

The Use of Geogebra Software in Learning Geometry Transformation to Improve Students' Mathematical Understanding Ability

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Abstract. This article reports the findings of one pretest-posttest design experiment with the control group and with GeoGebra software learning application to examine the mathematical understanding abilities and responses of students taking Geometry Transformation course. The subjects of this study were 24 students of mathematics education study program in Universitas Langlangbuana. The research instrument consisted of a mathematical comprehension ability test and a student response questionnaire. Based on data analysis using SPSS 2.0.0 and Microsoft Excel 2013, the study found that achievement and improvement in mathematical understanding skills and responses of students who received learning with GeoGebra software were better than achievement and improvement in student's ability who obtain conventional approach for the high, middle and low categories. The study also found a moderate relationship between mathematical understanding ability and student response.

1. Introduction

Geometry of transformation is a compulsory subject for students of mathematics education study program to be taken in the third semester. This subject is abstract so students need to learn more deeply for the concept of transformation geometry to be accepted, understood and comprehended. Mathematics is hierarchical or tiered, meaning that the concepts in the previous material will be the basis for further material. Transformation geometry is a very important subject because it is the basis of other elective courses in the following semester. If students experience difficulties in studying transformation geometry subject, students will find it increasingly difficult to study elective courses in the following semester. This will have an impact on high semester students who will take the Field Experience Practice (*Praktek Pengalaman Lapangan - PPL*). In addition, it also has an impact on graduates as prospective mathematics teachers who will later teach transformation geometry because the transformation geometry is available in the curriculum of Junior High School (SMP/MTs) and High School (SMA/SMK/MA.)



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In the subject of transformation geometry, the accuracy of the size and accuracy of the drawing area is very important. Differences in size can be a major problem, this is common when there is inappropriate use of instructional media or less-thorough use of the media so that it results in inaccuracies in the measurement data generated. From the existing problems, technological development can be used as an alternative problem solving. Through technology, it is created media that can change the learning of transformation geometry from abstract to concrete, from complex to simple so that it is easy to understand and support the quality learning.

The development of science and technology especially information and communication technology (ICT) can deliver the role and function of education to become more widespread and open. Thus the computer becomes important and potential to be widely used in the world of education (Munir, 2009). Information technology is developing so rapidly, thanks to the discovery of increasingly sophisticated means of communication by experts.

In line with the opinions of the experts, computers have now entered the world of education and are no longer a rare item, both at school and at the higher education level generally have computers. Even at the university level, each student normally has a mobile computer (laptop). Utilization of computers is widely used for the completion of administrative affairs as other offices in the field of non-education. Computers in the world of education should not be used as a typewriter. Computers are very potential for learning so they need to be widely used for learning. NCTM (National Council of Teachers of Mathematics) has principles regarding mathematics education, one of which is the technological principle as follows: "The NCTM Technology Principles: Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student's learning" [8].

NCTM clearly states that the use of technology is an important thing to support mathematics learning in this era. The use of technology will influence how mathematics should be taught and improve student learning outcomes. In line with NCTM, Arsyad [1] also stated that one of the functions of instructional media is as a teaching aid that is also influenced by the climate, conditions and learning environment that are arranged and created by someone, especially teachers in education. Computer technology has become one of the media that has great potential to be used as an interactive tool in the learning process.

GeoGebra is software developed for the benefit of the world of mathematics education. Judith and Markus Hohenwarter [3] explain that GeoGebra was developed by both of them for purely the interests of the world of mathematics education, not for sale. In the GeoGebra manual [4] explained as follows:

"GeoGebra provides three different views of mathematical objects: a Graphics View, a numeric Algebra View, and a Spreadsheet View. They allow you to display mathematical objects in three different representations : graphically (e. g., points, function graphs), algebraically (e. g., coordinates of points, equations), and in spreadsheet cells. Thereby, all representations of the same object are linked dynamically and adapt automatically to changes made to any of the representations, no matter how they were initially created".

In its use, GeoGebra can run on Windows, Mac OS X, and Linux family operating systems, it is quite easy to use because it can be run with basic commands such as scroll, zoom, delete, and can use hot keys like in Windows. By using this program, various mathematical problems can be solved in the form of arithmetic problems, algebra, trigonometry and calculus. By using GeoGebra, students will get better visualization to analyze various problems.

The Geogebra Provider facilitates the development of GeoGebra software add-on by providing services in various curricula and languages. On the site <http://www.GeoGebra.org/forum/> you can find many posts by math teachers from various countries. The contents of which are positive responses and suggestions from them after using GeoGebra in class. Unfortunately there are no posts or contributions from Indonesian teachers, so that Indonesia has not been included in the collection of GeoGebra development. This is an

indication that not many Indonesian teachers know and utilize GeoGebra. From such circumstances the authors are interested in conducting research on the use of GeoGebra.

To further direct the implementation of the research, the problems that will be examined in this study are formulated as follows: (1) Is the improvement of students' mathematical understanding abilities whose learning use GeoGebra software better than students' abilities whose learning use conventional learning in transformation geometry course?; (2) Are there differences in the improvement of students' mathematical understanding abilities that obtain learning using GeoGebra software with students who obtain conventional learning based on the KAM category (high, middle, low) in transformation geometry? (3) Is the increase in mathematical response of students whose learning use GeoGebra software better than students whose learning use conventional learning in transformation geometry course?; (4) Is there a correlation between mathematical understanding ability and mathematical response of students who have learned with GeoGebra software.

2. Research Method

This research is a quasi-experimental study because the subjects in this study were not randomly grouped, but the researchers accepted the research subject's condition as it is. The selection of this study is based on consideration that the research subjects have been grouped into classes that already existed and it is not possible to group students randomly. In this study, two classes were taken as samples, namely the experimental class which was given treatment in the form of learning using GeoGebra software and the control class using conventional learning. The design of this study uses the following non-equivalent control group design [6][9]:

Experimental Class : $\frac{O}{O} - \frac{X}{O} - \frac{O}{O}$
 Control Class : $\frac{O}{O} - \frac{O}{O} - \frac{O}{O}$

Notes:

O: pretest and posttest of mathematical understanding ability

X: mathematics learning by using GeoGebra software

-----: Subjects are not randomly grouped

The population in this study was all semester III students who took the Transformation Geometry course in the Mathematics Education study program FKIP UNLA Bandung academic year 2018/2019.

The sample of this study is students of class A as the experimental class and class B as the control class. Sampling is determined based on purposive sampling, namely sampling based on certain considerations [7].

The type of data collected in this study is quantitative descriptive data consisting of 3 types, namely: (1) Student activities during the learning process; (2) Student Learning Outcomes; (3) Student responses.

3. Result And Discussion

Quantitative data were obtained through tests of mathematical understanding ability at the beginning and end of learning. The data was obtained from 24 students consisting of 12 experimental class students (learning with GeoGebra software) and 12 control class students (conventional learning).

Mathematical understanding ability is obtained through pretest and posttest. From the pretest and posttest scores, the normalized gain (N-gain) of the comprehension ability in the experimental class which was learned by GeoGebra software and the control class was calculated by conventional learning.

Table 1. Descriptive Statistics of Mathematical Understanding Ability

KAM Category	Statistics Data	Experimental Class (<i>GeoGebra</i>)			Control Class (Konvensional)		
		Pretest	Posttest	N-gain	Pretest	Posttest	N-gain
High	\bar{x}	16,17	32,33	0,82	16,33	28,50	0,62
	s	1,17	1,21	0,06	1,63	1,05	0,07
Middle	\bar{x}	11,22	25,61	0,58	12,90	22,65	0,42
	s	2,28	3,53	0,13	1,48	1,90	0,09
Low	\bar{x}	10,50	19,50	0,35	10,33	17,50	0,28
	s	1,73	1,29	0,08	1,75	4,76	0,16
Total	\bar{x}	12,03	26,09	0,60	13,06	22,78	0,43
	s	2,83	4,67	0,17	2,41	4,22	0,14

Ideal Maximum Score = 36

Based on table 1 above, it can be seen that the mean score of the experimental class pretest using the GeoGebra software approach is 12.03 while the average score of the conventional class pretest is 13.06. Pretest data for all KAM categories in the experimental class and the control class are relatively the same. Based on these data both reviewed as a whole student and in the KAM category it can be concluded that the initial abilities of students in the two classes are the same.

The average posttest experimental class with the GeoGebra software approach is 26.09 while the posttest conventional class is 22.78. In the low KAM category, the average posttest of the experimental class was 19.50 and the average posttest of the control class was 17.50. When seen as a whole, it was found that the experimental class students got an average gain of 0.60 and a control class of 0.43. The data shows that the improvement of the quality of the two classes is relatively the same, but the improvement in learning outcomes of the experimental class is better than the control class. Thus it can be concluded that learning with GeoGebra software provides a better contribution in the development of students' overall mathematical understanding abilities.

Finding out an increase in mathematical understanding in students whose learning uses learning models with GeoGebra software and students whose learning uses conventional learning models will be done by testing the difference in normalized gain. The statistical test used to prove the hypothesis stating "improvement of mathematical understanding ability of students who obtain learning with GeoGebra software is better than improvement of mathematical understanding ability of students who obtain conventional learning" namely the test of the average difference in N-gain scores.

Table 2. Similarity Test of N-gain Score Average in Mathematical Understanding

Class	T	Df	Sig. (2-tailed)	Sig. (1-tailed)	Note	Conclusion
Exp Cont	4,25	22	0,00	0,00	H ₀ rejected	Better

In table 2 you can see the sig value. (1-tailed) $< \alpha$ is 0,000. This shows that H₀ is rejected. It means that the improvement of students' mathematical understanding ability of the experimental class is better than the control class. Thus it is proven that the hypothesis which states that increasing the ability of mathematical understanding of students who get learning with GeoGebra software is better than students who get conventional learning.

Testing the difference in the average N-gain score based on KAM is done to find out whether there is a difference in the increase in mathematical understanding ability of students who get learning with GeoGebra software and students who get conventional learning in terms of the category of initial mathematical abilities (high, middle, low). Therefore, t-test was used to determine the differences in the mean of the two data groups.

This analysis was conducted to see the effect of different treatments on the ability of mathematical understanding in terms of the students' initial mathematical ability categories.

Table 3. Mean Similarity Result Based on KAM Category

KAM Category	Class	T	Df	Sig. (2-tailed)	Note	Conclusion
High	Experimental	5,659	3	0,000	H ₀ rejected	There are differences
	Control					
Middle	Experimental	4,833	15	0,000	H ₀ rejected	There are differences
	Control					
Low	Experimental	0,754	3	0,473	H ₀ rejected	There is no difference
	Control					

Based on table 3 above it can be concluded that the high and middle KAM categories of the experimental class and the control class provide a significant difference to the students' mathematical understanding ability because of the sig. $< \alpha = 0.05$ which is 0,000. So it can be concluded that there are differences in the improvement of students' mathematical understanding abilities in each high and middle KAM category for students whose learning uses an approach with GeoGebra software compared to conventional learning. Whereas for KAM it is low because of the sig. $> \alpha = 0.05$ which is 0.473, this means that there is no difference in the increase in students' mathematical thinking abilities in the low KAM category.

The results of the response attitude scale have been converted in the form of intervals using the Method of Successive Interval (MSI). The calculation uses STAT 97 software with the main software Microsoft Office Excel 2010. The intended student response statistics include the number of students, minimum value, maximum value, average, standard deviation, and normalized gain.

Table 4. Statistics Description of Responses Normalized Gain

Class	Number of Students (N)	X _{min}	X _{maks}	\bar{X}	Std. Deviation	N-gain Interpretation
Geogebra	12	0,082	0,512	0,296	0,114	Low
Conventional	12	-0,182	0,347	0,131	0,116	Low

Table 4 contains the normalized gain data from the two learning groups. Based on the table, it can be seen that the normalized gain of students' responses whose learning using the learning model with GeoGebra software is higher than the normalized gain of students' responses whose learning uses conventional learning models.

Similarity Test of the normalized response gain uses t-test. The statistical hypothesis is a one-way hypothesis, the hypothesis testing criteria if $1/2 \text{ sig. (2-way)} = \text{sig. (1-way)} > 0.05$ then H₀ is accepted, whereas if otherwise the H₀ is rejected. The results of the calculation of the normalized average of the response to the normalized gain can be seen in table 5 below :

Table 5. Mean Similarity Test of Responses Normalized Gain

Class	T	df	Sig. (2-tailed)	Sig. (1-tailed)	Note	Conclusion
Experimental	5,798	22	0,000	0,000	H ₀ rejected	There are differences
Control						

Based on the results of the normalized gain calculation, it is obtained $1/2 \text{ sig. (2-way)} = 0,000 < 0.05$, so H_0 is rejected. In other words, there is a difference in the final response improvement between students learning using GeoGebra software and students using conventional learning models.

After presenting two ways of seeing improvement in student responses in the two groups of learning models, the two test mean responses concluded the same thing, an increase in the response of students who use learning with GeoGebra software is better than increasing responses of students who use conventional learning.

The next research question is about the correlation between improvement of mathematical understanding ability and improvement of student responses after using learning with GeoGebra software. Furthermore, a correlation test will be conducted between improvement of students' understanding and response skills.

Table 6. Correlation Test of Normalized Gain in Understanding and Response

	Correlation	Pearson	Sig.	Ket.	Conclusion
Gain	Understanding Ability and Response	0,589	0,000	H_0 rejected	There is a correlation

In Table 6 above it can be seen that the value of $\text{sig.} = 0,000 < 0.01$, so H_0 is rejected in other words H_1 is accepted, so it can be concluded that there is a significant relationship between understanding and response. The magnitude of the correlation coefficient between comprehension ability and 0.589 responses are included in the category of sufficient correlation.

4. Conclusion

The following are conclusions from the research activities, namely:

1. Improvement of students' mathematical understanding abilities whose learning using GeoGebra software is better than students whose learning uses conventional learning in transformation geometry courses.
2. There is a difference in the improvement of students' mathematical understanding abilities that obtain learning using GeoGebra software with students who obtain conventional learning based on the KAM category (high, middle, low) on the geometry of transformation.
3. The improvement of mathematical response of students whose learning using GeoGebra software is better than students whose learning uses conventional learning in transformation geometry courses.
4. There is a correlation between students' mathematical understanding abilities and mathematical responses of students who have learned with GeoGebra software

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