



Effect of problem based learning model learning on learning outcomes of mathematics based on early knowledge from students

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Abstract

Teacher-oriented learning, thus the teacher's ignorance of the initial knowledge of mathematics, students allegedly resulted in a lack of student mathematics learning outcomes. The Problem Based Learning (PBL) model places students at the center of learning which builds creativity, challenging conditions, contextual, and diverse student learning experiences to solve problems related to the material. The purpose of this study was to see the effect of the PBL model on mathematics learning outcomes in terms of initial knowledge. This research is a quasi-experimental study with a Complete Randomized Block Design. The sample of this study was Class 8A students as the experimental class and Class 8B as the control class at SMP Negeri 2 Belang. Each class is taken by 16 students, divided by high and low initial knowledge. The results showed there was an influence of learning models on mathematics learning outcomes, there was an influence of initial knowledge on mathematics learning outcomes, there was an interaction between learning models and initial knowledge on mathematics learning outcomes, there were no significant differences in learning outcomes between classes with PBL models and classes with models conventional for students with high initial knowledge, there are significant differences in learning outcomes between classes with PBL models and classes with conventional models for students with low initial knowledge, there are no significant differences in learning outcomes between students with high initial knowledge and students with low initial knowledge in the classroom with the PBL model, and there are significant differences in learning outcomes between students with high initial knowledge and students with low initial knowledge in the classroom with conventional models.

Keywords: PBL, conventional, early knowledge, learning outcomes, mathematics

Introduction

Mastery of mathematics material by students is very closely related to the completeness of learning mathematics. Mathematical learning materials are generally arranged in a hierarchical manner, i.e. one material is the basis/prerequisite for the next material. If a student's initial knowledge is lacking, which does not master the basic material needed, the student may not be able to master the learning material properly. Students who lack good basic knowledge and do not receive attention in the learning process, these students cannot achieve mastery learning. Therefore, teachers are required to apply a model and method that can help students in all levels of initial ability, both low, medium, and high to achieve mastery learning.

Initial knowledge is an ability/knowledge that is seen as input (input) that must be possessed by students before gaining new abilities and new knowledge. A student will more easily understand and learn new subject matter, if the teaching-learning process is based on material that has been previously known so that students only have to develop their initial abilities into new higher abilities.

Based on the observations of researchers at SMP Negeri 2 Belang, students still experience problems in terms of learning outcomes. The average grade of mathematics in grade 7 students is 51 and grade 8 is 53. This was allegedly the researchers because of the low initial student knowledge. According to Reuven Lazarowitz and Carl Lieb (2006) ^[1] which states that students will get obstacles/difficulties in gaining new knowledge when the ability/initial knowledge of misunderstanding occurs ^[1]. The other side, at SMP Negeri 2 Belang, while implementing the 2013 curriculum in the teaching and learning process. Nevertheless, the situation of learning in the classroom is still dominated by the teacher (teacher-centered).

A wise response is needed by the teacher to address the above problems, namely returning to the essence of teaching. The essence of teaching (Munir, 2010) ^[2] itself is an effort in order to encourage (guide and support) students to organize activities, store, and find the relationship between new knowledge with existing knowledge ^[2]. Therefore, teachers should seek an activity that can increase student activity (student-centered). Learning centered on student activities can improve student processing skills that encourage students to be active in critical thinking and foster student interest in learning in mathematics.

Concrete efforts that can be done by teachers to increase student activity in learning are through the use of constructivism learning models. Constructivist learning models prioritize student activities in constructing their own thinking. The constructivism learning model is carried out not only in the same direction (teacher to student) but to create a learning process from various directions (teacher to student, student to teacher, student to fellow students). There are several constructivism learning models that can optimize student-centered activities, one of them is the Problem Based Learning (PBL) learning model. The Problem Based Learning (PBL) learning model is one model in which activities are centered on student activities (student-centered). Therefore, the current curriculum, the 2013 curriculum, states that the PBL learning model is one of the recommended learning models. Even according to Ibragimov *et al* (2016) ^[3] stressed that PBL must be seen as a type of basic training that allows to integrate educational opportunities and other learning technologies ^[3]. According to Arends (Setiawan, 2014) ^[4], PBL is a learning model by exposing students to authentic and interesting problems so that students can compile their own knowledge, develop problem solving skills, and find solutions to problems that are given ^[4]. Students in the PBL model are placed as learning centers (student centered) ie students are directed to solve problems related to the material that will be discussed so that creativity, challenging conditions, contextual, and diverse learning experiences will develop. According to Oguz-Unver & Arabacioglu (Setiawan, 2014) ^[4], the main principle of PBL is to maximize learning by investigating, explaining, and solving contextual and meaningful problems ^[4]. Therefore, this PBL model can be used to encourage students to be active in the learning process.

Research methods

This study uses a quasi-experimental research method. This study uses a Complete Randomized Block Design as in Mattjik and Sumertajaya (2002) ^[5] and hereinafter referred to as Factorial Design in a Complete Randomized Block Design or Factorial RAKL ^[5]. With the experimental design as follows:

Table 1: Research design

Early Mathematics Knowledge (B)	Learning Model (A)	
	PBL (A ₁)	Conventional (A ₂)
High (B ₁)	Y _{A1B1}	Y _{A2B1}
Low (B ₂)	Y _{A1B2}	Y _{A2B2}

Information

Y_{A1B1}: score of learning outcomes in the PBL model class with high initial knowledge.

Y_{A2B1}: score of learning outcomes in conventional model classes with high initial knowledge.

Y_{A1B2}: score of learning outcomes in the PBL model class with low initial knowledge.

Y_{A2B2}: score of learning outcomes in conventional model classes with low initial knowledge.

This research was conducted at Belang 2 Public Middle School in June 2019. The population of this study is students of Belang 2 Public Middle School in odd semester 2019/2020. The class 8 research class consisted of class 8A as the experimental class, and class 8B as the control class. Determination of the sample in this study using a purposive sampling technique, i.e. the sample was chosen based on certain considerations and objectives (Riduwan, 2013) ^[6], with the determination of sample size using a grouping method according to Naga (2010) ^[7], namely ^[6, 7]

Table 2

M _T	27%
M _S	
M _R	27%

M_T = 27% and M_R = 27%.

M_T = Height Group Size

M_R = Low Group Size.

The dependent variable in this study is student learning outcomes, where what is meant by student learning outcomes are scores obtained after written tests, in the form of THB.

The independent variable is a learning model and early mathematical knowledge. The learning model is divided into two, PBL models and Conventional models. The initial knowledge of mathematics is divided into two categories, namely high initial knowledge and low initial knowledge.

Preliminary knowledge of mathematics students will use an instrument in the form of a written test using an initial mathematical knowledge test. The implementation of this initial knowledge data retrieval will be carried out at the beginning of the research carried out.

Student learning outcomes will be measured through written tests using evaluation of learning outcomes. Learning outcomes are limited to the cognitive realm. The implementation of learning data retrieval will be done at the end of the study.

The research instruments will be subject to content validation by experts then tested through validity and reliability tests before being used as research instruments.

Data analysis techniques used two-way variant analysis (Supardi, 2011). Prior to that, tests of normality and homogeneity were conducted [8].

Result and discussion

This research was conducted with a number of situations and conditions in accordance with quasi-experimental research. This study applies two different learning models, namely the Problem Based Learning (PBL) model for the experimental class and the conventional model for the control class. This research in its implementation will be reviewed from the students' initial mathematical knowledge which is limited to two, namely low initial knowledge and high knowledge. As for the learning material used, namely the Numbers Pattern material and the Cartesian Coordinate material.

The research data were taken from research subjects, namely class 8A and class 8B. Class 8A is an experimental class and 8B is a control class. Each class is grouped according to the level of students' initial mathematical knowledge. Students' initial knowledge of mathematics can be divided into three, namely high, medium and low initial mathematics knowledge.

After conducting an initial knowledge of mathematics test, the test results are then processed using a ranking sequence of the three ranks. The number of students in each factor level combination was taken by 8 people. The data used in this study are the data of students who have high prior knowledge of mathematics and low initial knowledge of mathematics. From the results of this grouping, the learning outcomes data obtained from the Material Pattern and Cartesian Coordinates were subsequently tested using inferential statistical analysis of variance (Anava) of two paths with experimental design, Factorial Design in a Completely Randomized Group Design or Factorial RAKL.

Data on the preliminary mathematical knowledge scores of students (high and low) based on the PBL model class and conventional models are presented in the following table:

Table 3: Scores of early mathematical knowledge of students

Early Mathematics Knowledge (B)	Learning Model (A)	
	PBL (A ₁)	Conventional (A ₂)
High (B ₁)	76	76
	72	76
	72	72
	68	72
	68	72
	68	68
	68	68
	64	64
Low (B ₂)	32	40
	28	40
	24	40
	24	32
	24	28
	20	28
	16	25
	16	16

Learning outcomes data on the application of learning models and initial knowledge of mathematics and standardized residuals (RT) are as follows.

Table 4: Learning outcomes by class and early knowledge

		Learning Model			
		PBL		Conventional	
		Score	RT	Score	RT
Early Mathematics Knowledge	High	90	1.03	90	1.73
		90	1.03	72	-1.24
		86	0.37	84	0.74
		76	-1.28	90	1.73
		82	-0.29	70	-1.57
		80	-0.62	76	-0.58
		84	0.04	74	-0.91
		82	-0.29	80	0.08
	Average	83.75		79.5	

	Low	86	0.66	56	-0.74
		80	-0.33	60	-0.08
		76	-0.99	54	-1.07
		84	0.33	54	-1.07
		78	-0.66	72	1.89
		78	-0.66	60	-0.08
		86	0.66	60	-0.08
		88	0.99	68	1.24
	Average	82		60.5	

Based on the data above, the researcher estimates that there are 2 factors that have a big influence on student learning outcomes, namely the initial knowledge of mathematics and the learning model used. Researchers limit the types of students' initial mathematical knowledge in 2 levels, namely high and low. Researchers know that applying the right learning model can optimize student learning outcomes. To optimize it the researchers used 2 types of learning models, namely the Problem Based Learning (PBL) model and the conventional model. In this experiment, researchers tested 8 students in each combination of initial mathematical knowledge and learning models.

Before testing the hypothesis using the two-way Anava test, the Normality Test and the Variance Homogeneity Test are performed. The data used are standardized residual/residual data of learning outcomes from both classes. The standardized residual data was obtained with the help of the SPSS version 25.0 statistical special calculation program. Analysis of the standardized residuals of the learning outcomes of the two classes was carried out to determine the normality and uniformity of the data.

1. Prerequisite test

a. Normality test

Normality test is used to find out whether data is normally distributed or not. This normality test uses a special statistical calculation program SPSS version 25.0. The criteria used are normally distributed data if the significant value ≥ 0.05 . The results of the normality test can be seen in the following table.

Table 5: Normal residual value normality test results

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual for Learning Outcomes	0.103	32	0.200	0.959	32	0.265

Based on the table above, the significance of the standard residual value of mathematics learning outcomes is $0.265 > \alpha = 0.05$. It can be concluded that the data obtained are normally distributed.

b. Homogeneity test

Homogeneity test is used to find out whether the two groups in homogeneous research or not. As for testing using the SPSS program. Homogeneity criteria are said to be homogeneous if sig. $> \alpha = 0.05$ and not homogeneous if sig. $< \alpha = 0.05$.

Table 6: Results of variant homogeneity tests

Levene Statistic	df1	df2	Sig.
1.267	3	28	0.305

From the results of the analysis in the above table, found Levene Statistics = 1.267, df1 = 3, df2 = 28 and significant value = $0.305 > 0.05 = \alpha$. Thus, the data of student mathematics learning outcomes are homogeneous.

c. Hypothesis testing

From the results of data collection obtained mathematics learning outcomes for each sample group as the following table.

Table 7: Mathematics Learning Outcomes Data for Each Study Sample Group

Early Mathematics Knowledge (B)	Learning Model (A)		Total	Average
	PBL (A1)	Conventional (A2)		
High (B1)	90	90	1306	81.625
	90	72		
	86	84		
	76	90		
	82	70		
	80	76		

	84	74		
	82	80		
Low (B2)	86	56	1140	71.25
	80	60		
	76	54		
	84	54		
	78	72		
	78	60		
	86	60		
88	68			
Total	1326	1120		
Average	82.9	70		

The descriptive statistical measures needed for the two line Anava for each group are presented in the following table.

Table 8: Two line Anava helper table

B	A		ΣB
	A1	A2	
B1	$n_{11} = 8$	$n_{12} = 8$	$n_{10} = 16$
	$\bar{Y}_{11} = 83.75$	$\bar{Y}_{12} = 79.5$	$\bar{Y}_{10} = 81.625$
	$\Sigma Y_{11} = 670$	$\Sigma Y_{12} = 636$	$\Sigma Y_{10} = 1306$
	$\Sigma Y^2_{11} = 56276$	$\Sigma Y^2_{12} = 50992$	$\Sigma Y^2_{10} = 107268$
B2	$n_{21} = 8$	$n_{22} = 8$	$n_{20} = 16$
	$\bar{Y}_{21} = 82$	$\bar{Y}_{22} = 60.5$	$\bar{Y}_{20} = 71.25$
	$\Sigma Y_{21} = 656$	$\Sigma Y_{22} = 484$	$\Sigma Y_{20} = 1140$
	$\Sigma Y^2_{21} = 53936$	$\Sigma Y^2_{22} = 29576$	$\Sigma Y^2_{20} = 83512$
ΣK	$n_{01} = 16$	$n_{02} = 16$	$n_{00} = 32$
	$\bar{Y}_{01} = 82.875$	$\bar{Y}_{02} = 60.5$	$\bar{Y}_{00} = 76.4375$
	$\Sigma Y_{01} = 1326$	$\Sigma Y_{02} = 484$	$\Sigma Y_{00} = 2446$
	$\Sigma Y^2_{01} = 110212$	$\Sigma Y^2_{02} = 80568$	$\Sigma Y^2_{00} = 190780$

a. Calculates the Number of Squares for each variant source

1. Total Number of Squares (JK_T)

$$JK_T = \sum Y_{00}^2 = 190780$$

2. Average Number of Squares (JK_R)

$$JK_R = \frac{(\Sigma Y_{00})^2}{n_{00}} = \frac{(2446)^2}{32} = 186966.125$$

3. Total Squares in Reduction (JK_{TR})

$$JK_{TR} = JK_T - JK_R$$

$$= 190780 - 186966 = 3813.88$$

4. Number of Squares Between Groups (JK_A)

$$JK_A = \left[\frac{(\Sigma Y_{11})^2}{n_{11}} + \frac{(\Sigma Y_{12})^2}{n_{12}} \right] + \left[\frac{(\Sigma Y_{21})^2}{n_{21}} + \frac{(\Sigma Y_{22})^2}{n_{22}} \right] - JK_R$$

$$= \left[\frac{(670)^2}{8} + \frac{(636)^2}{8} \right] + \left[\frac{(656)^2}{8} + \frac{(484)^2}{8} \right] - 186966$$

$$= 2782.38$$

5. Number of Squares Between Columns (JK_{Ak})

$$\begin{aligned}
 JK_{Ak} &= \left[\frac{(\sum Y_{01})^2}{n_{01}} + \frac{(\sum Y_{02})^2}{n_{02}} \right] - JK_R \\
 &= \left[\frac{(1386)^2}{16} + \frac{(1120)^2}{16} \right] - 186966 \\
 &= 1326.13
 \end{aligned}$$

6. Number of Squares Between Lines (JK_{Ab})

$$\begin{aligned}
 JK_{Ab} &= \left[\frac{(\sum Y_{10})^2}{n_{10}} + \frac{(\sum Y_{20})^2}{n_{20}} \right] - JK_R \\
 &= \left[\frac{(1306)^2}{16} + \frac{(1140)^2}{16} \right] - 186966 \\
 &= 861.125
 \end{aligned}$$

7. Number of Interaction Squares (JK_I)

$$\begin{aligned}
 JK_I &= JK_A - JK_{Ak} - JK_{Ab} \\
 &= 2782.38 - 1326.13 - 861.125 \\
 &= 595.125
 \end{aligned}$$

8. Number of Squares in the Group (JK_D)

$$\begin{aligned}
 JK_D &= JK_{TR} - JK_A \\
 &= 3813.88 - 2782.38 = 1031.5
 \end{aligned}$$

b. Calculates the free degrees (db) of each variant source

1. $db_T = n_{00} = n_T = 32$
2. $db_R = 1$
3. $db_{TR} = n_T - 1 = 31$
4. $db_A = (b \times k) - 1 = 2 \times 2 - 1 = 3$
5. $db_{Ak} = k - 1 = 2 - 1 = 1$
6. $db_{Ab} = b - 1 = 2 - 1 = 1$
7. $db_I = (b - 1)(k - 1) = 1$
8. $db_D = n_T - (b \times k) = 32 - (2 \times 2) = 28$

c. Calculates the Average Number of Squares (RJK) for a variant (s^2) for the required variant source

1. RJK or average/correction variant

$$\begin{aligned}
 s_R^2 &= RJK_R = \frac{JK_R}{db_R} \\
 &= \frac{186966.125}{1} = 186966.125
 \end{aligned}$$

2. RJK or the total variant in Reduction

$$\begin{aligned}
 s_{TR}^2 &= RJK_{TR} = \frac{JK_{TR}}{db_{TR}} \\
 &= \frac{3813.875}{31} = 123.03
 \end{aligned}$$

3. RJK or intergroup variant

$$s_A^2 = RJK_A = \frac{JK_A}{db_A} = \frac{2782.38}{3} = 927.46$$

4. RJK or Inter Column variant

$$s_{Ak}^2 = RJK_{Ak} = \frac{JK_{Ak}}{db_{Ak}} = \frac{1326.125}{1} = 1326.125$$

5. RJK or Line Variant

$$s_{Ab}^2 = RJK_{Ab} = \frac{JK_{Ab}}{db_{Ab}} = \frac{861.125}{1} = 861.125$$

6. RJK or Interaction variant

$$s_I^2 = RJK_I = \frac{JK_I}{db_I} = \frac{595.125}{1} = 595.125$$

7. RJK or In-Group variants

$$s_D^2 = RJK_D = \frac{JK_D}{db_D} = \frac{1031.5}{28} = 36.84$$

d. Calculates the price of F_{count} (F_h) for the required variant source1. F_{count} Between Columns

$$Fh_{Ak} = \frac{RJK_{Ak}}{RJK_D} = \frac{1326.125}{36.84} = 36$$

2. F_{count} Between lines

$$Fh_{Ab} = \frac{RJK_{Ab}}{RJK_D} = \frac{861.125}{36.84} = 23.375$$

3. F_{count} Interaction

$$Fh_I = \frac{RJK_I}{RJK_D} = \frac{595.125}{36.84} = 16.1546$$

4. F_{count} Between groups

$$Fh_A = \frac{RJK_A}{RJK_D} = \frac{927.46}{36.84} = 25.176$$

e. Prices for JK, db, RJK, F_h , plus F_t in the anava two-line summary table

This is to facilitate the interpretation or testing of hypotheses. The following is a summary table of the two-way Anava.

Table 9: Summary of two way anava

Source of Variance	db	JK	RJK	F_h	F_t
Inter Column (Ak)	1	1326.125	1326.125	36	4.20
Between Lines (Ab)	1	861.125	861.125	23.4	4.20
Interaction (I)	1	595.125	595.125	16.15	4.20
Intergroup (A)	3	2782.375	927.46	25.176	2.95
In Groups (D)	28	1031.5	36.84		
Total in Reduction (TR)	31	3813.875	123.03		
Average/Correction (R)	1	186966.12	186966.12		
Total (T)	32	190780			

Hypothesis testing

The research hypothesis was tested with the Anava technique (Supardi, 2011) [8]

1. Hypothesis 1: [Main effect 1]

Effect of Learning Model (A) on Mathematics Learning Outcomes (Y)

Hypothesis tested:

$$H_0: \mu_{01} = \mu_{02}$$

$$H_1: \mu_{01} \neq \mu_{02}$$

Testing

From the Inter-Column (Ak) summary table of Anava Dua Path, the price of $F_h = 36 > 4.20 = F_t$ is then H_0 is rejected and H_1 is accepted, so it can be concluded that there are significant differences in the average mathematics learning outcomes between students who are given PBL model treatment and conventional model. This shows that there is a significant influence of the learning model on student mathematics learning outcomes. Average learning outcomes of each learning model, found 82.9 for PBL models and 70 for conventional models. Thus we can assume the application of the PBL model is better than the Conventional model. PBL models condition students to develop problem-solving skills and find solutions to given problems (Setiawan, 2014) ^[4]. This optimizes students' dynamic thinking skills compared to passive remembering and understanding. Which has an impact on student achievement / learning outcomes (Argaw, 2016) ^[9]. The other side of the conventional learning model brings students to get information quickly (Wardita, 2010) ^[10], which empowers students' ability to remember and understand those that are passive.

2. Hypothesis 2: [Main effect 2]

Effect of Early Mathematical Knowledge (B) on Learning Outcomes of Mathematics (Y)

Hypothesis tested

$$H_0: \mu_{10} = \mu_{20}$$

$$H_1: \mu_{10} \neq \mu_{20}$$

Testing

From the Inter-row (Ab) row of the Anava Dua Path summary table, the price of $F_h = 23.4 > 4.20 = F_t$ is then H_0 is rejected and H_1 is accepted, so it can be concluded that there are significant differences in the average mathematics learning outcomes between students who have initial knowledge high mathematics and students who have initial knowledge of mathematics. This shows that there is a significant influence of the initial knowledge of mathematics on student mathematics learning outcomes.

Average learning outcomes of each initial knowledge found 81,625 for high initial knowledge and 71.25 for low initial knowledge. Thus we can assume the initial knowledge of mathematics is directly proportional to student mathematics learning outcomes. Hamzah B. Uno (Santoso, 2009) ^[10] states that initial knowledge is very important in its role in increasing the meaningfulness of learning, which in turn has an impact in facilitating the internal processes that take place in students when learning. Students will have difficulty in gaining new knowledge when the ability/initial knowledge of misunderstanding occurs (Lazarowitz & Lieb, 2006) ^[1, 11].

3. Hypothesis 3: [Interaction effect]

The interaction of learning models (A) and initial mathematical knowledge (B) to mathematics learning outcomes (Y)

Hypothesis tested

$$H_0: A \times B = 0$$

$$H_1: A \times B \neq 0$$

Testing

Based on the Anava Two Path Summary table above from the Interaction row (I), the value of $F_h = 16.15 > 4.20 = F_t$ is then H_0 is rejected and H_1 is accepted, so it can be concluded that there is a significant interaction between learning models and mathematical initial knowledge of student learning outcomes in mathematics.

Student-centered learning models (PBL) make students learn how to construct their own knowledge (Trianto 2007), develop students' thinking abilities (take longer), where knowledge stays longer. Whereas the teacher-centered learning model (conventional) makes students quickly get information without training students' thinking skills ^[12]. On the other hand, initial knowledge influences the learning process and outcomes (Lazarowitz & Lieb, 2006) ^[1].

Simple effect testing

Because the number of data/samples in each treatment group is the same, even in the interaction interaction hypothesis test a significant interaction is obtained, so the simple effect test can be done using the Tukey test.

1. The hypothesis of differences in mathematics learning outcomes (Y) between the PBL (A1) and Conventional (A2) models specifically for the high mathematics initial knowledge group (B1).

H0: There is no difference in mathematics learning outcomes from students (Y) classes using PBL (A1) models and classes using Conventional models (A2) for students who have high initial mathematical knowledge (B1).

H1: There are differences in mathematics learning outcomes of students (Y) classes using PBL (A1) models and classes using Conventional models (A2) for students who have high prior knowledge of mathematics (B1).

Statistically

$$H_0: \mu_{11} = \mu_{12}$$

$$H_1: \mu_{11} \neq \mu_{12}$$

Test criteria

Reject H_0 (accept H_1), if $Q_h > Q_{table}$

Reject H_1 (accept H_0), if $Q_h < Q_{table}$

At $\alpha = 0.05$ $dbv_1 = 4$ and $dbv_2 = 8$ the price of $Q_t = 4.53$ is obtained

Price of Q_h namely

$$Q_h = \frac{|\bar{Y}_{11} - \bar{Y}_{12}|}{\sqrt{\frac{RJK_D}{n}}} = \frac{|83.75 - 79.5|}{\sqrt{\frac{36.84}{8}}}$$

$$= \frac{4.25}{2.146} = 1.98$$

Conclusion

Because $Q_h = 1.98 < 4.53 = Q_{table}$, H_0 is accepted. This shows that “There is no difference in mathematics learning outcomes of students (Y) classes that use the PBL (A1) model with classes that use Conventional models (A2) for students who have high prior knowledge of mathematics (B1)”.

The mean learning outcomes of each learning model for high initial knowledge were found to be 83.75 for the PBL model and 79.5 for the conventional learning model. According to Reuven Lazarowitz and Lieb (2006) ^[1] states students will have difficulty in gaining new knowledge when the ability/initial knowledge of misunderstanding occurs, so not if the initial knowledge is good ^[1]. It can be concluded that whatever model is used is not very influential when students have good initial knowledge of mathematics.

2. The hypothesis of the difference in mathematics learning outcomes (Y) between the PBL (A1) model and the Conventional model (A2) specifically for the low mathematics initial knowledge group (B2).

H₀: There is no difference in mathematics learning outcomes from students (Y) classes using PBL (A1) models and classes using Conventional models (A2) for students who have low initial mathematical knowledge (B2).

H₁: There are differences in mathematics learning outcomes of students (Y) classes using PBL (A1) models and classes using Conventional models (A2) for students who have low initial mathematical knowledge (B2).

Statistically

$H_0: \mu_{21} = \mu_{22}$

$H_1: \mu_{21} \neq \mu_{22}$

Test criteria

Reject H_0 (accept H_1), if $Q_h > Q_{table}$

Reject H_1 (accept H_0), if $Q_h < Q_{table}$

At $\alpha = 0.05$ $dbv_1 = 4$ and $dbv_2 = 8$ the price of $Q_t = 4.53$ is obtained

Price of Q_h namely

$$Q_h = \frac{|\bar{Y}_{21} - \bar{Y}_{22}|}{\sqrt{\frac{RJK_D}{n}}} = \frac{|82 - 60.5|}{\sqrt{\frac{36.84}{8}}}$$

$$= \frac{21.5}{2.146} = 10.02$$

Conclusion

Because $Q_h = 10.02 > 4.53 = Q_{table}$, H_0 is rejected. This shows that “There is no difference in mathematics learning outcomes of students (Y) classes using PBL (A1) models with classes using Conventional models (A2) for students who have low initial mathematical knowledge (B2)”.

The mean learning outcomes of each learning model for low initial knowledge were found to be 82 for the PBL learning model and 60.5 for the conventional learning model. According to Reuven Lazarowitz and Lieb (2006) ^[1] states students will have difficulty in gaining new knowledge when the ability/initial knowledge misunderstanding occurs ^[1].

3. The hypothesis of the difference in mathematics learning outcomes (Y) between high initial mathematics knowledge (B1) and low mathematical initial knowledge (B2) specifically for the PBL model group (A1).

H₀: There is no difference in mathematics learning outcomes (Y) students with high initial mathematical knowledge (B1) with students with low mathematical initial knowledge (B2) for students learning with the PBL (A1) model.

H₁: There is a difference in the results of learning mathematics (Y) students with high initial mathematics knowledge (B1) with students with low initial mathematical knowledge (B2) for students learning with the PBL (A1) model.

Statistically

$$H_0: \mu_{11} = \mu_{21}$$

$$H_1: \mu_{11} \neq \mu_{21}$$

Test criteria

Reject H_0 (accept H_1), if $Q_h > Q_{table}$

Reject H_1 (accept H_0), if $Q_h < Q_{table}$

At $\alpha = 0.05$ dbv1 = 4 and dbv2 = 8 the price of $Q_t = 4.53$ is obtained

Price of Q_h namely

$$Q_h = \frac{|\bar{Y}_{11} - \bar{Y}_{21}|}{\sqrt{\frac{RJK_D}{n}}} = \frac{|83.75 - 82|}{\sqrt{\frac{36.84}{8}}}$$

$$= \frac{1.75}{2.146} = 0.816$$

Conclusion

Because $Q_h = 0.816 < 4.53 = Q_{table}$, H_0 is accepted. This shows that “There is no difference in mathematics learning outcomes (Y) students with high initial mathematical knowledge (B1) with students with low mathematical initial knowledge (B2) for students learning with the PBL (A1) model”.

The mean learning outcomes of each of the initial knowledge of mathematics for the PBL learning model were found to be 83.75 for high initial knowledge and 82 for low initial knowledge. According to Arends (Setiawan, 2014) [4], PBL is a learning model by exposing students to authentic and interesting problems so students can compile their own knowledge, develop their problem solving skills and find solutions to problems that are given [4]. According to Oguz-Unver & Arabacioglu (Setiawan, 2014) [4], the main principle of PBL is to maximize learning by investigating, explaining, and solving contextual and meaningful problems. This can explain why this PBL model can encourage students to be active in the learning process that impacts on learning outcomes [4].

4. The hypothesis of the difference in mathematics learning outcomes (Y) between high initial mathematics knowledge (B1) and low mathematical initial knowledge (B2) specifically for the Conventional model group (A2).

H₀: There is no difference in the mathematics learning outcomes (Y) of students with high initial mathematics knowledge (B1) and students with low mathematical initial knowledge (B2) for students learning with the Conventional model (A2).

H₁: There is a difference in mathematics learning outcomes (Y) students with high initial mathematical knowledge (B1) and students with low mathematical initial knowledge (B2) for students learning with the Conventional model (A2).

Statistically

$$H_0: \mu_{12} = \mu_{22}$$

$$H_1: \mu_{12} \neq \mu_{22}$$

Test criteria

Reject H_0 (accept H_1), if $Q_h > Q_{table}$

Reject H_1 (accept H_0), if $Q_h < Q_{table}$

At $\alpha = 0.05$ dbv1 = 4 and dbv2 = 8 the price of $Q_t = 4.53$ is obtained

Price of Q_h namely

$$Q_h = \frac{|\bar{Y}_{12} - \bar{Y}_{22}|}{\sqrt{\frac{RJK_D}{n}}} = \frac{|79.5 - 60.5|}{\sqrt{\frac{36.84}{8}}} = \frac{19}{2.146} = 8.85$$

Conclusion

Because $Q_h = 8.85 > 4.53 = Q_{table}$, H_0 is rejected. This shows that “There is a difference in mathematics learning outcomes (Y) students with high initial mathematical knowledge (B1) with students with low initial mathematical knowledge (B2) for students learning with the Conventional model (A2)”.

The mean learning outcomes of each of the earliest mathematical knowledge for Conventional learning models found 79.5 for high initial knowledge and 60.5 for low initial knowledge. Wortham (Wardita, 2010) suggests

that conventional learning has characteristics, that is, not contextual, not challenging, passive, and the learning material is not discussed with the learner ^[10]. This could explain why the Conventional model is only a few active students, where students are inclined to be passive in the learning process that impacts on learning outcomes.

Overall the description and discussion of the above research results are relevant to the theory of Reuven Lazarowitz and Lieb (2006) ^[1] which states students will experience difficulties and when initial knowledge occurs misconceptions/errors that impact on learning outcomes ^[1]. On the other hand, the theory from Arends (Setiawan, 2014) ^[4] states that PBL is a learning model by exposing students to authentic and interesting problems so that students can compile their own knowledge, develop their problem solving skills and find solutions to given problems ^[4]. This optimizes students' dynamic thinking skills compared to passive remembering and understanding. This is what causes students' mathematics learning outcomes to be directly proportional to initial knowledge, where the PBL model is better treated than conventional models, especially for students who have low initial mathematical knowledge.

Conclusion

1. There is a significant effect of learning models of students who learn with PBL models and students who learn with Conventional models on learning outcomes in mathematics.
2. There is a significant influence of initial high mathematics knowledge and low mathematical knowledge on student mathematics learning outcomes.
3. There is an interaction between learning models and initial knowledge of mathematics on student mathematics learning outcomes.
4. There is no significant difference in learning outcomes between students learning with the PBL model and students learning with the Conventional Model for students with high prior knowledge of mathematics.
5. There is a significant difference in learning outcomes between students learning with the PBL model and students learning with the Conventional model, for students who have low initial mathematical knowledge.
6. There is no significant difference in learning outcomes between students with high prior knowledge of mathematics and students with low initial knowledge of mathematics in learning with PBL models.
7. There are significant differences in learning outcomes between students with high prior knowledge of mathematics and students with low initial knowledge of mathematics in learning with Conventional models.

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