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The effect of dynamic mathematics software geogebra on student achievement in teaching of trigonometry

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Abstract

The purpose of this study is to determine the effects of dynamic mathematics software GeoGebra on student achievement in teaching of trigonometry. The sample of the study consists of 51 students. The experimental group was subjected to the lessons arranged with the GeoGebra software in computer assisted teaching method, while the control group was subjected to the lessons shaped with constructivist instruction. The data collected after 5 weeks of application show that there is a meaningful difference between experimental and control groups' achievement in trigonometry. This difference is in favor of the experimental group which had lessons with GeoGebra.

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Keywords: Trigonometry, Dynamic mathematics software, GeoGebra, Achievement

1. Introduction

The computer is a powerful and helpful tool in teaching and learning mathematics, in particular in understanding the mathematical concepts, as it was noted by many authors (Hohenwarter & Jones, 2007; Güyer, 2008).

There is a struggle to integrate the computer in school. This approach must be read: *"the integration of educational software in education"*. This is a related desire to implement new teaching methods in mathematics. An *"educational software application"* is something that everyone could use on a computer, without having advanced knowledge about computers and programming. Draw, build, unite, and investigate properties, change shape and size. Properties remain the same? Why? Can you formulate the theorem from this investigation? Prove it rigorously! (Antohe, 2010).

It is often said more about using interactive methods in teaching mathematics and about their implementation in the curriculum. However we appreciate that the first step must be done when the blackboard and chalk are replaced with dynamic image of mathematical phenomena, integrated in dynamic software like GeoGebra. There are no barriers to this and only the wish to use the system can produce the desired success (Antohe, 2010).

Many studies have been working for nearly fifteen years with several mathematical packages including *Logo*, *Geometer's Sketchpad*, *Cabri*, *Derive*, *Mathematica*, *Scientific WorkPlace*. In recent years, a number of studies in

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which dynamic mathematics software GeoGebra is used are seen in the literature (Reis, 2010; Kutluca & Zengin, 2011; Zengin, 2011; Tatar, 2012). The software that provide visual and effective learning environment for students have increased as Technological improvements have increase. One of these softwares, Geogebra, can be defined as Computer Algebra System (CAS) since it includes the symbolical and visualization features such as direct coding of equations and coordinates, defining functions as algebraical. It can also be defined as Dynamic Geometry Software (DGS) since it includes concepts such as points, segments, lines, conic segments and provides dynamic relationships between the concepts .It is the basic feature of GeoGebra that can be approached both CAS and DGS. In education of math, the ability of software making a relationship between geometry and algebra has become an important value in math curriculum (Hohenwarter & Jones, 2007).

During the past decades, there has been a great evolution in mathematical software packages. Of a great amount of software, there are two important forms of software contributing to the teaching and learning of mathematics; CAS and DGS. These two tools have had a high influence on mathematics education. However, these are not connected to each other at all. Fortunately there is a software system called GeoGebra that integrates possibilities of both dynamic geometry and computer algebra in one program for mathematics teaching (Hohenwarter & Jones, 2007; Dikovic, 2009; Antohe, 2009).

1.1. What is GeoGebra?

Created by Markus Hohenwarter in 2001, GeoGebra represents one such software program that was designed to combine geometry, algebra, and calculus in a single, dynamic environment. GeoGebra is an open-source (freely-available), dynamic mathematics software program created by Markus Hohenwarter for his master's thesis project at the University of Salzburg, Austria. The official GeoGebra website, located at <http://www.geogebra.org>, features the most recent version of the software download, access to GeoGebraWiki and the User Forum, related publications, and information regarding regional GeoGebra Institutes.

1.2. Why is GeoGebra?

GeoGebra is a dynamic learning environment that enables its users to create mathematical objects and interact with them. GeoGebra users, mostly teachers or students, can use this environment to explain, to explore, and to model mathematical concepts and the relationships between them, or mathematics in general (Hohenwarter & Jones, 2007).

GeoGebra accepts geometric, algebraic, and calculus commands and links multiple representations. It is also an open source mathematics software program. When developing this software, its programmers aimed to enable multiple representations and visualization of mathematical concepts. So, GeoGebra helps the users to create activities incorporating multiple representations of mathematical concepts that are dynamically linked. Using computer in geometry teaching is implemented with the new elementary mathematics curriculum in our country and has become indispensable (MEB, 2005). The most important role of computers in primary mathematics education is stated as “making the learning of abstract concepts easier” in the curriculum. Some previous researches in the area reported that computer use is more effective than the constructivist approach to learning.

1.3. Why is Trigonometry?

Trigonometry is one of the subjects in mathematics which students experience crucial difficulties in learning (Adamek, Penkalski & Valentine, 2005; Kutluca & Baki, 2009; Tatar, Okur & Tuna, 2008). In this study, the efficiency of the computer assisted instruction method, in which the GeoGebra software is used, in the teaching of trigonometric functions and graphs of trigonometric functions subtopics will be determined.

1.4. Purpose of this study

The purpose of this study is to determine the effects of dynamic mathematics software GeoGebra on students' achievements in trigonometric functions and graphs of trigonometric functions subtopics which are placed as trigonometry in math class.

2. Methodology

2.1. Research Model

The research was conducted in a Pretest-Posttest Control Grouped Half Experimental Pattern.

2.2. Experiment and Control Group

The pretest results show that there was not any statistically significant difference between the groups. Therefore, one of the groups selected as experiment and the other as control group. This experimental study is conducted in the fall semester of 2010-2011 academic years. The experimental group was subjected to the lessons arranged with the GeoGebra software in computer assisted teaching method to observe the effect of dynamic mathematics software GeoGebra, while the control group was subjected to the lessons shaped with constructivist instruction. A computer assisted instructional material was developed by the researchers for that purpose.

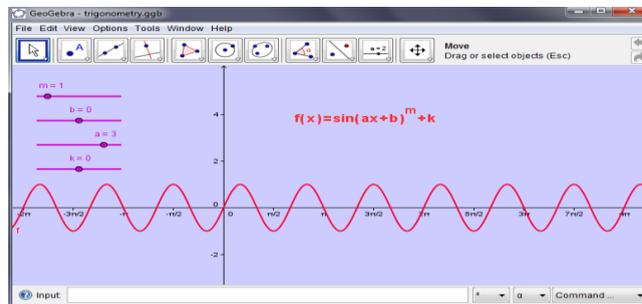


Figure 1. A view of the material for trigonometric functions

2.3. Process

A five weeks course which contained twelve main GeoGebra activities and many other practices about the stated achievements has been planned in accordance with the official mathematics curriculum. Then the activities were constructed with GeoGebra for the experiment group. The GeoGebra prepared activities aimed to make the subject more dynamic, concrete and visual. GeoGebra software was introduced in introductory hour of the course. In all of the other sessions, the GeoGebra prepared activities were shared with the students both with visual and dynamic features. Furthermore, examples and drawings on the textbooks were constructed with the GeoGebra during the sessions. In the official curriculum (MEB, 2005; Pieri & Diamantini, 2010) teaching of trigonometric functions and graphs of trigonometric functions subtopics for tenth grade takes total of 20 hours with nine different objectives.

2.4. Achievement Test

By examining the target behaviors determined by the Ministry of National Education for the unit trigonometric functions and graphs of trigonometric functions subtopics. The test involved 10 items with open-ended questions. In line with the targets of the given unit, an achievement test consisting of 10 open-ended questions prepared by using different test books and questions previously asked in high school entrance examinations was designed. The achievement test was designed to measure the following objectives that the students in both groups were expected to achieve during the study. The test was prepared by the researchers and checked by five mathematics teachers, three

of whom were mathematics educators. The test was piloted with 45 tenth grade students. The main purpose of the pilot was to determine students' difficulties in understanding the tasks used in the test and prepare open-ended explorations in the main study.

2.5. Sample

The sample of the study consists of 51 students attending to a general high school in Diyarbakır during the 2010-2011 academic year. 25 participants of that sample group were selected into experimental group while the other 26 ones were selected into the control group.

3. Results

Table 1. Pre-test Post-test Results of Control Group

Tests	N	Mean	SD	df	t	Significant
Pre Test	26	38.86	8.58			
				21	-5.36	.000
Post Test	26	54.09	9.83			

As the Table 5.1. is examined, it is seen that there is a statistically meaningful difference between the students' success points of the control group on pre-experimental process and the points on post experimental process ($t = -5.36$, $p < .05$). The origin of the difference is seen that students are more successful on post-experimental processes ($\bar{X} = 54.09$), than the pre-experimental processes ($\bar{X} = 38.86$). This finding can be interpreted that the lessons which are studied in constructive approach has a meaningful effect on students' learning of control group.

Table 2. Pre-test Post-test Results of Experimental Group

Tests	N	Mean	SD	df	t	Significant
Pre Test	25	39.78	9.70			
				22	-16.03	.000
Post Test	25	72.39	12.51			

As the Table 5.1. is examined, it is seen that there is a statistically meaningful difference between the students' success points of the experimental group on pre-experimental process and the points on post experimental process ($t = -16.03$, $p < .05$). The origin of the difference is seen that students are more successful on post experimental processes ($\bar{X} = 72.39$), than the pre-experimental processes ($\bar{X} = 38.86$). This finding can be interpreted that the lessons in which Geogebra software is used has a meaningful effect on students' learning of the experimental group.

Table 3. Independent-T Test Comparing The Result Post-Test Between Groups

Groups	N	Mean	SD	df	t	Significant
Control Group	26	54.09	9.83			
				43	5.43	.000
Experimental Group	25	72.39	12.51			

From the above table, the result of the independent-t test comparing the post-test results of the two groups showed that there was a significant difference between mean performance scores of the control group ($\bar{X}=54.09$, $SD= 9.83$) compared to GeoGebra group ($\bar{X}=72.39$, $SD= 12,51$; $t(51) = 5.43$, $p = .000 < .01$). The difference between the means is 18.30 points on a 100-point test. This finding indicated that students who had learned trigonometry using GeoGebra was significantly better in their achievement compared to students who underwent the constructivist instruction.

4. Conclusion

In this study, the effects of the computer assisted instruction method in which dynamic mathematics software is used on achievement in the subject of trigonometry are analyzed. With respect to the data belongs to trigonometry achievement pre-test, there is not a meaningful difference between the groups. Throughout the study, both groups' success was increased. According to trigonometry achievement post-test results, the instruction structured according to trigonometry teaching approach is more successful than constructivist instruction. The results of the study indicated that there was a significant difference between the means of the students' scores on the posttest in favor of the GeoGebra group.

The findings showed that computer assisted instruction as a supplement to constructivist instruction is more effective than constructivist teaching method. The findings of this study is consistent with the study by Ross & Bruce (2009), Reis (2010), Tatar (2012) which found positive impact of utilizing mathematical learning softwares thus enhancing students learning and understanding. After the study, it is found a difference between the mean scores of trigonometry achievement test of two groups and this difference is statistically meaningful in favor of GeoGebra group.

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