JPI, Vol 7 No 2 Oktober 2018
ISSN: 2541-7207 DOI: 10.23887/jpi-undiksha.v7i2.11682

The Application of Inquiry-Based Learning to Improve Students' Spatial Capability in SMA YPK Medan

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Abstract

This study stems from the writer's anxiety about the low ability of spatial students in SMA YPK Medan. The low spatial ability was caused by the ineffectiveness of the learning applied by the teacher. The purpose of this study was to describe the data of students' spatial ability improvement as a result of the application of the inquiry learning model. This research was a quasi-experimental research with a design used was a pretest-posttest control group design. The sample of this research were 69 students of SMA YPK Medan. Data to be collected in this research was the data of students' spatial ability. The instrument used to collect the data was a spatial ability test. The data were collected then analyzed by using one-way ANOVA in SPSS program. From result of SPSS obtained data Fcount> Ftable, that is 8,945 > 3,973 and Sig. < $\propto$, that is 0,04 < 0,05. Based on the results of data analysis could be concluded that the improvement of the spatial ability of students who received inquiry learning was higher than the improvement of spatial ability that gets regular learning.

Keywords: *Inquiry; Spatial; Improvement*

1. Introduction

NCTM (2000) stated that there are 5 content standards in mathematics learning, number operations, measurement, geometry, algebra, data analysis, and opportunities. Through content standards, some mathematical abilities will be developed. One of the abilities demanded in mathematics learning is spatial ability. This ability is obtained by students through geometry material. Even though, the spatial ability is one of seven bits of intelligence possessed by humans (Gardner, 1989).

According to Piaget and Inhelder (Marliah, 2006), the spatial ability is an ability to observe the relationship of the position of objects in space, the ability to see objects from various points of view, the ability to estimate distances between two points and other abilities related to building space. This understanding by Piaget and Inhelder confirms that spatial ability is the ability to think about the nature and problems of building space.

This spatial ability is not only an ability that should be mastered by High School students to understand the concept of building space but also spatial ability indirectly affects the overall mathematics learning outcomes. This was also confirmed by Hanafin, Truxaw, Jenifer, and Yingjie (Indriyani, 2013) that spatial ability also influences the mathematical abilities of high school students. Likewise stated by Shermann (Marliah, 2006) that he found a positive relationship in the form of mutually reinforcing relationships and the mutually debilitating relationship between the spatial and mathematical ability of a high school student.

From some results of these studies, there is a relationship between the spatial ability of high school students with the general mathematical ability. If the spatial ability of high school students significantly increases, hence the mathematical ability will also increase. This confirms that spatial ability is an ability that has an important role.

In the national curriculum, high school students are required to be able to master space geometry material (Syahputra, 2013). While learning it requires good spatial ability. It means high school students are required to have good spatial ability to understand space geometry material.

Maier (1998) divided spatial ability into five aspects. Spatial perception is the ability to recognize that the size and shape of the subject remain even though the stimulus is different based on what we feel from that perspective. Visualization is the ability to imagine a change in shape from a particular object or a change in the arrangement of part of an object. Mental

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rotation is the ability to think quickly and precisely about the rotation of a 2-dimensional or 3-dimensional object. Spatial relation is the ability to comprehend the shape of an object or part of an object and the relationship between parts of the object. Spatial orientation is the ability to recognize the arrangement or shape of an object in certain perspectives and situations. From five aspects found by Maier (1998), then an indicator of spatial ability can be designed in Table 1.

Tabel 1. Aspect and Indicators of Spatial Ability

Spatial Aspects	Description	Indicator
Spatial perception	The ability to recognize that the size and shape of the object remains even though the stimulus is different based on what we feel from that perspective	Can state the actual shape or size of a three-dimensional view based on a particular perspective
Visualization	The ability to imagine a change in shape from an object or change in the arrangement of parts of an object	Can state the actual condition (shape) of a change in the composition or part of a particular object
Mental Rotation	An ability to think quickly and precisely about rotation on 2-dimensional or 3-dimensional objects	Can state the shape or position of building space as a result of the rotation
Spatial Relation	The ability to understand the shape object or part of the object and the relationship between parts of the object	Can express the relationship of elements in dimension 3 (relationship of lines, fields, and points)
Spatial orientation	The ability to recognize the arrangement or shape of an object in certain perspectives and situations	Can express the shape of an object when viewed from various perspectives and certain situations

In daily life, the spatial ability also has an important role. It refers to Barke and Engida's (2001) opinion who argued that spatial ability not only plays an important role in the success of mathematics and other lessons, but also spatial ability is very influential on various types of professions. In the National Academy of Science (Syahputra, 2013) stated that many fields of science that require spatial ability in the application of science include astronomy, education, geography, geosciences, and psychology. Nemeth (2007) in his research found the importance of spatial ability in engineering and mathematics, especially geometry.

Some facts state that spatial ability is one of the most important mathematical abilities in life. Of course, high school students are expected to have the good spatial ability so that they can be used in carrying out their life activities. However, in reality, the spatial ability of high school students is still relatively low. This is evidenced by the result of a trial test of spatial ability for YPK Medan high school students. From the result of students' answers, it was found that there were only 39.5% of students who could solve this problem correctly, 60.5% of other students answered incorrectly.

The inability of the student to comprehend the concept of building space material is caused by a lack of student involvement in the learning process. This was found from the result of interviews with YPK Medan high school mathematics teachers that students were not much involved in constructing their knowledge, students received more of what the teacher said. The material given by the teacher is only memorizing formulas or memorizing algorithms for students, without knowing where the formula is obtained and what the meaning of the sequence of algorithms is doing. It means the learning process that occurs has not maximized the ability of students to construct knowledge.

Whereas according to the 2013 curriculum (Appendix Permendikbud No. 65, 2013) learning is not telling students, but students find out about things to learn. In the process of students finding out, the teacher applies the scientific approach in an interactive group learning where the students observe, ask their friends, collect the data needed, make connections between the information they get, and communicate the result they get to other students.

For that, learning that requires students to inspect, investigate, and finally find their mathematical concept is needed. Through this process, students can interpret each step they do, so students can find out the origin of the formula that will be used or the meaning of the order of algorithm that is implemented (Nurhadi, 2004). Saragih (2011) also states that the learning process should be carried out in a small group which will be a facility for students to express their ideas or find solutions to problems encountered during the learning process. The learning meant is inquiry-based learning.

According to Beyer (1979), inquiry-based learning is learning that involves the process of creating, evaluating the learning experiences that require students to go through a certain process and then they will build or use the related knowledge to solve a particular problem. It explains that inquiry-based learning is learning that optimize students' ability to find and discover the answer by themselves of a problem or something that is questioned.

There are six syntaxes of inquiry-based learning according to Eggen and Kauchak (Trianto, 2009). Those are, (1) presenting questions or problems, at this phase teacher guides students to identify the problem and ask students to work in the group. (2) creating hypotheses, where the teacher provides an opportunity for students to give opinions in the form of hypotheses, the teacher guides students to find relevant hypotheses. (3) designing experiment, at this phase teacher, provides an opportunity for students to determine the steps based on the hypotheses that have been formed. (4) conducting experiments, the teacher guides the students to get information through the experiment. (5) collecting and analyzing data, the teacher provides opportunities for each group to convey the result of data collection. (6) creating a conclusion, where the teacher guides students in concluding.

Inquiry-based learning requires students to find their concepts and algorithms. Through discovery activities, students will certainly understand the concepts and algorithms, so students know when the concept is used or how certain algorithms work. It certainly will affect increasing the spatial ability of students when understanding the three dimensions. Discussions that occur among students will also make students have a better understanding of spatial (Saragih, 2011).

In other words, inquiry-based learning is very influential in improving students' spatial ability. It is in line with the research conducted by Siswanto and Kusumah (2017) which states that the improvement of students' spatial ability who are taught by inquiry-based learning is better than students who are taught by conventional learning.

2. Method

This research was categorized into quasi-experimental research with pretest-posttest control group design as the study design (Emzir, 2010). The population involved entire students of X grade of SMA YPK Medan which amounts to 234 students, while the sample consists of 69 students divided into control class and experiment class.

The experiment class was the class that was taught by inquiry-based learning, while the control class was the class that did not get any treatment, and the learning process was going as usual. In this case, the researcher called it as ordinary learning. Russefendi (1999) stated that ordinary learning begins with lectures, students ask, then the teacher gives examples of questions about the material.

The data to be collected in this study were data on students' spatial ability. The process of data collection used spatial ability tests. In this research, the test was divided into pretest to identify spatial ability before the experiment was conducted and the posttest to identify spatial ability after the experiment was conducted.

The score obtained from the test result before and after being given inquiry-based learning treatment was analyzed by comparing it with the score obtained from the test result before and after being given the conventional learning treatment. The increasing amount before and after learning was calculated by normalized gain formula as follows:

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$$g = \frac{\text{posttest score} - \text{pretest score}}{\text{ideal score} - \text{pretest score}}$$

(Hake, 1998)

Furthermore, this gain data were tested for statistical requirements needed as a basis of hypotheses testing, including the normality of the data test and the variance homogeneity test. Next, an analysis of variance (ANOVA) was carried out to make a predetermined hypothesis.

3. Finding and Discussion

The initial calculation was to identify the average and standard deviation from the index gain of students' spatial ability. The result of these calculations was stated in the following table 2:

Tabel 2. Average and Standard Deviation of Gain Index Results of Spatial Ability Test in Experimental Class and Control Class

Group	Students	Average	Standard Deviation
Experiment Class	35	0,409	0,209
Control Class	34	0,271	0,170

Table 2 showed that the average gain index result of the spatial ability test in the experimental class was higher than the control class, which is 0.409 > 0.271. The average gain index results of the spatial ability test in the experimental class rather than the control class indicate that the increase in the spatial ability of students in the experimental class is higher than the increase in the spatial ability of students in the control class.

To conduct an ANOVA statistical test, the gain index of students' spatial ability must meet the test requirements for one-way ANOVA. The test conditions are normality and homogeneity.

The result of normality testing of the spatial ability test in the experimental class and control class used the Kolmogorov-Smirnov test through SPSS 16.00 were presented in table 3:

Tabel 3. Normality Testing of the Gain Index of Spatial Ability Test Result in Experimental Class and Control Class

Group	Students	T_{count}	T_{table}	*Asymp.Sig. (2-Tailed)*	$\propto$
Experiment Class	35	0,137	0,229	0,530	0,05
Control Class	34	0,156		0,378	

Based on table 3, it was found that in the experimental class at a significance level of 5% or $\propto$ = 0.05 with df of 35 obtained T_{table} of 0.229 while T_{count} was 0.137, it meant T_{count} < T_{table} and *Asymp.Sig.(2-Tailed)* > $\propto$ 0,530 > 0,05, so that H_0 was accepted and H_a was rejected. Likewise, in the control class, at the significance level of 5% or 0.05 with df of 34 obtained T_{table} of 0.229 while T_{count} was 0.156, it means T_{count} < T_{table} and *Asymp.Sig.(2-Tailed)* > $\propto$ 0,378 > 0,05, so that H_0 is accepted and H_a is rejected. From this normality testing, it was found that the data obtained from the gain index result from the test of the spatial ability of students in the experimental class and the control class with the normal distribution.

However, the result of homogeneity testing of spatial ability test using the Levene test through SPSS 16.00 are presented in table 4:

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Tabel 4. Homogeneity Test Gain Index Result of Spatial Ability Test in Experimental Class and Control Class

Group	Student	F_{count}	F_{table}	*Sig.*	∝
Experiment Class and Control Class	69	1,441	3,986	0,234	0,05

Based on table 4, it was found that at a significant level of 5% or ∝ = 0.05 with $df_{numerator}$ of 1 and $df_{denominator}$ of 66, obtained $F_{count} < F_{table}$, that was 1.441 < 3.986 and Sig. > ∝ , which was 0.234 > 0.05 so that the H0 was accepted and Ha was rejected. Thus, the variance of the test result of students' spatial ability tests in the experimental class and homogeneous control class.

Because the index data met the requirements for normality and homogeneity ANOVA test might be carried out. The result of the test data on students' spatial ability was:

Tabel 5. Result of One-way ANOVA test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.337[a]	1	337	8.945	.004
Intercept	8.284	1	8.284	219.580	.000
Model	.337	1	337	8.945	.004
Error	2.641	70	.038		
Total	11.476	72			
Corrected Total	2.978	71			

Based on table 5, it was found that at a significant level 5% or ∝ = 0.05 with $df_{numerator}$ of 1 and $df_{denominator}$ is 72, $F_{count} > F_{table}$ is 8.945 > 3.973 and Sig. < ∝, which is 0.04 < 0.05. so that H_0 was rejected and H_a was accepted. Thus, the improvement of students' spatial ability taught by inquiry-based learning was higher than the improvement of students' spatial ability who were taught by conventional learning.

Some of the results above showed that the average normalized gain score of students' spatial ability taught with inquiry-based learning was 0.409 higher than the average normalized gain score of students' spatial ability taught by conventional learning that was equal to 0.271. the data showed that the average increase of students' spatial ability taught by inquiry-based learning was higher than the average increase of students' spatial ability taught by conventional learning.

The average improvement of students' spatial ability in inquiry-based learning was caused by several things, one of them was the characteristic of inquiry-based learning. One of the characteristics was learning that required students to find out themselves and construct their knowledge using some information obtained or learning experience that have been obtained previously. Inquiry-based learning also maximized students thinking activities, discussion sessions, or students' work activities, so that they could accomplish the best learning achievement. Of course, a pack of learning activities would have implications for the development of spatial ability that students have.

Whereas, in the conventional learning process that was usually implemented by the teacher in school did not have special characteristics compared to inquiry-based learning. In conventional learning, the teacher was dominating the learning, where the teacher explained the material, then gave an example of the question and gave some exercises. When working on the exercise, students were only able to do exercises that resemble the example questions given by the teacher, but if the exercises which were given having different levels of difficulty, students could not answer the exercises. Things like this would cause constraints on the process of developing the spatial ability that students had.

Based on this case, it was certainly necessary to improve the learning process that the teacher normally did by using inquiry-based learning which was able to improve students' mathematical spatial ability. The teacher should use inquiry-based learning to improve students' spatial ability day by day. So that inquiry-based learning could be alternative learning to teach space geometry material.

The result of this research also in line with the research that was conducted by Eva (2012) which concludes that "there is a significant impact of inquiry-based learning on mathematics learning outcomes". Likewise, the research conducted by Kusumaningtyas (2016) stated that "the inquiry type of cooperative learning is effectively used in the circle subject matter". Some of these studies emphasized that inquiry-based learning has been shown to improve students' spatial ability.

4. Conclusion

Based on the result and discussion, the conclusion obtained were the students' spatial ability that was taught by inquiry-based learning was higher than the improvement of students' spatial ability that was taught by conventional learning.

The suggestion that could be used for the next research is the teacher should be more active in going around the class and giving admonition to students who do not take the learning process seriously. In addition, the teacher should give various questions to each group, then each group presents the questions in front of the class, so all group can understand the various forms of the questions.

For other research, it was expected to develop inquiry-based learning in other material, while for the next researcher to be able to examine the weaknesses of this learning and examined how the impact on other mathematical abilities.

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