



The Effect of Interactive Computer Program on Student Accomplishment in Teaching Trigonometry

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Abstract

The aim of this research is to consider the effect of using an interactive computer program in trigonometry learning. Counterbalance research design was used with a sample of 43 students. The sample was spread in two experimental classes, namely acceleration classes of 24 students and regular classes of 19 students. Both classes received the same learning treatment, namely learning designed using GeoGebra software and ordinary learning without using GeoGebra software. Research data were analysed applying the SPSS 24 program for Windows with the significance level (two-tailed) determined to 0.05. The analysis shows that there are significant differences in learning outcomes between the two types of learning. The superior learning outcomes were obtained in learning that was designed using GeoGebra software.

Keywords: Trigonometry; GeoGebra software; Accomplishment.

1. Introduction

The mathematics learning outcomes in Indonesia are still far behind other countries. Some indicators are rank in the Program for International Student Assessment (PISA) and in the Trend in International Mathematics and Science Study (TIMSS). In 2015 Indonesia ranked 104 out of 115 countries in PISA [1] and 45 out of 57 participating countries in TIMSS [2]. Similarly, Indonesia's results in the Computer-Based National Examination (UNBK) in mathematics subjects are still low [3].

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Mathematics has many applications but is difficult to understand by students. For example, the topic of trigonometry is widely used in mechanical engineering, vibration modelling and analysis of structural oscillations, land measurement surveys, distance measurement, navigation, astronomy, oceanography and other fields. For example, Lumbantobing and Haaker [4, 5, 6] applied the properties of trigonometric functions in modelling and analysis of the equation systems of aeroelastic oscillations of several aeroelastic oscillators. However, the topic of trigonometry is a mathematical topic that is particularly difficult to understand by students, as Adamek, Penkalski and Valentine found [7]. This is also supported by Kamber and Takaci's research [8], which revealed that students have difficulty in learning trigonometry because trigonometric functions are not an injective but periodic functions. Trigonometric function variables are angles in radians size associated with unit circles.

The use of computer-based interactive learning media is one of the alternative solutions to overcome the difficulties of students learning mathematics. The interactive computer program is a very useful, attractive and powerful device in the process of teaching and learning mathematics, especially for understanding concepts of mathematics, as indicated by Hohenwarter, Preiner, Jones and Güyer [9, 10, 11]. In the last two decades, the development of mathematics learning using computers as a learning aid is very rapid. Some of the mathematical packages include Matlab, Maple, SPSS, and Geometer's Sketchpad. In recent years, a number of researchers [12, 13, 14, 15, 16, 17, 18] have examined the use of an interactive mathematics software, namely GeoGebra software, in mathematics learning.

The GeoGebra application was developed by Markus Hohenwarter in 2001 [9]. This application is free and can be downloaded at <https://www.geogebra.org/>. GeoGebra is a dynamic program aimed at learning and teaching mathematics and science. This software can provide interactive animation in the fields of geometry, algebra, statistics and calculus application. GeoGebra is very helpful in teaching and learning mathematics because it can be a dynamic geometry software and computer algebra system. This program can easily and quickly display graphics, images of geometry objects and mathematical simulations. GeoGebra can be used as a tool to construct mathematical concepts.

2. Methodology

2.1. Research Methods

This research is a quasi-experiment using a counterbalance design implemented in two experimental classes.

2.2. Sample

The sample of this study consisted of two experimental classes in level 10 high school. The classes consist of 24 students and 19 students, respectively. The first class is an acceleration class and the second class is a regular class. The acceleration class has an above average level of academic achievement so students are able to learn faster and can complete their studies faster than the study time specified.

2.3. Research Design

In this study two different types of trigonometric learning treatments were carried out. Treatment A was learning designed using GeoGebra software and treatment B was ordinary learning without using GeoGebra software. Both types of treatment were applied to the two experimental classes in different sequences.

There are four compulsory trigonometry subtopics in level 10, so each experimental class gets two treatments A and two treatments B. The researcher used counterbalanced design to control the order effects of the treatments [19].

At each time, the treatment was carried out pre-test and post-test, so that the progress of student learning could be seen immediately whenever applying certain treatments. In this way, the counterbalanced designs were able to control the order effects of treatments and effects of treatments. This was done to control the effect of the treatments given, because the research treatment was carried out several times on different days. Figure 1 illustrates the counterbalanced design used.

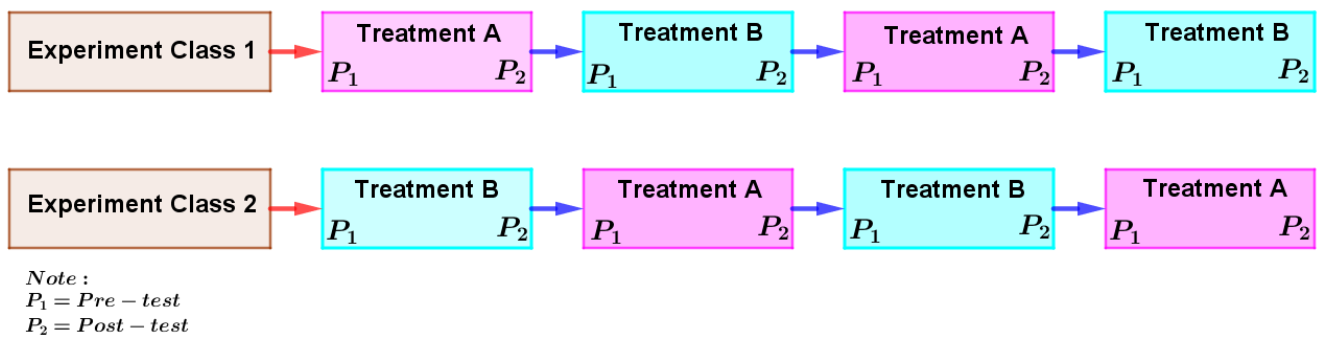


Figure 1: Counterbalance Research Design

2.4. Process

Before conducting the research, the researcher conducted GeoGebra training on both experimental classes.

The researcher conducted four times of learning in accordance with the specified research design.

The class that received treatment A was taught in a computer laboratory room, so that each student was free to explore the properties of trigonometric functions using the GeoGebra application.

The use of the GeoGebra application was designed so that trigonometric material was more dynamic, visual and concrete.

Furthermore, examples and graphs of trigonometric functions were created using GeoGebra during the learning process.

Students who got treatment B were taught in the classroom where they normally studied.

In the official curriculum, teaching of trigonometry in classes at level 10 take a total of 16 hours with four

different subtopics [20]. In each learning process, pre-test and post-test were carried out to see the students' progress after attending the teaching and learning process.

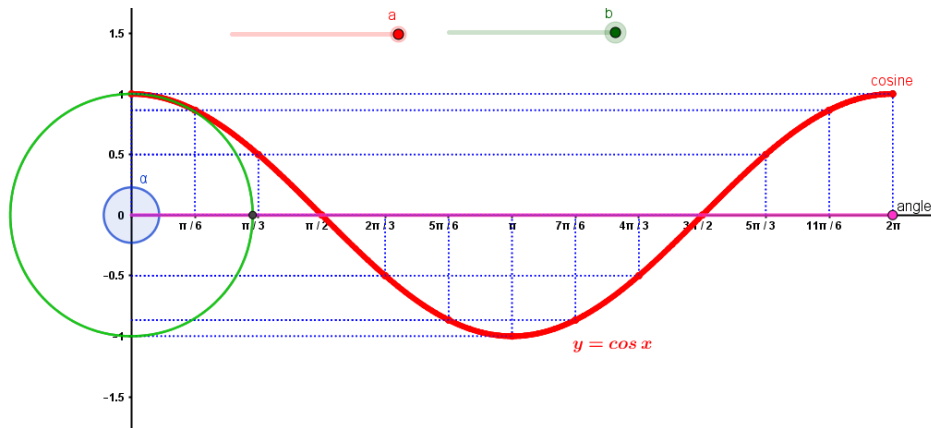


Figure 2: A View of Basic Interactive Material for Trigonometric function

2.5. Accomplishment Test

The learning outcomes test was constructed in line with the mathematics syllabus for trigonometry topics, determined by Ministry of Education and Culture [20]. The test involved 16 items questions developed by using different text books. The accomplishment test was constructed to assess mathematical competency associated with the topics. The researcher developed the test and two mathematics teachers validated them.

3. Data Analysis

In this study, 43 samples were analysed using treatment A and treatment B. The data analysed were the average pre-test scores and the average post-test scores from both experimental classes. Normalized gain score data [21, 22] is obtained using the formula:

$$g = (P_2 - P_1) / (\text{maximum score} - P_1),$$

where g is normalized gain score, P_1 is average pre-test scores, and P_2 is average post-test scores.

The analysis was carried out using the SPSS 24 program for Windows with the significance level (two-tailed) determined to 0.05. Since the data of this research comprised fewer than 50 samples, the Shapiro-Wilk test was applied to decide whether the data obtained were normally scattered. For the data that was normally scattered, the paired samples t-test was performed, and for the data that was not normally scattered, the paired samples Wilcoxon Signed Ranks test was implemented to investigate whether there was a significant difference between data attained [22, 23].

4. Results

Data normality based on the Shapiro-Wilk test are presented in Table 1.

Table 1: Data Normality

Teaching Groups	Data	p values	Distributions
Treatment A	Pre-test	0.001	Not Normal
	Post-test	0.304	Normal
	Normalized Gain	0.200	Normal
Treatment B	Pre-test	0.148	Normal
	Post-test	0.023	Not Normal
	Normalized Gain	0.006	Not Normal

Based on the data distribution presented in Table 1, the statistical test used in analysing data was the Wilcoxon Signed Ranks test on 2-related samples.

Table 2: Pre-Test Results between Teaching Groups

Pre-Tests	N	Mean	SD	Z	Asymp Sig. (2-tailed)
Treatment A	43	33.16	15.85	-0.592 ^b	0.554
Treatment B	43	33.96	16.21		

b = Based on negative rank

Treatment A = Learning using GeoGebra software
 Treatment B = Learning without using GeoGebra software

As seen in Table 2, the results of the 2-related Wilcoxon Signed Ranks test comparing the pre-test of two types of learning displayed that there was no difference in the pre-test average of students educated using GeoGebra software ($\bar{X} = 33.16$, $SD = 15.85$) compared to students educated without using GeoGebra software ($\bar{X} = 33.96$, $SD = 16.21$; $Z = -0.592$, $p = 0.554 > 0.05$).

Table 3: Pre-Test versus Post-Test Results of Treatment A

Tests	N	Mean	SD	Z	Asymp.Sig (2-tailed)
Pre-Test	43	13.33	15.85	-5.712 ^b	0.000
Post-Test	43	62.22	8.62		

Treatment A = Learning using GeoGebra software

b = based on negative ranks

Table 3 shows that a meaningful difference was found between the pre-test and post-test scores of students educated using GeoGebra software ($Z = -5.712$, $p < 0.05$). The difference is that students were more successful

in answering exam questions after participating in learning ($\bar{X} = 62.22$) than before participating in the learning process ($\bar{X} = 13.33$). This finding can be interpreted as indicating that learning designed using GeoGebra software has a meaningful effect on the progress of student learning outcomes.

Table 4: Pre-Test versus Post-Test Results Treatment B

Tests	N	Mean	SD	Z	Asymp.Sig (2-tailed)
Pre-Test	43	33.96	16.21	-5.675 ^b	0.000
Post-Test	43	62.68	22.68		

Treatment B = Learning without using GeoGebra software

b = based on negative ranks

Table 4 shows that a meaningful difference was found between the pre-test and post-test scores of students educated without using GeoGebra software ($Z = -5,675, p < 0.05$). The difference is that students were more successful in answering exam questions after participating in learning ($\bar{X} = 62.68$) than before participating in the learning process ($\bar{X} = 33.96$). This finding can be interpreted as indicating that learning without using GeoGebra software has a meaningful effect on the progress of student learning outcomes.

In addition, to see the difference in the progress of student learning outcomes, the normalized gain score data [21, 22] was calculated using the following formula:

$$g = (P_2 - P_1) / (100 - P_1).$$

Normalized gain data description for each learning are shown in Figure 3.

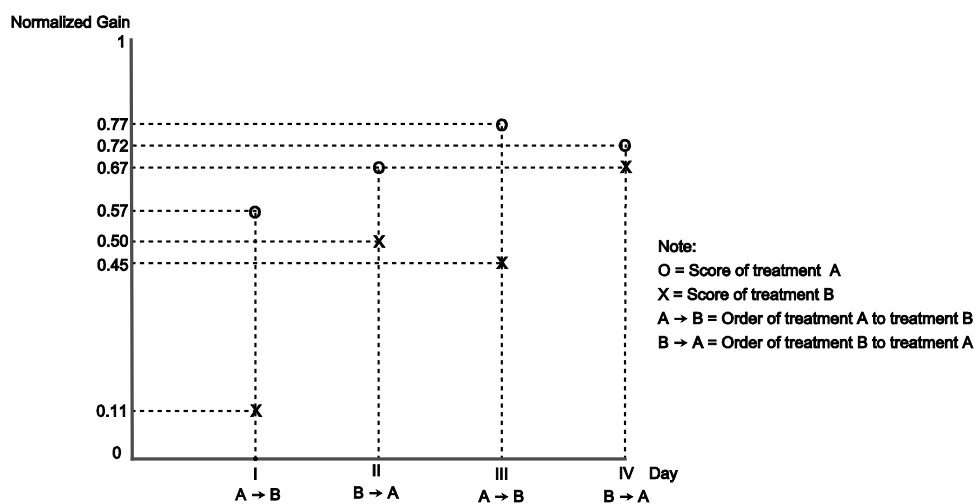


Figure 3: Distribution of Normalized Gain

Figure 3 shows that the progress of student learning outcomes is always higher in learning designed with learning tools using GeoGebra software.

The normalized gain category [22] of both learning models are given in the table below.

Table 5: Category of Normalized Gain

Category	Treatment A (%)	Treatment B (%)
High	55.81	30.23
Medium	39.54	37.21
Low	4.65	32.56

Treatment A = Learning using GeoGebra software

Treatment B = Learning without using GeoGebra software

Table 5 shows that normalized gain with medium and high category is dominated by learning using GeoGebra software.

Table 6: Wilcoxon Signed Test Comparing Normalized Gain between Treatments

Normalized gain	N	Mean	SD	Z	Asymp.Sig (2-tailed)
Normalized gain of Treatment A	43	0.86	0.10	-4.390 ^b	0.000
Normalized gain of Treatment B	43	0.46	0.25		

Treatment A = Learning using GeoGebra software Treatment

B = Learning without using GeoGebra software

b = based on positive ranks

Table 6 shows that a meaningful difference was established between the normalized gain scores of students taught using learning devices with GeoGebra software ($Z = -4.390, p < 0.05$). The difference was that students who were educated using the learning tool with GeoGebra software achieved higher normalized gain ($\bar{X} = 0.86$) result in contrast to students who were educated without using GeoGebra ($\bar{X} = 0.46$). This finding can be explained as indicating that the use of GeoGebra software has a significant effect on the progress of student learning outcomes on the topic trigonometry.

5. Discussion

This research has revealed the effectiveness of mathematics learning using interactive computer programs in the topic of trigonometry. This study shows that the progress of student taught using GeoGebra software far exceeds the progress of student taught using regular learning without using GeoGebra software. The results of this study are in line with the results of research conducted by Zengen, Furkan and Kutluca [12] who found that

trigonometry learning using GeoGebra software was superior to learning without using GeoGebra.

Based on normalized gain data, the progress of student learning outcomes taught using soft GeoGebra is in the medium category (39.54%) and high category (55.81%). This shows that learning the trigonometry topic using the GeoGebra application can help students to understand the concepts, properties and graphical function of trigonometry, according to Hohenwarter and Preiner [9] and Hohenwarter and Jones [10].

Students can learn independently using their own computers to explore, understand and see clearly through GeoGebra's animation of the graphs of trigonometric functions, the characteristics of trigonometric functions, and the periodization of trigonometric functions. In this way, the student's difficulties in learning the concept of trigonometry, as described by Adamek, Penkalski and Valentine [7], Kamber and Takaci [8], can be overcome. In addition, using GeoGebra software would make it easier for teachers when teaching the concepts and characteristics of trigonometric functions. GeoGebra software would enable teachers to visualize trigonometric function graphics in an interactive way, so students can understand them easily and quickly. This is consistent with the results of research conducted by Tatar [14] who stated the use of GeoGebra software in mathematics learning has a positive contribution.

6. Limitation

This study has several limitations. Firstly, this research was not cost-effective as this requires computer devices for every student. Secondly, the teachers and students must have basic knowledge of computers. Finally, this study took only four compulsory trigonometry subtopics, hence it did not cover the whole material of trigonometry. Therefore, further research is needed.

7. Conclusion

In this study, the effect of using GeoGebra software in the learning of trigonometry topic was reviewed. Based on the data obtained from the pre-test results, there was no meaningful difference between students who were taught with learning designed using GeoGebra software and students who were taught with learning without using GeoGebra software. Based on the results of the pre-test versus post-test analysis, both types of learning show that they are able to improve student learning outcomes.

However based on normalized gain data analysis, it was found that there were meaningful differences in the students' learning progress in two types of learning, where the progress of learning using GeoGebra software was higher.

8. Recommendations

This research recommends to mathematics teachers to use GeoGebra software to teach the trigonometry topic and to train students to use GeoGebra software in learning mathematics.

Further research is needed about the application of GeoGebra software in mathematics learning.

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