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ANALYSIS OF STUDENTS' MATHEMATICAL REASONING ABILITY BASED ON SELF-REGULATED LEARNING: A CASE STUDY ON ALGEBRAIC EXPRESSIONS

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ABSTRACT

The role of mathematics is not only to emphasize mastery of formulas and calculations, but also to develop students' mathematical reasoning skills, enabling them to think logically, systematically, and critically in problem-solving. This study aimed to analyze students' mathematical reasoning skills in terms of self-regulated learning on the topic of algebraic expressions for class VII-B students at SMP Negeri 1 Suwawa. This research employed a descriptive method with a quantitative approach. The sample consisted of 27 students from class VII-B, selected using purposive sampling. The research instruments included a mathematical reasoning skills test and a self-regulated learning questionnaire, both of which had been tested for validity and reliability. Data were analyzed descriptively through the calculation of mean scores, percentages, and the categorization of students' mathematical reasoning skills and levels of self-regulated learning. The results showed that: 1) students with high self-regulated learning had high mathematical reasoning skills, with an average score of 70.50; 2) students with moderate self-regulated learning had moderate mathematical reasoning skills, with an average score of 43.67; and 3) students with low self-regulated learning had low mathematical reasoning skills, with an average score of 22.50. Thus, it can be concluded that the higher the students' level of self-regulated learning, the better their mathematical reasoning skills.

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INTRODUCTION

Mathematics occupies a crucial position in the world of education due to its significant role, both in supporting daily life and in supporting the development of various other branches of science. According to Sholihah & Mahmudi in Rezki Amaliyah, Aprianti (2022: 760), mathematics is a fundamental source for other sciences, meaning that many discoveries and advances in various fields of science depend on mathematics. In addition, mathematics is

established as a subject taught at every level of education, from elementary school to higher education, because it plays a role in developing logical and systematic thinking skills, as well as encouraging students to actively discover, apply, and solve various problems (Pauweni & Iskandar, 2021: 23). The National Council of Teachers of Mathematics (NCTM) has formulated five competency standards that serve as a reference in mathematics learning: problem solving, communication, connections, reasoning, and representation. Among these standards, mathematical reasoning occupies a crucial position because its role in supporting optimal learning outcomes and increasing learning effectiveness. This is in line with the Minister of Elementary and Secondary Education Regulation No. 13 of 2025 on Mathematics Learning Outcomes, which stipulates reasoning and proof as essential components of learning. Reasoning is applied to analyze situations and formulate conjectures, while proof serves to verify the validity of principles or theorems. Thus, both are core competencies that should be cultivated in mathematics education at schools.

According to the OECD's Programme for International Student Assessment (PISA) study, Indonesian students' mathematics achievement remains relatively low. The latest data shows a decline in the average score, from 379 in 2018 to 366 in 2022. This achievement places Indonesia in 70th place out of 81 countries, indicating that student achievement remains below the average for OECD member countries. Based on interviews with mathematics teachers at SMP Negeri 1 Suwawa, it was found that students' mastery of algebraic expressions is still suboptimal. This is evident from the results of the daily tests, where the average scores were 32.33 for class VII-A, 28.23 for class VII-B, and 29.70 for class VII-C. These scores are still below the Learning Achievement Criteria (KKTP) set by the school. The teacher explained that the low learning outcomes were caused by students' difficulties in solving problems that require conceptual understanding and thinking skills, such as translating word problems into algebraic models and simplifying algebraic operations. This condition indicates that the students' low achievement in algebraic expressions is closely related to their limited mathematical thinking abilities, particularly in the aspect of reasoning.

Rezki Amaliyah, Aprianti (2022: 760) Rezki Amaliyah, Aprianti (2022: 760) stated that mathematical reasoning ability is one of the factors that influences students' achievement of learning outcomes in mathematics. Mathematical reasoning is the skill of using systematic and logical thought patterns to solve problems, by utilizing existing knowledge to find the right solution (Salam et al., 2023: 2351). Consistent with the view of Rufianti et al., (2025: 989), mathematical reasoning constitutes the essence of mathematics learning, as reasoning is fundamentally a systematic cognitive process that connects facts to derive logical conclusions in a critical and structured manner. Mathematics serves as a subject that functions as a means of fostering logical, systematic, objective, and critical thinking patterns. Consequently, mathematics and mathematical reasoning are inseparable, as the understanding of mathematical content is attained through reasoning, while reasoning ability itself can be developed through the learning of mathematics (Nosva et al., 2019: 31). Furthermore, in mathematics learning, reasoning skills play an essential role to be cultivated, since the material taught requires the capacity for critical, logical, creative, and mathematical thinking. Such abilities are necessary for students to solve various mathematical problems and, at the same time, to gain a deeper understanding of mathematical concepts (Paputungan et al., 2024: 44).

Given the importance of reasoning, students need to have attitudes that support the development of mathematical reasoning skills in mathematics learning, one of which is self-regulated learning (Paokuma et al., 2023: 2). Self-regulated learning refers to the ability of students to regulate their own learning process, have confidence in problem-solving, actively seek information, and not rely on the assistance of others (Pramestisari et al., 2022: 28). In addition, self-regulated learning is a crucial capability for students to manage and direct their learning experiences autonomously in order to achieve optimal educational outcomes (Kadir et al., 2025: 610). However, the results of observational assistance indicate that some students still tend to rely on teachers or friends when solving math problems. Meanwhile, only a few students appear to take the initiative to try to complete assignments independently.

Farhan (2020: 352) states that self-regulated learning plays a role in developing critical and logical thinking skills. One important aspect that needs to be considered and developed in every learning process is students' ability to reason mathematically (Zannati et al., 2018: 107). Meanwhile, according to Nuridawani et al., in Ariani et al., (2022: 939), self-regulated learning is an effective and efficient way to optimize students' abilities without always having to rely on teachers, thus maximizing the learning process. High levels of self-regulated learning in students have the potential to increase learning success, with mathematical reasoning being a crucial aspect contributing to this achievement (Ariani et al., 2022: 939). Previous studies have indeed shown a relationship between self-regulated learning and mathematical reasoning ability. Research conducted by Paokuma et al., (2023: 8) found that students with high self-regulated learning tend to have high mathematical reasoning abilities. However, a study by Lestari (2021: 129) revealed that not all students with high self-regulated learning possess high reasoning abilities; in fact, some of them demonstrated low mathematical reasoning ability. These differing findings indicate an inconsistency in research results, thereby highlighting the need for further investigation in different contexts.

Based on this description, the researchers took the initiative to examine and determine students' mathematical reasoning skills in algebraic forms material from the perspective of self-regulated learning.

METHOD

This research uses a descriptive method with a quantitative approach. According to Ramadhan, (2021), descriptive research aims to systematically describe, explain, and confirm a phenomenon being studied. Meanwhile, Creswell in Amruddin et al, (2022: 8) states that a quantitative approach is based on the assumption that human behavior is predictable, social reality is objective, and all aspects of the research can be measured empirically.

This research was conducted at SMP Negeri 1 Suwawa with the research sample consisting of Class VII-B students in the second semester of the 2024/2025 academic year, totaling 27 students. The sample was selected using purposive sampling, namely a sampling technique based on specific considerations relevant to the research objectives, in this case students who had already studied algebraic expressions in mathematics learning.

In this study, data were collected using two instruments: a test to assess mathematical reasoning abilities and a questionnaire measuring self-regulated learning. The test instrument was first

given to students to measure the level of students' mathematical reasoning abilities, especially in algebraic forms. Before being used, the test instrument had gone through a validation process. Based on the results of the empirical validity analysis, 7 items were declared valid, while 3 items were invalid. Furthermore, the calculation results showed that the number of item variances was 24.7219 and the total variance was 80.0237, so that the test reliability value obtained was 0.8062, categorized as high. The indicators employed in this study were: (1) proposing conjectures; (2) performing mathematical manipulations; (3) collecting evidence and providing justification for the validity of solutions; and (4) drawing conclusions from statements.

Meanwhile, a questionnaire instrument was used to measure the level of students' self-regulated learning in mathematics. Before being used, this instrument had gone through a validation process. Based on the results of the empirical validity analysis, 26 statement items were declared valid, while 9 items were invalid. Furthermore, the calculation results showed that the number of statement item variances was 40.9260 and the total variance was 402.3136, so that the questionnaire reliability value obtained was 0.9342, categorized as very high. The indicators of self-regulated learning used in this study include: (1) self-confidence; (2) ability to work independently; (3) mastering expertise and skills appropriate to the task; (4) respecting time; and (5) being responsible. This study used descriptive statistical analysis as the data analysis technique. Data collected through a mathematical reasoning ability test and a self-regulated learning questionnaire were analyzed to answer the research questions in accordance with the stated objectives. According to Sugiyono, (2021: 206), descriptive statistics is a data analysis method used to objectively describe collected data, without the aim of drawing conclusions or generalizing the results to a wider population.

The first stage in data analysis is calculating the final scores for each instrument. This calculation is conducted to obtain the final scores of students' mathematical reasoning abilities as well as their self-regulated learning based on the responses provided during the research. The determination of these final scores is carried out using the following formula:

$$Score = \frac{Total\ \ score\ obtained}{Maximum\ score} \times 100$$

The data were processed using descriptive statistical measures, including: mean, median, mode, maximum score, minimum score, range, standard deviation, and variance. After obtaining the results of the students' mathematical reasoning tests and questionnaire data, the next step was to classify the levels of mathematical reasoning ability and self-regulated learning. The classification was conducted based on the mean and standard deviation, referring to Arikunto's criteria (Nurhalin & Effendi, 2022: 182) as presented in Table 1.

Table 1. Criteria for Classifying Mathematical Reasoning Ability and Self-Regulated Learning

Score Criteria	Category
$x > \bar{x} + SD$	Tinggi
$\bar{x} - SD \leq x \leq \bar{x} + SD$	Sedang
$x < \bar{x} - SD$	Rendah

Explanation:

x = Student Score

$\bar{x}$ = Mean Score (Average)

SD = Standard Deviation

RESULTS AND DISCUSSION

Results

Data Description of Mathematical Reasoning Ability and Self-Regulated Learning

This study examined the mathematical reasoning skills and self-regulated learning of grade VII-B students at SMP Negeri 1 Suwawa. The collected data were analyzed to determine the mean, median, mode, maximum, minimum, and standard deviation. A summary of the results is presented in Table 2 below.

Table 2. Data on Mathematical Reasoning Ability and self-regulated learning

Variabel	N	Max score	Min Score	Mean	Median	Mode	Standard Deviation
Mathematical Reasoning Ability	27	73	16	44,20	43,35	42,16	16,67
Self-Regulated Learning	27	79	28	55,33	53,93	50,63	13,03

According to the data from 27 students, the scores for self-regulated learning ranged from a minimum of 28 to a maximum of 79. The average score was 55.33, with a median of 53.93, a mode of 50.63, and a standard deviation of 13.03.

The self-regulated learning questionnaire completed by the 27 students showed a maximum score of 79 and a minimum score of 28. The average score for self-regulated learning was 55.33, with a median of 53.93, a mode of 50.63, and a standard deviation of 13.03.

After the data were processed, an examination of students' mathematical reasoning performance was conducted by category, as shown in Table 3.

Table 3. Categories of Mathematical Reasoning Ability

Score Range	Category	N	Percentage (%)
$x > 60{,}87$	High	6	22,22
$27{,}53 \leq x \leq 60{,}87$	Medium	15	55,56
$x < 27{,}53$	Low	6	22,22
Total		**27**	**100**

According to Table 4, the mathematical reasoning abilities of the 27 seventh-grade students at SMP Negeri 1 Suwawa were distributed as follows: 6 students (22.22%) fell into the high category, 15 students (55.56%) into the moderate category, and 6 students (22.22%) into the low category. Next, an analysis of the students' self-regulated learning levels was conducted by category group, as presented in Table 4.

Table 4. Self-Regulated Learning Categories

Score Range	Category	N	Percentage (%)
$x > 68.36$	High	4	14,81
$42,3 \leq x \leq 68,36$	Medium	18	66,67
$x < 42,3$	Low	5	18,52
Total		**27**	**100**

According to Table 4. the levels of students' autonomy in learning among the 27 students in Class VII at SMP Negeri 1 Suwawa were distributed as follows: 4 students (14.81%) fell into the high category, 18 students (66.67%) into the medium category, and 5 students (18.52%) into the low category.

Description of Mathematical Reasoning Ability Data Reviewed from the Perspective of Self-Regulated Learning

Data on students' mathematical reasoning skills, as reviewed from self-regulated learning, were collected through a mathematical reasoning test. The results were then classified into categories based on students' levels of self-regulated learning. A summary of this data is presented in Table 5.

Table 5. Mathematical Reasoning Ability Data Reviewed from Self-Regulated Learning

	Mathematical Reasoning Ability							
Level of Self-Regulated Learning	**N**	**Max Score**	**Min Score**	**Mean**	**Median**	**Mode**	**standard deviation**	**Kategori KPM**
High Self-Regulated Learning	4	73	66	70,50	71,5	73	2,87	High
Moderate Self-Regulated Learning	18	64	16	43,67	45	48	12,25	Medium
Low Self-Regulated Learning	5	30	16	22,50	23	16	5,68	Low

Based on Table 5, the data on students' mathematical reasoning ability reviewed from the perspective of self-regulated learning can be described as follows. The total sample of the study consisted of 27 students from grade VII-B at SMP Negeri 1 Suwawa.

1. High Self-Regulated Learning

   Students with high levels of self-regulated learning achieved an average mathematical reasoning score of 70.50, which falls into the high category. The maximum score in this group was 73, while the minimum was 66, with a standard deviation of 2.87. This relatively small standard deviation indicates that student achievement in this group is consistent and evenly distributed. The median score of 71.5 and mode of 73 suggest that most students in this group obtained scores close to the average.

2. Moderate Self-Regulated Learning

   Students with moderate levels of self-regulated learning had an average mathematical reasoning score of 43.67, which falls into the moderate category. The maximum score in this group was 64, while the minimum was 16, with a standard deviation of 12.25. This relatively large standard deviation indicates that student achievement in this group is uneven. The median score of 45 and mode of 48 suggest that some students scored around this range, although there were also students who scored far below or above the average.

3. Low Self-Regulated Learning

   Students with low levels of self-regulated learning achieved an average mathematical reasoning score of 22.50, which falls into the low category. The maximum score in this group was 30, while the minimum was 16, with a standard deviation of 5.68. This relatively small standard deviation indicates that student achievement in this group is fairly consistent. The median score of 23 and mode of 16 indicate that although students' performance is low, the score distribution is not very far from the average.

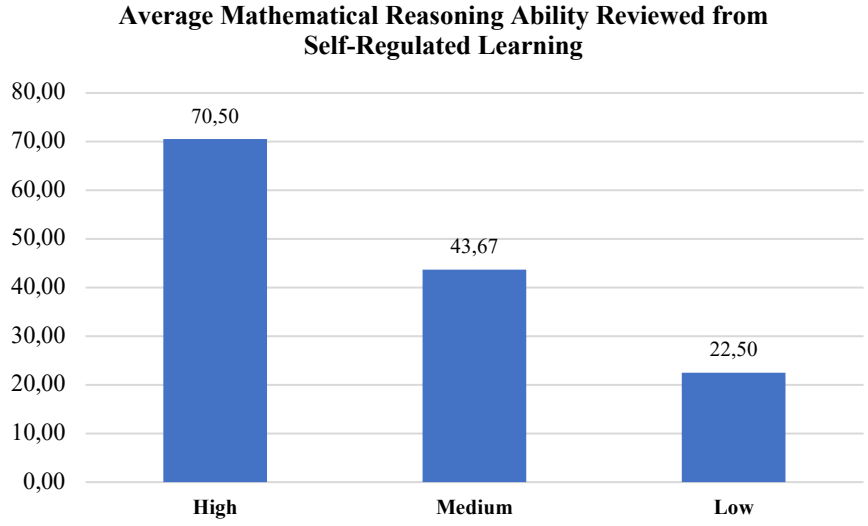

Figure 1. Average Mathematical Reasoning Ability Reviewed from Self-Regulated Learning

Next, students' mathematical reasoning achievement is assessed based on their level of self-regulated learning, with reference to the specific indicators of mathematical reasoning ability, as presented in Table 6. This approach allows the researcher to examine how students' self-regulated learning relates to their performance on each aspect of mathematical reasoning.

Table 6. Mathematical Reasoning Achievement Based on Indicators Reviewed from Self-Regulated Learning

Mathematical Reasoning Ability Indicators	Percentage Value of Mathematical Reasoning Ability		
	High Self-Regulated Learning	**Moderate Self-Regulated Learning**	**Low Self-Regulated Learning**
Submitting allegations	37,50%	15,97%	12,50%
Performing mathematical manipulations	100%	72,22%	36,25%
Compiling evidence, providing reasons or proof for the truth of the Solution	75%	41,67%	20%
Drawing conclusions from statements	50%	25,46%	11,67%

1. Indicator: Making Conjectures

   This indicator measures students' ability to make conjectures based on information in the problem, such as converting sentences into algebraic models or identifying patterns and writing them in formulas. Students with high self-regulated learning achieved 37.50%, indicating that a portion of students in this category could interpret the problem correctly and make conjectures. Students with moderate and low self-regulated learning scored 15.97% and 12.50%, respectively, showing that most students struggled with this skill.

2. Indicator: Performing Mathematical Manipulations

   This indicator measures students' ability to simplify algebraic forms and perform calculations correctly. Students with high self-regulated learning scored 100%, showing full mastery. Those with moderate self-regulated learning scored 72.22%, while students with low self-regulated learning scored 36.25%, indicating significant difficulties in algebraic manipulation.

3. Indicator: Providing Evidence and Justifying Solutions

   This indicator measures students' ability to verify solutions by substituting variable values. Students with high self-regulated learning scored 75%, students with moderate self-regulated learning 41.67%, and students with low self-regulated learning 20%, reflecting varying abilities in checking solution validity.

4. Indicator: Drawing Conclusions

   This indicator measures the ability to draw conclusions from algebraic simplification or identified patterns. Students with high self-regulated learning achieved 50%, students with moderate self-regulated learning 25.46%, and students with low self-regulated learning 11.67%, showing that most students with moderate and low self-regulated learning still struggled to draw accurate conclusions.

The percentage achievement of mathematical reasoning skills, analyzed according to each indicator as reviewed from self-regulated learning, is clearly illustrated in the bar chart shown in Figure 2.

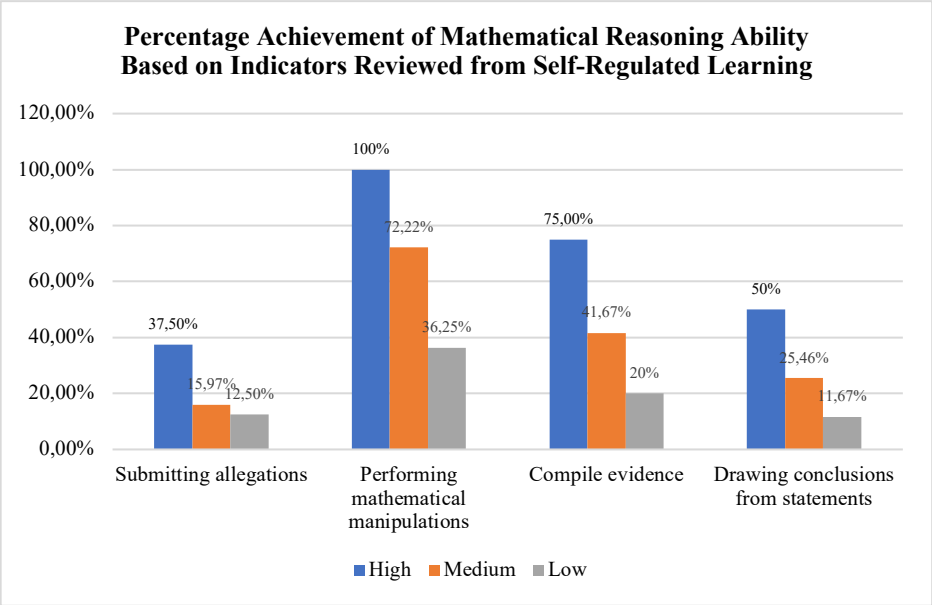

Figure 2. Percentage Achievement of Mathematical Reasoning Ability Based on Indicators Reviewed from Self-Regulated Learning

Discussions

This research was carried out at SMP Negeri 1 Suwawa to investigate students' mathematical reasoning skills in relation to their self-regulated learning levels. The study aimed to describe how students' mathematical reasoning performance varies among those with high, moderate, and low self-regulated learning.

Farhan (2020: 352) states that self-regulated learning plays a role in developing critical and logical thinking skills. One important aspect that needs to be considered and developed in every learning process is students' ability to reason mathematically (Zannati et al., 2018: 107).

The analysis results show that variations in students' self-regulated learning influence their mathematical reasoning skills. Students with high self-regulated learning exhibit stronger reasoning abilities than those with moderate or low self-regulated learning. These results confirm that higher self-regulated learning is associated with better mathematical reasoning skills, as supported by the studies of Maulandani & Afriansyah (2024: 27) and Khairunnisa et al., (2020: 356), which indicate that students with high self-regulated learning generally achieve better reasoning performance.

In contrast to the findings of Lestari et al, (2021: 117), which indicate that students with high self-regulated learning generally have high mathematical reasoning abilities, although a small portion of them show low mathematical reasoning skills. Meanwhile, students with moderate self-regulated learning mostly demonstrate low mathematical reasoning abilities. Whereas students with low self-regulated learning are generally classified in the low category of mathematical reasoning ability.

In addition to calculating the overall mathematical reasoning scores of students based on their self-regulated learning levels, this study also analyzed mathematical reasoning skills according to indicators as reviewed from self-regulated learning in the high, medium, and low categories.

This study found that students with high self-regulated learning tended to perform better in mathematical manipulation, constructing proofs, and drawing conclusions, although their ability to propose conjectures was still limited. Students with moderate self-regulated learning performed well in manipulation and proofs, but struggled with drawing conclusions and proposing conjectures. Meanwhile, students with low self-regulated learning struggled in all aspects, especially in inferencing and proposing conjectures. Overall, students with higher self-regulated learning demonstrated better mathematical reasoning skills compared to students with moderate and low self-regulated learning, especially in manipulation, proof-building, and conclusion drawing.

This study is in line with the findings of Hakim (2022), who stated that students with a high level of self-regulated learning are able to meet all indicators of mathematical reasoning ability with few errors, and are therefore categorized as having good ability. In contrast, students with low self-regulated learning can only achieve some indicators of mathematical reasoning ability, resulting in less satisfactory outcomes. A similar finding was reported by Natalia et al., 2024: 77), who stated that the level of self-regulated learning affects students' mathematical reasoning ability. Students with high self-regulated learning are able to meet all indicators of mathematical reasoning, students with moderate self-regulated learning can only meet some indicators, while students with low self-regulated learning are unable to meet all indicators.

CONCLUSION

Based on the results of the study and discussion conducted with class VII-B students of SMP Negeri 1 Suwawa, the findings revealed that students' mathematical reasoning abilities in terms of self-regulated learning were as follows: 1) Students with high self-regulated learning had mathematical reasoning abilities in the high category with an average score of 70.50, 2) Students with moderate self-regulated learning had mathematical reasoning abilities in the moderate category with an average score of 43.67, and 3) Students with low self-regulated learning had mathematical reasoning abilities in the low category with an average score of 22.50. These results indicate that the higher the level of students' self-regulated learning, the better their mathematical reasoning abilities.

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