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Differences in the influence of self-regulated learning levels on enhancing students' mathematical reasoning abilities

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Abstract: Self-regulated learning allows students to organize, monitor, and evaluate their learning process, which has a positive impact on mathematical reasoning abilities. This research aims to analyze and describe the differences in the influence of the level of self-regulated learning on students' mathematical reasoning abilities. The research method used is quantitative, which allows the collection and analysis of numerical data to identify patterns and relationships. The method's goal is to measure variables, test hypotheses, and make generalizations from a sample to a broader population. The sample for this research was eighth-grade students in Bandung. The research instrument is in the form of 30 questionnaire statements about students' self-regulated learning. The research hypothesis, there are differences in the influence of self-regulated learning levels on enhancing students' mathematical reasoning abilities. The research results show that there are differences in the influence of the level of self-regulated learning on students' mathematical reasoning abilities. In addition, variations were found in the influence of the level of self-regulated learning on enhancing students' mathematical reasoning abilities. This research concludes that the level of self-regulated learning plays an important role in enhancing students' mathematical reasoning abilities.
Keywords: Junior High School Students; Learning levels; Mathematical Reasoning Ability; Self-Regulated Learning.

INTRODUCTION

Abstract thinking, creative thinking, data processing, and problem solving are examples of broader reasoning abilities (Sternberg, 1985; Kaufman & Sternberg, 2010). To further enhance reasoning abilities, a person must become more aware of how they think, conduct analysis, and assess how they think. Reasoning abilities help students become aware of their thought processes, making it easier to think reflectively. Mathematical reasoning abilities can be applied to any subject. By developing this ability, children will gain more comprehensive abilities to solve various problems. For example, in science subjects, mathematical reasoning abilities can help students analyze data, formulate hypotheses, and conclude experimental results. In the field of language, this ability can help students understand the logical structure of language and design strong arguments. The impact of developing this reasoning ability will give children more comprehensive abilities to solve the various problems they face.

In subjects such as economics or social sciences, mathematical reasoning abilities can be used to analyze economic data patterns or interpret social data. These abilities can also provide an edge when solving practical problems in everyday life, such as budget planning or problem solving in everyday life situations. Overall, the development of mathematical reasoning abilities provides a strong foundation for analytical thinking and problem solving, which can be widely applied in various fields of study. Reasoning abilities are an important part of mature and developing thinking, which children will need both at school and outside of school (Dweck, 2006; Duckworth, 2016). A person's metacognition enhances as a result of their reasoning abilities. This allows students to observe and assess their own thinking, which gives them more freedom to determine for themselves what they are learning and gives them more awareness of their abilities. Reasoning abilities help students see things from various points of view.

Students who have good reasoning abilities are able to identify the best solution from various available alternatives, they tend to see problems with a more comprehensive approach and can consider the consequences of each choice (Aliseda, 2003). Not only choose solutions that may seem good immediately, but also understand the long-term implications and possible impacts of those decisions. The ability to consider consequences is an important aspect of mature reasoning. Students who are able to see more than one side of an issue can avoid narrow thinking and explore possible impacts at various levels (Haidt, 2012; Nugroho et al., 2020). This not only enriches the decision-making process but also helps in the development of students' critical and analytical thinking.

By using reasoning abilities effectively, students can better meet challenges, design more efficient solutions, and make more informed decisions. Therefore, building reasoning abilities has a positive impact on students' development in responding to various problems and situations in everyday life. Students can develop their creativity by engaging in innovative thinking. Good reasoning abilities enable students to detail problems in depth and find creative and unique solutions (Gultom et al., 2022). By using reasoning, students can explore different ways of approaching problems, create space for new ideas, and integrate concepts that may not seem directly related. This process builds a foundation for creativity as students learn to think outside conventional boundaries and seek unconventional solutions.

Reasoning-driven creativity also involves the ability to connect ideas from different disciplines or concepts. Students can combine mathematical, scientific, and language knowledge to create more holistic solutions or ideas. Reasoning abilities combined with creativity give students powerful tools to explore, develop, and apply new ideas in a variety of contexts (Lestari, 2019). This not only enhances their understanding of the subject matter but also helps them become innovators who can contribute to solving real-world problems.

Students who have strong reasoning abilities tend to have a tendency to ask more questions, look for connections between the concepts being taught, and involve themselves actively in the learning process (Resnick, 1987; Hattie, 2013; Glass & Marzano, 2018). They don't just memorize facts, but try to understand "why" and "how" a concept works. Through reasoning, students can relate new concepts to knowledge they already have, building a cohesive series of thoughts or mental models. This helps them organize knowledge in a more structured and comprehensive way. Additionally, the ability to analyze information from multiple perspectives gives students a broader view of a topic. They can view these concepts from multiple points of view, allowing for

a more holistic understanding. Developing reasoning abilities not only increases the depth of students' understanding of subject matter but also helps them develop the critical thinking patterns needed to solve problems and face challenges in various fields of study (Willingham, 2012; Samo, 2016).

Students can make better decisions because they understand the implications and impact of each choice. The ability to consider the consequences of decisions is an important aspect of the informed decision-making process. Students who use reasoning in decision-making tend to be more careful and thorough. They are able to consider factors that might influence the outcome of their decisions, both directly and indirectly. This helps them anticipate long-term consequences and make decisions that are more aligned with their goals. By understanding the implications of each choice, students can avoid making decisions that are impulsive or based on limited information. This ability also helps them face complex situations with more confidence because it involves mature thinking in the decision-making process. Involving reasoning in decision-making helps students develop critical evaluation abilities and a deeper understanding of the consequences of their actions (Mumu & Tanujaya, 2019). This is a valuable ability that can be applied in a variety of contexts, both in the classroom and in everyday life.

Students who have good reasoning abilities tend to be more effective at communicating (Divakaran, 2015; Gee, 2015). They are able to organize arguments logically and can explain their ideas in more detail. Reasoning abilities help students organize arguments in a structured manner, present facts in a logical order, and include organized thinking. This makes them better able to defend or explain their opinions in a convincing way. Additionally, students with good reasoning abilities can identify and present connections between concepts, making their presentations or arguments more cohesive. They also tend to use strong evidence and logic to support their claims, increasing the effectiveness of their communications. The ability to explain ideas in detail is the result of a deep understanding of a concept. Students who are able to apply reasoning in communication can convey information more clearly and in detail, helping listeners or readers understand the content better (Blesch, 2012). Developing reasoning abilities not only enriches students' thinking processes but also enhances students' ability to communicate effectively, both in oral and written form.

Mathematical reasoning abilities also support students' creativity, helping them make connections and see problems as a whole. Apart from comprehension, fluency, and problem solving, mathematical reasoning is one of the four necessary abilities (Douek, 1999). Comprehension and fluency are related to reasoning. Comprehension includes students' ability to remember various mathematical ideas and rules. Fluency includes a student's ability to apply shared concepts and rules to solve problems and find solutions. To make estimates and find the right solution, students need to recall their personal experiences. By applying their knowledge and understanding, students can learn what works, and more importantly, they can learn what goes wrong (Shaw et al., 2021). These important experiences help students' reasoning when they try to solve problems or challenges later in life.

To enhance students' mathematical reasoning abilities, the learning model is not the only factor that influences it; it is likely to be influenced by students' self-regulated learning (SRL), so that self-regulated learning is a factor that attracts the attention of prospective researchers. Students become experts in their own learning process (Zimmerman, 2000). Learners who have self-reliance actively participate to maximize their learning opportunities. Students have the ability to critically assess and

intentionally change the ways in which thinking, attitudes, behavior, and work environments contribute to learning outcomes.

Planning goals, planning strategies, managing behavior, and evaluating self-enhancement are all abilities students will gain with self-regulated learning. This is in accordance with research results (Fauzi & Widjajanti, 2018), which found that students with high self-regulated learning tend to have high motivation and achievement, while students with low self-regulated learning tend to have low achievement. However, other research findings show that average-ability students have self-regulated learning that exceeds students with low and high self-regulated learning (Samo, 2016).

Additional results from several meta-analyses conducted by Wang & Sperling (2020) are that of 36 self-regulated learning intervention studies, recent interventions were more likely to use social-cognitive self-regulated learning models and use standardized knowledge assessments. In research conducted by Nasution et al. (2022) which used self-regulated learning as a mediator, it was found that parental support, attitudes towards mathematics lessons, and goal mastery orientation had no impact on mathematics learning achievement. Based on the problem identification stated above, researchers are interested in the differences in the influence of the SRL level on students' mathematical reasoning ability.

METHODS

The research method used in this research is a quantitative research method. Quantitative research methods involve the study of samples and populations and rely heavily on numerical data and statistical analysis (Gall et al., 2003). This method involves both sample and population studies, meaning that the researcher takes a small portion of a larger population to represent the entire population. Quantitative approaches rely heavily on numerical data and statistical analysis to answer research questions and test formulated hypotheses. According to Gall et al. (2003), quantitative research uses various instruments, such as questionnaires, tests, and surveys, to collect data from representative samples. The data obtained from these instruments is then analyzed using statistical techniques to find patterns, relationships, or differences between the variables studied. In this research, the data collected includes students' mathematical reasoning ability scores and their SRL level. By using statistical analysis, researchers can determine whether there is a significant difference in the increase in mathematical reasoning ability between students with high, moderate, and low levels of self-regulated learning.

The advantage of quantitative methods is their ability to produce objective and generalizable data, so that research results can be applied to a wider population. Additionally, the use of statistical analysis allows researchers to scientifically test hypotheses and draw valid conclusions based on empirical evidence. In the context of this research, quantitative methods help to identify the influence of self-regulated learning levels on increasing student mathematical reasoning ability in a systematic and measurable manner, as well as provide clear insight into the relationship between these two variables. It is important to understand how self-regulated learning development can influence students' academic abilities, especially in the field of mathematics.

The design used was an experimental design in which researchers compared two groups of students: one group studying with an experiential learning assisted by augmented reality and one group studying with a directed instruction assisted by augmented reality. Researchers measured the self-regulated learning of both groups of

class VIII students with a quantitative scale before and after implementing the model. Students are given a self-regulated learning questionnaire that contains 30 statements with answer choices that refer to a Likert scale reference. Research participants were selected based on several specific reasons or purposive sampling. The data analysis technique used is a general linear model. The research question, Is there a difference in the influence of the level of Self-Regulated Learning on increasing students' Mathematical Reasoning Ability? The research hypotheses, there are differences in the influence of self-regulated learning levels on enhancing students' mathematical reasoning abilities.

RESULTS AND DISCUSSIONS

Result

To answer the research question, the number depends on whether the research hypothesis is rejected or accepted, which states: There are differences in the influence of the SRL level on increasing students' mathematical reasoning abilities.

$H_0 : \beta_1 = \beta_2 = \beta_3$
$H_1 : \text{not } H_0$

Notes:

1. α_i describes the influence of implementing experiential learning assisted by augmented reality (EL-AR) with directed instructions assisted by augmented reality (DI-AR) on increasing students' mathematical reasoning abilities.
2. β_i describes the influence of the level of self-regulated learning (SRL) on increasing students' mathematical reasoning abilities.
3. $\alpha_i\beta_j$ describes the influence of the interaction influence between learning and the SRL level on increasing students' mathematical reasoning abilities.

To test the hypothesis stated above, the Statistical Product and Service Solutions (SPSS) version 29 software is used, which is related to the general linear model (two-way anova). By taking into account the score data for increasing the mathematical reasoning abilities of students who study with EL-AR and DI-AR, and by taking into account the level of SRL, the following output is obtained:

Table 1. Output The General Linear Model

Tests of Between-Subjects Effects

Dependent Variable: Ngain_Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1.220[a]	5	.244	8.665	<.001	.514
Intercept	13.024	1	13.024	462.435	<.001	.919
SRL_Level	.771	2	.386	13.693	<.001	.400
Learning	.211	1	.211	7.478	.009	.154
SRL_Level * Learning	.236	2	.118	4.185	.022	.170
Error	1.155	41	.028			
Total	15.387	47				
Corrected Total	2.375	46				

a. R Squared = .514 (Adjusted R Squared = .454)

From the SPSS output above (Table 1), namely the test of the between-subject effect, it turns out that the significance value is for: The Self-Regulated Learning (SRL) level is $< 0{,}001$ and this value is smaller than $0{,}05$ (α), then H_1 is rejected and H_0 is accepted so that thypothesis which states that there is an influence of the level of Self-Regulated Learning (SRL) on increasing students' mathematical reasoning abilities is accepted.

This means that there is a difference in the influence of the level self-regulatedt learning (SRL) on increasing mathematical reasoning abilities student.

Table 2. Output Post Hoc Tests

Multiple Comparisons

Dependent Variable: NGain_Score

Tukey HSD

(I) SRL_Level	(J) SRL_Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
High	Moderate	.2537*	.06031	<.001	.1070	.4003
	Low	.2875*	.05933	<.001	.1432	.4318
Moderate	High	-.2537*	.06031	<.001	-.4003	-.1070
	Low	.0338	.06031	.841	-.1128	.1805
Low	High	-.2875*	.05933	<.001	-.4318	-.1432
	Moderate	-.0338	.06031	.841	-.1805	.1128

Based on observed means.
The error term is Mean Square (Error) = .028.
*. The mean difference is significant at the .05 level.

Post-Hoc students in Table 2 who have high self-regulated learning have a higher influence on enhancing students' mathematical reasoning abilities than students who have moderate and low self-regulated learning. Students who have moderate and low self-regulated learning have an average increase in mathematical reasoning abilities that is not significantly different, which means that there is no difference in the influence of moderate and low levels of SRL on increasing students' mathematical reasoning abilities.

Discussions

From the results of the analysis of answers to research questions, information was obtained that there were differences in the influence of the level of self-regulated learning (SRL) on enhancing students' mathematical reasoning abilities. This analysis is supported by research by Zimmerman (2000), which shows that students with high SRL tend to have better learning outcomes, including mathematical reasoning abilities, compared to students who have low SRL. Based on Murwaningsih et al. (2022) show that there is a significant, positive and high influence between Self-Regulated Learning abilities and pupils' interest in learning. Students with high SRL are more effective in organizing and monitoring their learning process, which contributes to enhanced mathematical reasoning abilities (Ansari et al., 2021). In addition, students with high SRL show better performance in mathematics tasks that require high levels of reasoning (Cleary & Zimmerman, 2004). High self-regulated learning (SRL) can enhance various academic abilities (Roth & Walshaw, 2019), including mathematical reasoning abilities, through several main mechanisms: (1) Students with high SRL tend to set clear learning goals, specifically by using appropriate learning strategies to achieve these goals; (2) Students who have high SRL actively monitor their progress in learning and reflect on the learning process. Students will evaluate whether the strategies used are effective or not and make adjustments if necessary; (3) Students with high SRL have strong motivation and perseverance in facing academic challenges; (4) Students with these abilities can plan their study time well, ensuring that they have enough time to understand difficult material and complete assignments well; (5) Students with high SRL also tend to organize their learning environment in such a way that it is conducive to

learning, such as by avoiding distractions, finding necessary resources, and creating an environment that supports focus and concentration.

Based on the post-hoc analysis of the research (Cohen, 1988), it can be concluded that there is a significant difference in the influence of the level of SRL on enhancing students' mathematical reasoning abilities. The following is a more detailed explanation of these findings:

Students with high self-regulated learning

Students who have a high level of self-regulated learning show a higher increase in mathematical reasoning ability compared to students with moderate or low self-regulated learning (Panadero, 2017). This may be caused by several factors:

Better Self-Regulation Abilities

Students with high self-regulated learning are more effective at setting learning goals, planning strategies, and managing their time. They are also better at monitoring and evaluating their own learning progress, so they can quickly identify and overcome learning difficulties.

Effective Use of Learning Strategies

These students tend to use deeper learning strategies, such as understanding concepts thoroughly and applying knowledge in various contexts

Motivation and Perseverance

Students with high self-regulated learning usually have stronger motivation and persistence in facing learning challenges, which contributes to increasing their mathematical reasoning ability.

Students with moderate and low self-regulated learning

For students who have moderate or low self-regulated learning, the average increase in their mathematical reasoning ability does not show a significant difference. This indicates that:

Limitations in Self-Regulation

Students with moderate self-regulated learning may have some self-regulation abilities, but they are not strong enough to make a significant difference in enhancing mathematical reasoning ability compared to students with low self-regulated learning.

Less Effective Learning Strategies

Students with moderate and low self-regulated learning may tend to use more superficial learning strategies, such as memorizing without deep understanding, which are less effective in increasing mathematical reasoning ability.

Lack of Motivation and Support

These students may be less motivated or not get enough support to enhance their self-regulation abilities, so their mathematical reasoning ability increase is not as good as students with high self-regulated learning.

This research also shows that interventions designed to enhance SRL can have a positive impact on students' mathematical reasoning abilities. For example, training in study strategies, such as time management, creating study schedules, and problem-

solving techniques, can help students enhance their self-regulation abilities. When students are equipped with the right tools and strategies, they are better able to control their learning process, which in turn increases mathematical reasoning ability. In addition, this research highlights the important role of teachers in supporting self-regulated learning development. Teachers can play an important role in helping students develop self-regulation abilities through ongoing guidance and feedback. The use of teaching methods, such as project-based learning and collaborative learning, can also enhance students' self-regulated learning. When students engage in activities that require them to plan, monitor, and evaluate their own work, they learn to become more independent and self-directed learners. Furthermore, this research also found that a supportive and motivating learning environment can strengthen the influence of self-regulated learning on mathematical reasoning ability. Environments that provide sufficient resources, including access to supplemental instructional materials and educational technology, as well as emotional and social support, can enhance students' ability to regulate their own learning. Students who feel supported and motivated tend to be more eager to develop their self-regulated learning levels, which contributes to increased mathematical reasoning ability.

Implications of the Findings

These findings indicate that increasing self-regulated learning can significantly influence students' mathematical reasoning ability. Therefore, educational interventions that focus on enhancing self-regulated learning, such as training in self-regulation abilities, guidance in setting learning goals, and the use of effective learning strategies, are essential. Support from teachers and a conducive learning environment can also play a big role in helping students develop their self-regulated learning (Sommerauer & Müller, 2014). Beside that, Digital literacy and critical thinking abilities in primary school pupils were significantly enhanced by AR media (Fajari & Meilisa, 2022). Overall, this research confirms the importance of developing self-regulated learning as a key factor in increasing students' mathematical reasoning ability. By paying more attention to self-regulated learning development, it is hoped that students can achieve better learning outcomes and have the abilities necessary for success in various aspects of life.

CONCLUSION

Based on the research that has been conducted, it can be concluded that there are differences in the influence of the level of self-regulated learning (SRL) on enhancing students' mathematical reasoning abilities. Students who have high SRL have a higher influence on enhancing students' mathematical reasoning abilities than students who have moderate or low SRL. This research reveals that students with high SRL have several characteristics that support increasing mathematical reasoning ability more effectively. They tend to be better at setting clear learning goals, planning study strategies, and managing time efficiently. These students are also better able to monitor their learning progress, seek help when needed, and reflect on their learning outcomes to continuously enhance the learning process. On the other hand, students with moderate or low self-regulated learning are often less able to regulate their own learning process. They may have difficulty setting appropriate goals, lack ability in selecting effective learning strategies, and be inconsistent in monitoring and evaluating their learning progress. As a result, enhancement in their mathematical reasoning abilities tends to be slower and less significant.

Students with high self-regulated learning usually show more active involvement in the learning process, both cognitively and metacognitively. They use a variety of deep learning strategies, such as analyzing problems carefully, making connections between learned concepts, and applying knowledge in different contexts. This allows them to build a stronger and deeper understanding of mathematical concepts, thereby enhancing their reasoning abilities. On the other hand, students with moderate self-regulated learning may only use more superficial learning strategies, such as memorizing without understanding concepts in depth. Students with low SRL show high dependence on external assistance and lack initiative to manage their own learning process, which has a negative impact on increasing mathematical reasoning ability. In conclusion, this research confirms the importance of developing self-regulated learning in mathematics education. By encouraging students to enhance their self-regulation abilities so that the SRL level plays an important role in enhancing students' mathematical reasoning abilities that are more effective and sustainable.

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