Journal of Physics: Conference Series

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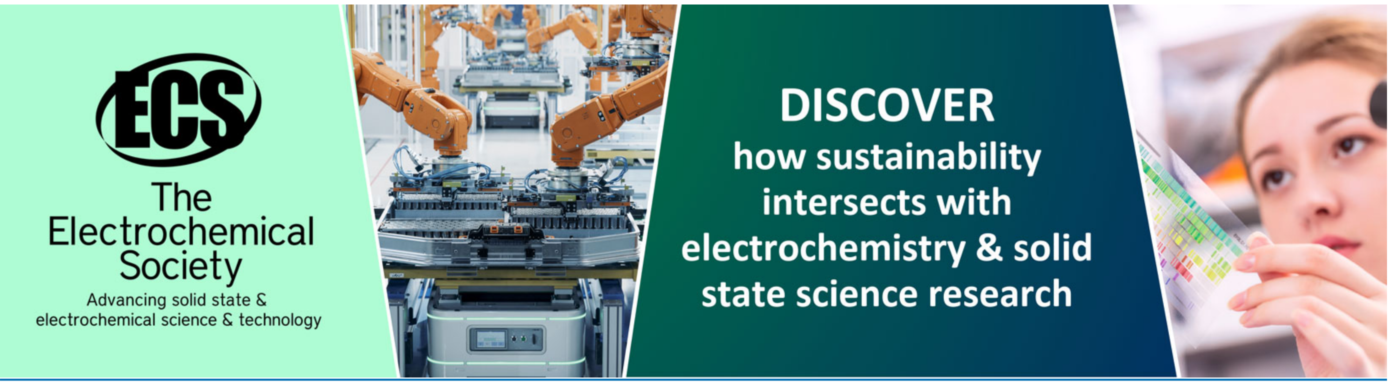

IOP Conf. Series: Journal of Physics: Conf. Series **1317** (2019) 012113 doi:10.1088/1742-6596/1317/1/012113

The impact of problem-based learning model and visual-spatial intelligence to geometry achievement of junior-high-school students

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Abstract. The aim of this study was to determine the effect of problem-based learning model and visual-spatial intelligence in developing student's geometry achievement. This study used non-equivalent control group design and the sample collection technique was purposive sampling. The populations were students of class VIII SMP 7 Padang in the school year of 2017/2018 involving 32 students of class VIII.2 as an experimental class and 32 students of class VIII.1 as the control class. The instrument used in this study was test of visual-spatial intelligence and geometry achievement. The data were analyzed quantitatively by using independent samples two path analysis of variance. Based on the data analysis, it was found that: (i) the geometry learning outcomes of students learning with PBL model was higher that those learning with DL model; (2) geometry learning outcomes of students having high spatial-visual intelligence were higher than students having low spatial-visual intelligence; (iii) there was interaction between the application of PBL model and spatial-visual intelligence; (4) students having high spatial-visual intelligence got higher geometry learning outcomes after learning with PBL model compared with that after learning with DL model.

1. Introduction

The enhancement of learning outcome in mathematics, especially in learning geometry, needs a serious attention because geometry occupies a special position in mathematics curriculum. Geometry contains many mathematical concepts, which are important to be learned by students not just for the school's needs but also for their daily life. Board of Studies, New South Wales says that "the goals of geometry learning are to develop thinking abilities as a foundation for the real world, and to convey the knowledge needed in geometry and to teach how to read and interpret mathematical arguments. In the secondary school, geometry in the mathematical curriculum involves recognizing and naming geometrical shapes, using the symbolism for geometrical concepts, developing skills with measurement and construction tools (ie compass, ruler and protractor), and using formulae in the measurement" [5]

Despite the the importance of geometry, the fact in schools is that many students in primary level (junior-high-school students), such as student in SMP (junior high school) 7 Padang, have low spatial-visual intelligence. The students have less understanding in solving geometry problems because the abstractness level in geometry object is high and they lack of ability to visualize abstract objects or see the object in mind. This ability is one element of visual abilities that must be owned by students [1].

Therefore, Nova Riastuti suggested that mathematics teachers are expected to provide more questions for practicing that reinforce students' geometry skills including visual skills, descriptive skills, drawing skills, logical skills, applied skills [4].

Test of spatial-visual intelligence is intended to test the extent to which the ability to visualize something, introduce objects and make it and think abstractly through objects or symbols [9]. The results of test spatial visual ability according to Richard M. Onyancha is that the training is produced in all spatial abilities test scores of students and these improvements occur across all geometry objects and rotation types [10] . Based on these two opinions, it can be concluded that the test of visual-spatial intelligence examines visual patterns, such as: points, lines, fields, and objects of space and their properties, their sizes and relationships with others. While having the ability to appropriately capture the world of space, and connect mathematics with the physical world or the real world are characteristics of students who have visual-spatial intelligence.

As spatial-visual intelegence is crucial, the teacher must give students the opportunity to develop thinking processes corresponding with spatial-visual ability. Exploring students' ideas could be done by applying problem-based learning (PBL), which is expected to help students to understand mathematics materials so that they become more interested in mathematics. In addition, it is also hoped that this model can improve the results of student's learning. Futhermore, PBL model is expected to overcome the problems that occur in SMP 7 Padang as mentioned before. This expectation could be obvious because some studies confirm that learning mathematics by using problem-based learning model have a significant influence on the ability to think critically [2], which later could increase the results of learning. Besides, "PBL assisted mathematics pop up book is effective against the spatial abilities in grade VIII on the geometry material" [3].

Suprijono also mentions that, "problem-based learning involves the presentation of authentic and meaningful situations that serve as a basis for investigation by students" [6] . Furthermore Padmavathy in his research states that: [7]

The major study reveals PBL method of teaching is more effective for teaching mathematics. By adopting PBL method in teaching mathematics teacher can create a number of creative thinkers, critical decision makers, problem solvers which is very much needed for the competitive world. And also problem based learning instructional strategy which has students' active participation, motivation and interest among the learners. This leads the learners to have a positive attitude towards mathematics and help them to increase their achievement to a large extent and which will lead to long term memory. It gave a kind of experience for the students.

The saying by Padmavathy shows the needs of using an effective PBL in learning mathematics because this model is an example used by experts in preparing the steps in carrying out learning [8]**.**

Based some explanations above, this study focuses on the use of PBL model and visual-spatial intelligence, which raises 4 research questions, namely:

Are there differences on geometry learning outcomes, between students who receive learning with PBL models and students who study with the DL model?

Are there difference on geometry learning outcomes between students having high spatial-visual intelligence and students having low spatial-visual intelligence?

Is there interaction between the treatments given and spatial-visual inteeligence on geometry learning outcomes.

Is there difference on geometry learning outcomes between students having high spatial-visual intellignce and were taught by PBL model and those were taught by DL model

2. Research Methods

This research was a quasi-experimental research because the treatments were given to the sample of the research in order to further know the effect of the treatments. The treatments were learning with PBL (problem-based learning) model in the experimental class and learning with the DL (discovery learning) model in the control class. The research design used was the non-equivalent posttest-only control group design combined with 2×2 design, namely: two groups of students (a. Students having high spatial-visual intelligence; b. Students having low spatial-visual intelligence) and two learning models (PBL model and DL model). The matrix of the research design was shown by Table.

Table 1. Design matrix of the treatments (Spatial-Visual Intelligence vs PBL model and DL model)

Spatial Visual Intelligence (A)	Model Learning (B)	
	PBL ($\boldsymbol{B_1}$)	DL ($\boldsymbol{B_2}$)
High (($\boldsymbol{A_1}$))	$\boldsymbol{A_1B_1}$	$\boldsymbol{A_1B_2}$
Low (($\boldsymbol{A_2}$))	$\boldsymbol{A_2B_1}$	$\boldsymbol{A_2B_2}$

The populations were students of class VIII SMP 7 Padang in the school year of 2017/2018. The research sample involved 32 students of class VIII.2 as an experimental class and 32 students of class VIII.1 as the control class. The data was obtained by using a test to measure the results of geometry learning after applying the treatments in the teaching and learning processes. The technique of data analysis used in this research was ANAVA two pathways that aimed to test the truth of the proposed hypotheses. Before testing the hypotheses, the normality and homogeneity testing of the data were carried out.

3. Results and Discussion

Testing the hypothesis in this study was carried out using two-ways-variance analysis. It was obtained two main effects between columns as treatment variables and the main influence between lines as attribute variables (simple effect), as well as interaction (interaction effect) between columns and rows or between PBL as independent variables and students' spatial-visual intelligence (geometry learning outcomes) as the dependent variable. The results of hypotheses testing can be summarized in table 2.

Table 2 . Two-paths-ANAVA table of data of geometry learning outcomes

Source of Variance	JK	db	RJK	F_{count}	F_{table}		Description
					α = 0.05	α = 0.01	
Learning model	271.43	1	271.43	6.38	4.08	6.96	Sig
Spatial Visual Intelligence	2.23	1	2.23	0.05	4.08	6.96	Sig
Inter AB	743.02	1	743.02	17.47	4.08	6.96	Sig
Inner error	1360.66	32	42.52	-	-	-	
Total	2377.33	35		-	-	-	

As there was an interaction and the main influence between PBL models and spatial-visual intelligence in variance analysis was so significant, then next testing, namely Tukey testing, was done among the pairs of data in order to determine the data average on which group was highest among two-paired data groups.

Table 3. Results of Tukey testing between group of data

Group	N	Q_{count}	Q_{table}		Conclusion
			α = 0.05	α = 0.01	
$A_1 - A_2$	36	7.72	3.86	2.88	Very significant
$B_1 - B_2$	36	0.70	3.86	2.88	Very significant
$A_1B_1 - A_2B_1$	18	14.49	4.07	2.97	Very significant
$A_1B_2 - A_2B_2$	18	3.57	4.07	2.97	Significant

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The results of testing done in Table 2 and Table 3 will be described as following.

3.1. The Difference of geometry learning outcomes between students learning with PBL model and those learning with DL model

From table 2, it can be seen that the value of F_{count} = 6,38 > $T_{Table\ (\alpha = 0,01;1/36)}$ = 4.08. This meant that H_o was rejected and H_1 was accepted. Therefore, the hypotesis stating that there was difference on geometry learning outcomes between students learning with PBL model and those learning with DL model was evidently significant. The geometry learning outcomes of students learning with PBL model was higher that those learning with DL model.

In order to see the difference in applying the treatments, which learning model produced higher geometry learning outcomes, Tukey testing was done. From table 3 (second line, third and fourth column), it can be seen that the value of Q_{count} = 7,72 > $Q_{table\ (\alpha = 0,01;\ 36)}$ = 3,86, which meant that there was a significant difference on geometry learning outcomes between students were taught by PBL model and those were taught by DL model. Additionally, geometry learning outcomes of students learning with PBL model were higher than those learning with DL model.

3.2. The difference on geometry learning outcomes between students having high spatial-visual intelligence and students having low spatial-visual intelligence.

To see the difference on geometry learning outcomes between students having high spatial-visual intelligence and students having low spatial-visual intelligence Tukey testing was done. From table 3 (third line, third and fourth column), it can be seen that the value of Q_{count} = 0,70 > $Q_{table\ (\alpha = 0,05;36)}$ = 3.86, which meant that there was a significant difference on geometry learning outcomes got by students students having high spatial-visual intelligence and students having low spatial-visual intelligence. Additionally, geometry learning outcomes of students having high spatial-visual intelligence were higher than students having low spatial-visual intelligence.

3.3. Interaction between the treatments given and spatial-visual intelligence on geometry learning outcomes.

From Table 2 (fourth line, fifth and sixth column), the results of calculation to check the interaction revealed that the value of F_{count} = 17.47 > $F_{table\ (\alpha = 0,01;1/18)}$ = 4.08. This meant that H_o was rejected and H_1 was accepted. Therefore, hypothesis stating that there was interaction between the application of PBL model and spatial-visual intelligence was evidently significant.

3.4. The difference on geometry learning outcomes between students having high spatial-visual intelligence and were taught by PBL model and those were taught by DL model.

From the result of Tukey testing, the average score of geometry learning outcomes got by students having high spatial-visual intelligence and were taught by PBL model got the average core was 84,38, while students having low spatial-visual intelligence and were taught by DL model got the average score of 78,88. Besides, the average square (RJK(D)) on two-path-ANAVA testing was 16.03. Next, from the Tukey testing, it was obtained the value of Q_{count} = 4.07 > $Q_{table\ (\alpha = 0,05;36)}$ = 2.97. Therefore, H_o was rejected and H_1 was accepted, which meant there was a significant difference on geometry learning outcomes got by students having high spatial-visual intelligence after being treated by both models. Students having high spatial-visual intelligence got higher geometry learning outcomes after learning with PBL model compared with that after learning with DL model.

4. Conclusion

Based on the explanation of hypothesis testing, this study formulated conclusions as followings: (i) the geometry learning outcomes of students learning with PBL model was higher than those learning with DL model; (2) geometry learning outcomes of students having high spatial-visual intelligence were higher than students having low spatial-visual intelligence; (iii) there was interaction between the application of PBL model and spatial-visual intelligence; (4) students having high spatial-visual

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intelligence got higher geometry learning outcomes after learning with PBL model compared with that after learning with DL model.

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