also supports this statement. In this research, it is known that the anxiety of female students is higher, with an average of 70.1 compared to the average of male students of 67.9 (Sembiring & Wardani, 2021, p8). Gender differences also affect students' psychology in learning mathematics, apart from cognitive, and non-cognitive factors affecting mathematics and science internationally (Parker et al., 2018).

CONCLUSION

This study shows a positive or unidirectional correlation between MS and MSRL. If MSRL is high, then MS is also high, and vice versa. There are 21% of students in this study have negative MS, the rest 79% of students, have positive metacognitive. In addition, in experiments that have been carried out using MSRL and MS variables when viewed from MA, male students have lower anxiety levels than girls. Students' anxiety in the low category as a percentage of 20%, while students who have moderate levels of anxiety reach a percentage of 79%, and students who have high anxiety are 19%.

This study also found that 88% of students had high MSRL levels and 12% had moderate MSRL levels. Thus, students have a positive MS and high MSRL. Therefore, it is reasonable to say that students with positive MS had higher attempts to hone MSRL than students with negative MS. MSRL and MS have an effect of 33% on students' MA. Thus the remaining 67% is explained by other factors not discussed in this study.

The existence of MS helps students have good problem-solving skills. In comparison, the MSRL strategy can significantly help students choose a good design in learning so that it can reduce students' MA. In addition to solutions in the form of methods and approaches that have been described previously, there are other solutions that students can do to reduce students' MA. The solution is to change negative perspectives about mathematics and believe that mathematics is easy and not a complex subject to understand (Disai et al., 2018).

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