The effect of discovery learning and problembased learning on middle school students' selfregulated learning

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Abstract. The aim of this research was to determine the effect of learning models on mathematics achievement viewed from student's self-regulated learning. The learning model compared were discovery learning and problem-based learning. The population was all students at the grade VIII of Junior High School in Boyolali regency. The samples were students of SMPN 4 Boyolali, SMPN 6 Boyolali, and SMPN 4 Mojosongo. The instruments used were mathematics achievement tests and self-regulated learning questionnaire. The data were analyzed using unbalanced two-ways Anova. The conclusion was as follows: (1) discovery learning gives better achievement than problem-based learning. (2) Achievement of students who have high self-regulated learning was better than students who have medium and low self-regulated learning. (3) For discovery learning, achievement of students who have high self-regulated learning was better than students who have medium and low self-regulated learning. For problem-based learning, students who have high and medium self-regulated learning have the same achievement. (4) For students who have high self-regulated learning, discovery learning gives better achievement than problem-based learning. Students who have medium and low self-regulated learning, both learning models give the same achievement. t.

1. Introduction

Suherman [1] mentions that in mathematics learning, students need to get used gain understanding through the experience of existing or not existing properties a set of objects. Furthermore, with this abstraction students are trained to make predictions, conjecture or tendency based on experience or knowledge developed through specific examples. Concepts in mathematics are mutually sustainable, from easily material increases to difficult material. Students who don't know basic concepts will have difficulty when confronted with other concepts that related to the basic concept. The implications, student mathematics achievement was unsatisfactory.

Low mathematics learning achievement, especially for junior high school students in Boyolali Regency, can be seen as the result of National Examination year 2013/2014 [2]. One of the mathematics material has a low absorption rate is polyhedral material. Absorption rate for the ability to solve problems are relating determine the elements in the polyhedral material, resolve issues related to the geometrical surface area and resolve issues related to geometrical volumes respectively are 48.68%, 45.38% and 47, 03%. Absorption rate in Boyolali is lower than the absorption rate of the province at 49.95%, 47.75%, and 49.11%. The absorption rate for polyhedra material is lower than absorption rate other materials.

Many factors can affect mathematics achievement. These factors which came from outside or from within students themselves. Factors from within e.g. intelligence, learning interest, learning motivation, learning styles and etc. While external factors such as learning models used by teachers there is no significant change from year to year. Allegedly lower mathematics achievement of students is due to lack of precise used the learning model. In line with the opinion of Carol in Sudjana[3] that students' learning achievement influenced by the quality of teaching used by the teacher. The quality of a teacher's learning can be shown through the approach and learning model used. Lack of variation in learning causes the learning becomes monotonous and boring, so students became less enthusiastic about learning.

According to Permendiknas Number 20 of 2006 [4], one of the goals in mathematics learning is to solve problems that include the ability to problems understanding, design mathematics models, solve models and interpretation the solutions. Based on these objectives required learning model that can facilitate students to achieve that goal. Learning model that can facilitate to achieve learning goals is discovery learning and problem-based learning.

The characteristic of discovery learning is discovery itself. Each student must make an invention to discover the concept of the material to be studied. This model provides an opportunity for students to discover and construct their own knowledge. Wong [5] points out that "discovery learning is one of the pedagogic deals that reduce teachers' direct instruction and have students construct knowledge on their own. Guided discovery is superior to pure discovery in helping students learning and transferring". Discovery learning is a learning that develops teachers' pedagogic ability and enables students to construct their own knowledge. Discovery is part of the discovery learning, which helps students how to learn and transfer their knowledge. The role of the teacher is more determined as a learning coach and learning facilitator. Research of Balim [6] gives the result that discovery learning is one of the variations of learning model that can improve students' and teachers' activeness as their mentor. Discovery learning can improve student learning outcomes and student discover skills compared conventional learning models. Alex and Olubusuyi [7] in their research found that there are significant differences in learning outcomes between students who used discovery learning and students who do not use discovery learning. Discovery learning has great potential to improve student learning outcomes.

Problem-based learning has characteristic learning based on problem-solving. The research results of Padmavathy and Mareesh [8] suggest that problem-based learning influences learning and improves student understanding, and increases the ability to used concepts already learned in real life. Krulik and Rudnick in Padmavathy and Mareesh [8] mentioned that problem-based learning is a problem-based mathematics learning and gives students more opportunities to think critically, present creative ideas and communicate with peers mathematically. The research results of Fatade et al [9] mentioned that there is a significant difference in mathematics learning achievement between problems based learning and traditional model. Problem-based learning provides better mathematics learning achievement. So problem-based learning recommended for teachers to use in classroom learning.

In addition to the approach and learning model, one of the factors that can affect student's mathematics learning achievement is self-regulated learning. Knowless at Scott [10] suggests that self-regulated learning is a process whereby individuals take their own initiative, with or without help from others, to diagnose learning needs, formulate learning objectives, identify learning objectives, select and define learning strategies, and evaluate learning outcomes. Research of Vrieling, et al [11] gives results that self-regulated learning has a strong relationship with the use of cognitive skills and student learning motivation. Students with high self-regulated learning have a stronger materials understanding when compared with medium and low self-regulated learning. According to the research results of Pintrich and De Groot [12] which states, students with high self-regulated learning will be easier to use their cognitive abilities and also maximize their learning outcomes.

The purpose of this research was to know the learning of mathematics of polyhedra material of grade VIII students of SMP Negeri in Boyolali Regency: (1) which one gives better mathematics achievement, discovery learning or problem based learning; (2) which one has better mathematics

achievement, students who have high, medium, or low self-regulated learning; (3) for each learning model, which one has better mathematics achievement, students who have high, medium, or low self-regulated learning; (4) For each category of self-regulated learning, which one gives better mathematics achievement, discovery learning or problem based learning.

2. Methods

This research is a quasi-experimental study with 2 × 3 factorial design as shown in Table 1 below.

Table 1. Research Design

B / A	Self-regulated learning		
	High (b_1)	Medium (b_2)	Low (b_3)
Discovery Learning	$(ab)_{11}$	$(ab)_{12}$	$(ab)_{13}$
Problem Based Learning	$(ab)_{21}$	$(ab)_{22}$	$(ab)_{23}$

The population in this research were students of class VIII SMP Negeri at Boyolali Regency. The population consists of 50 State Junior High Schools in Boyolali Regency. The sampling technique used in this research is stratified cluster random sampling. From the sample selection, the result for the sample is SMP 4 Boyolali, SMPN 6 Boyolali, and SMPN 4 Mojosongo.

There are two independent variables in this research, learning models and self-regulated learning, and one dependent variable that is mathematics learning achievement. Methods of data collection used achievement test, questionnaires, and documentation. The instruments used in this research are mathematics learning achievement test and self-regulated learning questionnaire. Mathematics learning achievement test consists of 25 multiple choice questions. Self-regulated learning questionnaire consists of 50 statements.

Data analysis techniques used to test the hypothesis in this study is unbalanced two-ways variance analysis with 0.05 significance level. Precondition data analysis of early mathematics ability data analysis using students' mathematics achievement test includes normality test using Lilliefors test and homogeneity test of variance using Bartlett test.

3. Results and Discussion

Normality data test result of student's early mathematics achievement test ability found that L_{obs} at discovery learning and problem based learning group are less than$L_{0,05;n}$. That means H_0 of both groups are accepted. In conclusion, each sample group came from a normally distributed population. Similarly, the homogeneity test of population variance on the student's early mathematics achievement test ability, obtained ${\chi^2}_{obs} = 0{,}38973$ with $DK= \{\chi^2|\chi^2 > 3{,}84146\}$, since ${\chi^2}_{obs} \notin DK$ then H_0 is accepted. Therefore it can be concluded that both groups of samples came from populations with equal variance.

Based on the result of equilibrium test on the student's early mathematics achievement test ability, obtained $F_{obs} = 0{,}62742$with $DK = \{F|F > 3{,}8872\}$. Then $F_{obs} \notin DK$, so H_0 was accepted and it was concluded that both groups of samples came from the population with a balanced mean early mathematics achievement test ability.

Before hypothesis test first tested the normality and homogeneity of the population on the mathematics learning achievement of students. Normality tests are done 12 times and Lobs is obtained for each group, it's smaller than$L_{0,05:n}$with $DK = \{L|L > L_{0,05;n}\}$, so $L_{obs} \notin DK$ and then H_o is accepted . It is concluded that all samples in this study came from normally distributed populations. For homogeneity test of population variance, it is found that ${\chi^2}_{obs}$ in each group is smaller than ${\chi^2}_{tabel}$with $DK = \{\chi^2|\chi^2 > {\chi^2}_{tabel}\}$, because ${\chi^2}_{obs} \notin DK$ then H_o is accepted. It was concluded that the population had the same variance.

Table 2 presents a summary of students' mathematics learning achievement mean data based on the learning model viewed from self-regulated learning.

Table 2. Mean of Data Students' Mathematics Learning Achievement On Each Learning Model and Self-Regulated Learning

Model	*Self-Regulated Learning*			Marginal Rate
	High	Medium	Low	
Discovery Learning	89,4194	75,3778	58,1538	75,2549
Problem based learning	74,3448	70,1395	60,0000	68,0377
Average of Marginal	82,1333	72,8128	89,2000	

Hypothesis test is conducted to find out whether there are differences in achievement between each learning models and self-regulated learning, its interaction on students' mathematics learning achievement

Table 3. Summary of the calculation unbalanced two-way analysis of variance

Source	JK	dk	RK	F_{obs}	F_{table}	Judgment
Model (A)	1893,5633	1	1893,5633	16,321	3,8881	H_{0A} Rejected
Self-regulated (B)	17557,734	2	8778,8671	75,669	3,0408	H_{0B} Rejected
Interaction (AB)	2405,7161	2	1202,8581	10,368	3,0408	H_{0AB} Rejected
Galat (G)	43667,225	205	116,0158			
Total	66795,443	206				

Table 3 is a summary of the results of unbalanced two-ways analysis of variance. Based on Table 3, it could be concluded as follows. (1) In the main effect (A), $F_{obs} = 16{,}321$with $DK = \{F|F > 3{,}8881\}$. Obtained $F_{obs} \in DK$, then H_{0A} rejected. This means that there are differences in students' mathematics achievement between discovery learning and problem-based learning. (2) In the main effect (B), $F_{obs} = 75{,}669$with $DK = \{F|F > 3{,}0408\}$. Obtained $F_{obs} \in DK$, then $F_{obs} \in DK$ rejected. That means that there are significant differences in the categories, high, medium, and low self-regulated learning in order to students' mathematics learning achievement. (3) In the interaction effect (AB), $F_{obs} = 10{,}368$ with $DK = \{F|F > 3{,}0408\}$. Retrieved $F_{obs} \in DK$, then H_{0AB} is rejected. It means there is interaction between learning models and self-regulated learning category on student's mathematics learning achievement.

The result of the Anava calculation shows that H_{0A} is rejected, So it must be tested the mean comparison between rows. The summary of the calculations is presented in Table 4 below.

Table 4. Summary of Intermediate Line Comparison Test

H_0	F_{obs}	$F = 2F_{table}$	Judgment	
$\mu_{1.} = \mu_{2.}$	23,337	7,7763	$\boldsymbol{H_0}$	Rejected

Based on Table 4 and the marginal rate in Table 1 it can be concluded that discovery learning provides better mathematics learning achievement than problem-based learning. In the discovery learning model students are given the opportunity to think experimentally, discovering and constructing their own knowledge. These results are in line with the study of Alex and Olubusuyi's [7] research, that there are significant differences in learning outcomes between students using discovery learning and students who do not use discovery learning.

The result of the analysis of variance calculation shows that H0B is rejected, So it must be tested the mean comparison between column. The summary of the calculations is presented in table 5 below.

Table 5. Summary of Inter-Column Mean Comparative Test

H_0	F_{obs}	$F = 2F_{table}$		Judgment
$\mu_{.1} = \mu_{.2}$	26,6830	7,7763	$\boldsymbol{H_0}$	Rejected

$\mu_2 = \mu_3$	56,4960	7,7763	H_0	Rejected
$\mu_1 = \mu_3$	135,9999	7,7763	H_0	Rejected

Based on Table 5 and the marginal rate in Table 1 it can be concluded that students 'mathematics learning achievement with high self-regulated learning is better than students with medium and low self-regulated learning, and students' mathematics learning achievement with medium self-regulated learning is better than students with low self-regulated learning. These results are consistent with the hypothesis proposed research. Better students' mathematics learning achievement that has high self-regulated learning in line with the results of research Pintrich and De Groot [12] which states that students with high self-regulated learning will be easier in using their cognitive abilities and learning outcomes more leverage. Students with high self-regulated learning manage their behaviour and thoughts in learning so they obtain the information they need when learning.

Furthermore, students' mathematics learning achievement with medium self-regulated learning is better than those with low self-regulated learning. In line with Vrieling, et al [11] research, gives results that self-regulated learning has a strong relationship with the use of cognitive skills and student learning motivation. Students with high self-regulated learning have a stronger understanding of the material when compared with medium and low self-regulated learning. Students with medium self-regulated learning are had better learning motivation than students with low self-regulated learning, so students with self-regulated learning have better learning achievement.

The results of ANOVA calculation show that H_{0AB} is rejected, so we need a mean comparison test between cells in the same row. The summary of the calculations is presented in Table 6.

Table 6. Summary of Mean Comparison between Cells on the Same Line

H_0	F_{obs}	F_{table}	*Judgment*	
$\mu_{11} = \mu_{12}$	31,1943	11,2950	H_0	Rejected
$\mu_{11} = \mu_{13}$	119,1445	11,2950	H_0	Rejected
$\mu_{12} = \mu_{13}$	42,1381	11,2950	H_0	Rejected
$\mu_{21} = \mu_{22}$	2,6400	11,2950	H_0	Accepted
$\mu_{21} = \mu_{23}$	27,7594	11,2950	H_0	Rejected
$\mu_{22} = \mu_{23}$	16,8258	11,2950	H_0	Rejected

Based on Table 6 and the marginal rate in Table 1 it can be concluded that in discovery learning, students 'mathematics learning achievement with high self-regulated learning is better than the students with low and medium self-regulated learning, students' learning achievement with medium self-regulated learning is better than low self-regulated learning students. Students with high self-regulated learning have a strong understanding of the material compared with medium and low self-regulated learning. In line with Vrieling, et al [11] research, gives results that self-regulated learning has a strong relationship with the use of cognitive skills and student learning motivation. Students with high self-regulated learning have a strong understanding of the material compared with medium and low self-regulated learning.

In problem-based learning, students' mathematics learning achievement with high and medium self-regulated learning as same as well. The factors caused by the understanding of student material with high and medium self-regulated learning is same. As a result students' ability in solving problems is same. Furthermore, the mathematics learning achievement of students with high self-regulated learning is better than those with low self-regulated learning. This is in line with the results of research Pintrich and De Groot [12] which states that students with high self-regulated learning will be easier in using their cognitive abilities and learning outcomes more leverage.

Furthermore, the mean comparative test between cells in the same column, the summary of the calculations are presented in Table 7 below.

Table 7. Mean Comparison Range Between cells in the same column

H_0	F_{obs}	F_{table}	Judgment	
$\mu_{11} = \mu_{21}$	29,3480	11,2950	H_0	Rejected
$\mu_{12} = \mu_{22}$	5,2006	11,2950	H_0	Accepted
$\mu_{13} = \mu_{23}$	0,4328	11,2950	H_0	Accepted

Based on Table 7 and the marginal rate in Table 1 it can be concluded that students with high self-regulated learning, discovery learning provides better mathematics learning achievement than problem-based learning. This is because students with high self-regulated learning have better cognitive and motivational skills. Students with high self-regulated learning viewed the problem as a challenge to overcome not a threat to avoid. In line with the results of the study of Alex and Olubusuyi [7] who found, there are significant differences in learning outcomes between students who use discovery learning and students who do not use discovery learning. This is also reinforced by high self-regulated learning so that mathematics learning achievement of students who used discovery learning is better than problem-based learning. In students with medium and low self-regulated learning, discovery learning and problem-based learning provide mathematics learning achievement as well. Students with high self-regulated learning have a strong understanding of the material compared with medium and low self-regulated learning. It is possible when students with medium and low self-regulated learning are confronted with a particular learning model they find it difficult and less motivated to learn. So in each learning model, students' mathematics achievement with medium and low self-regulated learning will be the same. In addition students with medium and low self-regulated learning when following the learning process need more guidance, but the guidance provided can't be maximized because of the limited time

4. Conclusion

From the results of the research can be concluded as follows. (1) Discovery learning gives better mathematics achievement than problem-based learning. (2) Mathematics achievement of students who have high self-regulated learning was better than students who have medium self-regulated learning, and both (high and medium) gives better mathematics achievement than low self-regulated learning. (3) For discovery learning, Mathematics achievement of students who have high self-regulated learning was better than students who have medium self-regulated learning. Both (high and medium) gives better mathematics achievement than low self-regulated learning. For problem-based learning, students who have high and medium self-regulated learning have the same mathematics achievement. Both (high and medium) gives better mathematics achievement than low self-regulated learning. (4) For students who have high self-regulated learning, discovery learning gives better mathematics achievement than problem-based learning. For students who have medium and low self-regulated learning, both learning models give the same mathematics achievement.

Suggestions from the results of this study are as follows, teachers should apply discovery learning as one of the references in learning on the polyhedral material in the classroom. Teachers should prepare them optimally, with the preparation of facilities, learning tools, and student conditioning that can support the learning process. So discovery learning really facilitates students' self-regulated learning. In addition, teacher guidance and encouragement are needed to help students with medium and low self-regulated learning.

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