

Profile and Association between *Self-Regulated Learning* and Quality of Student Understanding in Mathematics Learning

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Abstract

This study aims to describe the level of self-regulated learning for students with instrumental comprehension and relational comprehension and examine the association of comprehension quality with self-regulated learning of MTsN students in Banyuwangi Regency. This research is a survey research with quantitative approach. Sampling used proportional stratified random sampling. The sample size was 345 students from a population size of 2491. The instrument used was a self-regulated learning questionnaire. The validity used is content validation by experts and construct validity using Confirmatory Factor Analysis (CFA) while reliability uses Croncbach's alpha coefficient. All instruments were valid and reliable. Data analysis techniques used cross tabulation and Chi square test. The results showed that: (1) Students with instrumental understanding have a high level of self-regulated learning with an estimated proportion range between 46% and 71%. Students with relational understanding have a high level of self-regulated learning with an estimated proportion range between 47% to 74%, (2) There is a significant association between the quality of understanding and the level of self-regulated learning of students with a weak association strength using a significance level of 5%.

Keywords: Self-Regulated Learning; Relational Understanding; Instrumental Understanding; Mathematics

Introduction

Self-regulated learning relates to individuals who are active and have control over their own learning process. The development of *self-regulated learning* begins when students use a learning strategy and gradually they will learn other learning strategies. *Self-regulated learning* is considered an important prerequisite for individuals because it supports individuals to learn independently throughout life (Schunk & Greene, 2017). Self-regulated *learning* is defined as the ability to monitor and self-regulate their own metacognitive, motivational and active behaviours to acquire knowledge and skills such as setting goals, planning learning strategies, self-monitoring, self-reinforcement and responsibility to achieve goals (Boekaerts et al., 2005; Bandura, 1991; Pintrich, 2004; Duckworth, 2009; Zimmerman, 2008; Zimmerman, 2013; Schunk & Greene, 2017). Meanwhile, *self-regulated learning* is defined as the

skill of applying strategies to monitor oneself which includes metacognition (academic knowledge), metacognitive skills (planning), motivation and cognition (cognitive application strategies) (Butler, 2002; Schraw et al., 2006).

Differences in *self-regulated learning* in individuals are caused by several factors including individual factors, behavioural factors and environmental factors (Zimmerman, 2015). These factors are manifested in the aspects of *self-regulated learning*. The aspects of *self-regulated learning* according to Zimmerman (1990) include metacognition, motivation and behaviour. Teal (2010) divided the aspects of *self-regulated learning* into cognitive, metacognitive and motivational. Meanwhile, Schunk & Greene (2017) explain the aspects of *self-regulated learning* consist of cognition, metacognition and motivation. In the theory of developing *self-regulated learning* skills, Zimmerman (2000) proposed a three-phase model. The first phase, forethought, refers to a person planning and setting learning goals. Second, the implementation phase, refers to an individual executing a plan consisting of self-regulated skills and strategies. Finally, the individual evaluates the process and results achieved in the reflection phase.

Students' ability to organise their learning, determine strategies and gain awareness of the extent to which they are learning the material being studied is an important skill (Türker Biber, 2022). Awareness in students from an early age can help students in forming independent individuals. Yusuf (2011) stated that students who are able to manage learning strategies independently tend to have higher self-efficacy, thus increasing the likelihood of academic success. Harding (2018) stated that teachers reported that 99% of students who have *self-regulated learning* will have an impact on their academic success and students who have high *self-regulated learning* are likely to have better results in learning mathematics. Panadero (2017) and Yusuf (2011) stated through their research that *self regulated learning* can successfully improve students' learning outcomes if designed appropriately. Students who have independence will not experience learning difficulties without dependence on others and these students will show readiness to learn. Meanwhile, students who do not have *self-regulated learning* will tend to be passive and not confident, resulting in unpreparedness to learn. In line with the results of the study, Yıldızlı & Saban (2016) showed that the application of *self-regulated learning* activities in learning mathematics significantly improved academic achievement and their perception of motivation to learn mathematics.

One's ability to organise the learning process independently can be viewed from the quality of one's understanding of the material learned. This quality of understanding is not only determined by how much information is received, but also by how effectively individuals can apply appropriate learning strategies, monitor their progress and reflect on learning experiences to improve future outcomes. Understanding the quality of students' comprehension can help students design more effective teaching strategies. Star & Stylianides (2013) argue that the quality of understanding as it refers to the way something is known is essentially how well the knowledge is understood. This research focuses on the depth of how well the knowledge is understood, such that the concept understanding used is relational understanding and instrumental understanding. Relational understanding is understanding that focuses on connecting between concepts and explaining deeper structures (Dumas et al., 2013; Star & Stylianides, 2013). Instrumental understanding is an understanding that focuses on using mathematical procedures without the need to understand the reasons or understand the relationships between the concepts used (Hiebert, 2017; Mellin & Olsen, 1981).

Thus, the relationship between *self-regulated learning* and the quality of understanding is crucial in achieving deeper and more meaningful learning. (Zimmerman, 1990; Zimmerman, 2000; Zimmerman, 2008; Zimmerman, 2015) emphasises that the ability of individuals to regulate their own learning process through the phases of *self-regulated learning* contributes significantly to the quality of their understanding. In the process of learning mathematics in the classroom, teachers must know the quality of students' understanding. Individuals who are able to apply effective learning strategies, monitor their progress and reflect on the learning experience tend to have a better understanding of the material learnt.

In other words, a good *self-regulated learning* process can improve the quality of understanding, because individuals do not only rely on the information received but also actively engage in the learning process and adjust strategies as needed to achieve better results.

Zebua et al. (2022) stated that there is a relationship between *self-regulated learning* and students' mathematical concept understanding. Concept understanding is an important ability that students must have. Students must have basic concepts and correct procedures to solve a problem. Ergen & Kanadli (2017) and Cassidy, (2011) argue that students who have *self-regulated learning* strategies tend to have better conceptual understanding and higher motivation in learning. This opinion is reinforced by Azevedo et al. (2004) who suggest the need for longitudinal studies to evaluate the effect of long-term use of SRL on the quality of student understanding. In contrast to the previous opinion, Viberg et al. (2020) stated that only 20% of their research showed that *self-regulated learning* has a significant relationship to understanding and improving learning outcomes.

From the existing research results, it is necessary to describe the relationship between the quality of understanding category and self-regulated learning. This research was initiated based on the findings of various problems that demand the analysis of self-regulated learning in terms of the quality of students' understanding, which is an important aspect in learning mathematics. This research will answer the following questions.

- 1. What is the level of students' *self-regulated learning* for students with instrumental understanding and relational understanding?
- 2. Is there an association between the quality of understanding and the level of *self-regulated learning*?

Method

This research is a survey research with a quantitative approach. The population in this study were grade VIII students at MTsN Banyuwangi Regency. The sample size was 345 students from a population size of 2491 students. This study examines the phenomena and facts related to *self-regulated learning* in terms of the quality of understanding. Data collection was carried out in the form of a questionnaire that had fulfilled the validity and reliability tests (*Cronbach's Alpha* coefficient of 0.865)

The *self-regulated learning* questionnaire is a structured closed questionnaire that contains 30 statements. In the questionnaire, there are five alternative answers including always (SL), sometimes (KD), rarely (JR) and never (TP). The instrument grids can be seen at Table1table and the rating scale uses a Likert scale.

Indicators	Item Number
1. Using learning strategies	1 (+), 2 (-), 3(-), 4(+)
2. Understanding learning materials	5 (+),6 (-),7 (+)
3. Solve complex problems	8 (-),9 (-), 10(+)
4. Planning learning activities	11 (-),12 (+), 13 (+)
5. Monitoring learning progress	14(-), 15 (-),16 (-),17 (+)
6. Planning learning strategies	18(-),19 (+),20 (+)
7. Persistence in the face of adversity	21 (-), 22 (+), 23 (+), 24(-)
8. Self-satisfaction in achieving learning	25 (+),26 (-),27 (+)
goals	
9. Confidence to face challenges	28 (+),29 (+),30 (+)
	Indicators1. Using learning strategies2. Understanding learning materials3. Solve complex problems4. Planning learning activities5. Monitoring learning progress6. Planning learning strategies7. Persistence in the face of adversity8. Self-satisfaction in achieving learning goals9. Confidence to face challenges

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The minimum score of the *self-regulated learning* questionnaire is 30 and the maximum score is 150. The scores obtained are converted into qualitative criteria with five criteria asTable2

Interval	Criteria			
$126 < X \le 150$	Very high			
$102 < X \le 126$	High			
$78 < X \le 102$	Medium			
$54 < X \le 78$	Low			
$30 < X \le 54$	Very Low			
Source: (Widyoko, 2009)				

Table2. Self-regulated learning questionnaire score criteria

The correspondence analysis technique aims to visualise the rows and columns of a two-way contingency table simultaneously in a two-dimensional vector space (Greenacre, 1984). Contingency tables or *crosstabs* aim to test hypotheses about how some variables depend on others or about how increases in one variable affect changes in another (White, 2003). The cross tabulation test aims to determine the level of students' *self-regulated learning in* terms of the quality of understanding. Furthermore, the *Chi Square* Test was conducted to examine the association between *self-regulated learning* and the quality of students' comprehension. The strength of the *Chi Square* test association can be reviewed based on the contingency table as in Table 3

Table	3.	Contingency	/ Coe	fficient
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Coefficient Interval	Association Level
0,00-0,199	Very weak
0,20-0,399	Weak
0,40-0,599	Fair or Medium
0,60-0,799	Strong
0,80-1,000	Very Strong
Courses (Survivore 2014

Source: (Sugiyono, 2014)

Result and Discussion

1. Description of Self Regulated Leaning of Class VIII MTsN Students in Banyuwangi Regency

The questionnaire measurement of *self-regulated learning of* class VIII MTsN in Banyuwangi Regency is categorised into five criteria, namely very high, high, medium, low and very low. Descriptive data about *self-regulated learning* based on the criteria are presented in Table 33 below.

Description		Criteria Self regulated learning					U
		Very High	High	Medium	Low	Very Low	Overall
Number of students	f	10	190	123	22	0	345
Number of students	%	3%	55%	36%	6%	0%	100%
Average Score		133,7	113,1	94	75,22	0	104,15
Maximum Score		141	103	102	78	0	141
Minimum Score		127	23	80	70	0	70
Ideal Maximum Score		150	150	150	150	150	150
Ideal Minimum Score		30	30	30	30	30	30
Standard Deviation		4,23	6,29	5,77	2,48	0	13,59

Table 4 . Description of Self Regulated Learning Data

Based on Table 4 above, out of 345 students, there are 10 students who have very high self-regulated learning with an average score of 133.7. There are 190 students who have high self regulated learning ability with an average score of 113.1. Furthermore, students with moderate and low self-regulated learning ability were 123 and 22 students respectively. The average score of students with moderate self regulated learning is 94 while students with low self regulated learning is 75.2. The standard deviation coefficient in the high criterion of 6.29 is higher than the very high, medium and low criteria. Thus, the data of high self regulated learning ability is more diverse than very high, medium and low self regulated learning. Overall, the mean of students' *self-regulated learning* is 104.15 with high criteria.

Furthermore, this finding also explains the description of *self-regulated learning* data based on each aspect as in Table 5.

Decomintion	Aspects of Self Regulated Learning			
Description	Cognitive	Metacognitive	Motivation	
Average Score	32,26	34,54	37,33	
Maximum Score	46	50	48	
Minimum Score	19	17	24	
Ideal Maximum Score	50	50	50	
Ideal Minimum Score	10	10	10	
Standard Deviation	5,39	5,75	5,21	

Table 5 . Data Description Based on Self Regulated Learning Aspects

Based on Table 5, there is information related to data description based on aspects of self-regulated learning. These aspects consist of cognitive, metacognitive and motivation. Each aspect consists of 10 statement items. The maximum score of each aspect is 50 and the minimum score is 10. In the cognitive aspect, the average student score is 32.36. The average student score on the metacognitive aspect was 34.54. In the motivation aspect, the average score was 37.33. The standard deviation coefficient on the metacognitive aspect of 5.75 is higher than the cognitive and motivational aspects. Thus, the data on self-regulated learning ability in the metacognitive aspect is more diverse than the cognitive and motivational aspects.

1.2 Association of Understanding Quality and *Self-Regulated Learning of* Class VIII Students of MTsN in Banyuwangi Regency

The association of comprehension quality with the level of mathematical self-regulated learning presented in the cross tabulation aims to determine the relationship between each comprehension quality category and the level of self-regulated learning.

Quality of	Quality of Self-regulated learning level					Total
Understanding	Very High	High	Medium	Low	Very Low	- Total
Instrumental	0	55	30	8	0	93
Instrumental —	0%	59,1%	32,3%	8,6%	0%	100%
Deletional	9	53	24	1	0	87
Relational —	10,3%	60,9%	27,6%	1,1%	0%	100%
Not understood	1	68	85	11	0	165
	0,6%	41,2%	51,5%	6,7%	0%	100%

Table 6 . Cross Tabulation of Comprehension Quality and Level of Self Regulated Learning

Based on Table 6, the level of self-regulated learning between students with instrumental and relational understanding is mostly at a high level. However, if we look further, we will see the difference between the two. Students with relational understanding have a very high level of self-regulated learning at 60.9% while students with instrumental understanding only at 59.1%. In the moderate self-regulated learning category, students with relational understanding were 27.6% while students with instrumental understanding were 32.3%. Students with instrumental understanding had a low level of self-regulated learning of 8.6% which was greater than the low category for students with relational understanding of only 1.1%. In addition, students with relational understanding have very high self-regulated learning as many as 9 students or 10.3%.

The association analysis used Chi-square to determine the association between the quality of student understanding and self-regulated learning. The criteria for decision making if the significance value is <0.05 then it is rejected. This indicates that there is a significant association between mathematical representation ability and the quality of student understanding. Based on the calculation results, the significance value of 0.00 < 0.05 means that there is an association between the quality of understanding and self-regulated learning. The strength of the association between the two variables is 0.313, based on table 31 the association between the quality of understanding and self regulated learning is included in the weak category.

1.3 Estimation of the Proportion between the Quality of Comprehension and the Level of *Self-Regulated Learning of* Class VIII Students of MTsN in Banyuwangi Regency

An interval estimate is a confidence range that believes that the range includes the intended values and parameters. The interval estimation used in this study is the proportion estimation. Based on the formula by Walpole (2012), the proportion estimation results are obtained as follows.

Self-regulated	Quality of Understanding				
<i>learning</i> level	Instrumental	Relational	Not understood		
Vorullish	0%	10,3%	0,6%		
very High	$0\% \le P < 29\%$	0% < P < 30,1%	0% < P < 15,7%		
Uich	59,1%	60,9%	41,2%		
nign	46% < <i>P</i> < 71%	47,7% < P < 74%	29,5% < P < 52,8%		
Madium	32,3%	27,6%	51,5%		
Medium	15,5% < P < 49%	9,7% < P < 45,4%	40,8% < P < 62,1%		
Low	8,6%	1,1%	6,7%		
LOW	0% < P < 28,9%	0% < P < 21,5%	0% < P < 21,4%		
Vom Low	0%	0%	0%		
very Low	$0\% \le P < 29\%$	$0\% \le P < 31\%$	$0\% \le P < 55\%$		

Table 7 . Estimated Proportion of Comprehension Quality and Level of Self Regulated Learning

Table 7 shows the estimated proportion of comprehension quality students at each level of self regulated learning. Students with instrumental understanding have different proportions at the level of self-regulated learning. At high level criteria, the estimated proportion of students is in the range between 46% to 71%. The medium level shows an estimated proportion in the range between 15.5% to 49%. Meanwhile, the low level is in the range of 0% to 28.9%. There are no students with instrumental understanding at the very high and very low level criteria. Thus, the proportion of students with instrumental understanding is more at the high level of self-regulated learning.

Furthermore, students with relational understanding at a very high level have an estimated proportion in the range of 0% to 30.1%. At the high level criteria, the estimated proportion of students is in the range of 47.7% to 74%. The medium level shows an estimated proportion in the range between

9.7% to 45.4%. Meanwhile, the low level was in the range of 0% to 21.5%. There were no students with relational understanding at the very low level. Thus, the proportion of students with relational understanding is more at the high level of self-regulated learning.

Finally, the estimated proportion of students who did not understand at each level of self-regulated learning. At the very high level, the estimated proportion of students is in the range between 0% to 15.7% and at the high level is in the range between 29.5% to 52.8%. The medium level shows an estimated proportion in the range of 40.8% to 62.1%. Meanwhile, the low level was in the range of 0% to 21.4%. There were no students who did not understand at the very low level. Thus, the proportion of students who did not understand was more at the moderate level of self-regulated learning.

Discussion

Students' self-regulated learning in this study was measured by a questionnaire consisting of 30 statement items consisting of three aspects. The three aspects include cognitive, metacognitive and motivation. The cognitive aspect relates to problem-solving strategies and skills when dealing with problems. The cognitive aspect relates to problem solving strategies and skills when dealing with problems. The metacognitive aspect relates to students' awareness and control. The motivational aspect relates to how consistent and persistent one is in learning independently.

Research by Nufus et al. (2024) showed that students with high levels of self-regulated learning tend to have better creative thinking skills. They are able to produce more answers, and consider various alternatives. Whereas students with a low level of self-regulated learning can generate several answers and apply alternative methods but have difficulty in explaining and applying the desired method to solve the problem. High-achieving students tend to reread the material to deepen their understanding and they do not hesitate to ask for help if they have difficulties when understanding the learning. Conversely, if low-achieving students tend not to use strategies effectively which can hinder understanding of the material. Low-achieving students' ability to use these strategies is low, which has an impact on their success in mathematics examinations (Türker Biber, 2022).

Self-regulated learning is defined as the extent to which students are metacognitive, motivational and behavioural active participants during the learning process (Zimmerman, 2013). Students who have self-regulated learning they can adapt to challenging problems to find solutions and experience satisfaction from the efforts that have been made. This concept self-monitors students' understanding of the subject matter, the learning strategies used and the effectiveness of planning time to achieve the learning goals to be achieved. In this study, the level of self-regulated learning is categorised into very high, high, medium, low and very low.

The quality of students' understanding not only has an association with students' cognitive abilities but also associates with students' affective abilities. Students with relational understanding have effective planning, careful self-monitoring and can control themselves over the learning process. While students who have instrumental understanding students choose specific planning, students self-monitor the use of procedures and self-control the effectiveness of learning.

Based on the results of cross tabulation with the help of SPSS 25, it can be seen that both students with relational and instrumental understanding have a high level of self-regulated learning. However, if examined, there is a difference between the level of self-regulated learning of students with relational understanding. At the very high level of self-regulated learning, there are 9 students with relational understanding and no students with instrumental understanding and only 1 student with relational understanding and only 1 student with relational

understanding. In addition to these two qualities of understanding, this study also found that students who did not understand had a moderate level of self-regulated learning.

As explained above, there is an association between the quality of understanding and the level of students' self-regulated learning. Based on the results of overall data analysis with the help of SPSS 25, it can be obtained that there is an association between the quality of understanding and the level of students' self-regulated learning. The strength of the association between the two variables falls into the weak category. This study is in line with Viberg et al., (2020) which states that only 20% of their research shows that self-regulated learning has a significant relationship with understanding and improved learning outcomes. This means that the association can be said to be weak. The weak association is also possible that there are other factors such as cultural factors, gender and grade level as researched by (Tang & Neber, 2008).

Ergen & Kanadli (2017) and Cassidy (2011) argue that students who have self-regulated learning strategies tend to have better conceptual understanding and higher motivation in learning. Students plan learning goals, choose strategies and make plans to achieve these goals. In the cognitive aspect, students who have conceptual understanding tend to be able to monitor the development of the learning process, identify difficulties while learning and evaluate learning achievements, self-regulate and maintain motivation during the learning process. Students who have high understanding tend to be more active in monitoring learning progress and are able to evaluate their understanding of learning materials (Callan & Shim, 2019). Students' deep understanding can increase the effectiveness of students' self-regulated learning. Student understanding serves as a strong foundation for developing students' self-regulated learning skills (Brenner, 2022).

Conclusion

This study aims to describe the level of self-regulated learning for students with instrumental understanding and relational understanding and examine the association of understanding quality with self-regulated learning of MTsN students in Banyuwangi Regency. This result is based on descriptive analysis which shows that Class VIII MTsN students in Banyuwangi Regency who do not understand have a level of self-regulated learning at moderate criteria with an estimated proportion range between 40.8% to 62.1%. Students with instrumental understanding have a high level of self-regulated learning with a range of estimated proportions between 46% and 71%. Students with relational understanding have a high level of self-regulated learning with an estimated proportion range between 47.7% and 74%. In addition, this finding explains that there is a significant association between the quality of comprehension and self-regulated learning of class VIII students in MTsN Banyuwangi Regency with a weak strength of association using the 5% significance level

Based on the results of the study, the association between the quality of comprehension and selfregulated learning shows that self-regulated learning has a contribution to the quality of students' comprehension. Teachers can implement learning strategies that integrate self-regulated learning based on the quality of students' understanding. For example, students with relational understanding can be given the freedom to set goals and reflect on their learning strategies independently, students with instrumental understanding can be motivated in monitoring their understanding, students who do not understand need more support and need supervision in setting learning goals and so on. The limitation of this study is the mismatch of research time duration in two schools due to the school hosting the Madrasah Working Group level Sports and Arts Week which resulted in students working in a hurry. This time mismatch may have affected students' answers when filling out the questionnaire.

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