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# EFFECTIVENESS OF USING GEOGEBRA SOFTWARE ON STUDENTS' UNDERSTANDING OF THE CONCEPT OF CIRCLES

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**Abstract**

*The use of technology in the pedagogical process is growing at phenomenal rate, due to the vast availability of gadgets. Further, it is a challenging task for teachers to engage their students without technology integration, due to its popularity amongst their students. As a result, educationists see the urgent need of technology integration in students' mathematical activities. Therefore, the purpose of this experimental study was to identify whether GeoGebra enhances students' understanding of the concept of circles. Fifty-three grade nine students participated in this study and students were provided with six activities using GeoGebra to study the concept of circles. As a part of the quantitative analysis, survey questionnaires were distributed to the students and the results interpreted statistically. The results of this study showed that there existed a significance difference between the experimental and control group of students in understanding and analysing the concept of circles.*

***Keywords:*** technology, constructivism, effectiveness, GeoGebra, circles

## Background of study

Teaching and learning with the use of technology has many advantages such as providing greater learning opportunities for students (Roberts, 2012); enhancing student engagement (White, 2012) and encouraging discovery learning (Bennet, 1999). In the teaching and learning of Mathematics, especially in the study of geometry, it is important for students to be able to imagine, construct and understand geometrical constructions that are formed in order to connect them with related facts. Therefore, a computer will assist students to make observations as well as visualise the geometrical concepts (Dogan, 2010). There are a number of technology tools available such as interactive whiteboards, calculators, geometers sketchpad and GeoGebra. This paper will discuss in detail the use of GeoGebra software to conduct learning of circles in mathematics.

### *Statement of Problem*

In the teaching and learning of geometry, it has been often realised that students still lack the cognitive and process abilities in the total understanding of circles. Although the teacher delivers the required knowledge to assist students in understanding the concepts of circles, however students seem to face a challenge to apply the knowledge delivered to a given task. It is as though there is something more that is required to guide students so that they are able to manipulate circle properties to truly understand and visualise the topic of circles. This perception is supported by research (Battista, 1999; Mitchelmore, 2002), whereby they found students faced challenges in the study of geometry and many struggle to grasp the concepts and required knowledge.

A research by Dogan (2010), reveals that GeoGebra had an impact on students' learning and achievement and improved students' motivation. Another study by Erhan and Janet (2013), also suggested that students improved their understanding of mathematics using the dynamic GeoGebra software. A study done in Malaysia to evaluate the impact of GeoGebra in learning transformations by Bakar, Ayub and Tarzimi (2002) revealed that secondary school students achieved better results.

### *Objectives and Research Questions*

The main objective of this study was to investigate if the GeoGebra software will enable high school students to better visualize and understand the concept of circles. The research question was: Was there a significant difference in understanding mathematical concepts related to circles among the experimental and control group of Year 9 students?

### *Significance of Study*

The findings will reveal the processes involved, the challenges and issue that teachers will need to consider when using the GeoGebra software and outline how the different interactions with technology, peers and teacher affect learning. In addition, the study will provide information on how learners of different abilities interact to perform the tasks that they have been assigned. Such information is crucial in the planning of lessons in large classes and where learners of heterogeneous abilities are found.

### *The GeoGebra Software*

GeoGebra was designed by Markus Hohenwater as an open-source (free-available) dynamic mathematics software that incorporates geometry, algebra and calculus into a single, open-source, user-friendly package (Hohenwarter, Jarvis, Lavicza, 2008). This software is a combination of features of older software programs such as Maple, Derive, Cabri and Geometer's sketchpad (Sahaa, Ayub, & Tarmizi, 2010).

### **Conceptual framework**

The study draws upon the constructivist theory of social interaction for cognitive development. The main principles will anchor on the zone of proximal development (ZPD) and scaffolding. Students generally have challenges in understanding

mathematical concepts, therefore in this study, the GeoGebra software was introduced as a scaffold to enhance students understanding of the concept of circles. The ZPD is described as the variance between one's mental age and the level he might attain in problem solving with guidance. On the other hand, scaffolding is referred to the guidance that is provided for one to reach the ZPD. In this study the GeoGebra software basically acts as the primary scaffold in assisting and guiding the students to reach their ZPD. The students were required to work in pairs to construct diagrams and make observations based on their constructions. Therefore, students made formed their own interpretations through shared understanding with the guidance of the GeoGebra where they were able to explore and visualise on their own. On top of that, the teacher and peers also played a part in the scaffolding process.

The social interaction between the peers gave the students the opportunity to guide one another and reach to a level of shared understanding. Here the higher ability students play a big role in helping the lower ability students to reach their ZPD. The higher ability students also benefit through the new ideas and views of their fellow peers.

In this study, students were placed in groups where the scaffolding process can take place for students to construct circles based on what they already know and accept help from their peers when the need arises. In this environment the teacher acts as a mere facilitator. This manner of learning enhances critical thinking skills as students contribute their ideas and views and reach to a common understanding. The GeoGebra gave the students an opportunity to interact with their peers to enhance their understanding and visualization of the concept of circles.

**Review of Literature**

The integration of technology in assisting the teaching and learning process in the classroom has attracted a lot of attention in recent years. The NCTM (Principles and Standards for School Mathematics) (2000) listed technology as one of their key principles to enhance the quality of mathematics, suggesting, "Teachers should use technology to enhance their students' learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently and well – graphing, visualizing and computing" (NCTM, 2000, p.25). In the fast moving era of technology, it is essential to keep up with the current interventions and innovations in relation to technology to meet its relevance for the present and future (Abd. Rafie, 2002, Bitter & Hafield, 1994; Pomerantz, 1997; Noraini Idris, 2006).

Dogan, (2010), conducted an experimental design study using a pre-post test to evaluate evaluate the success of students learning using the GeoGebra software. It was a twelve hours course that was held for a period of two weeks involving two eighth grade classes. It was observed that computer based activities can efficiently be used in the learning process and the GeoGebra software encouraged higher order thinking skills. In addition to that it was also observed that the software had a positive effect in motivating students towards their learning and students were able to retain their knowledge for a longer period of time. This was proven based on a recall test that was conducted a month later.

Herceg and Herceg (2010) conducted a study on two groups of students. One group used applets only, whilst the other used the GeoGebra software and applets. The purpose of the study was to incorporate computer-based learning to reduce the working process of numerical integration. The results of this study showed that the group of students that used the GeoGebra gained more knowledge and skills than the other group. It was also suggested in this study that the use of GeoGebra is helpful for students that face difficulty in solving mathematical problems since they do not have to spend so much time solving by hand. Erhan and Janet (2013) conducted a study to show how dynamic software improves students' understanding of mathematics. Students were able to explore and form conjectures and therefore had better overall score.

Bakar, Ayub and Tarzimi (2002), compared the GeoGebra to a software program created by them on two groups of Malaysian secondary school students and found that students using the GeoGebra software to study the topic of transformation achieved better results than students using the software created by them.

Leong (2013), conducted a study to determine the effects of using the dynamic software, Geometer's Sketchpad (GSP) in the teaching and learning of graph functions. This study was conducted amongst Form six students in a Malaysian secondary school. A quasi-experimental design using intact sampling was employed. It was observed that there was a significant difference in the achievement of the experimental group as compared to the control group. This indicates that the dynamic software (GSP) had a positive effect on students' achievement and attitude towards learning graph of functions.

## Research Design

The research study employed a quasi-experimental, pre-test and post-test design. The experimental group underwent an intervention where they learnt mathematics using the GeoGebra software for one week where each activity lasted for approximately 40 minutes. The control group on the other hand learnt mathematics using the traditional learning method. The post-test served as a ground to evaluate the extent to which the GeoGebra has executed its impact.

### *Participants*

The participants for this study were selected from an International school in Selangor, consisting of five Year 9 classes. Two intact classes consisting of 53 students were selected for this study from a population of 133 students. One class was assigned as an experimental group and the other as a control group. The experimental group consisted of 28 students and the control group consisted of 25 students.

### *Treatment*

At the beginning of the study the experimental and control group took a pre-test consisting of 21 questions, 8 multiple choice questions and 13 problem solving questions on the concept of circles. The study was conducted for over a period of a week and involved six activities to determine students' understanding of the concept

of circles. On the other hand, the control group followed their regular traditional mode of study.

At the end of the treatment, a post-test was administered to test the impact of the GeoGebra software on learning.

## Data Analysis

The *t*-test was used to test for statistical significance difference between the control and experimental groups at the beginning of the study and at the end of the study. This was done primarily by comparing the mean score of the pre test and post score of both the groups.

## Results

### *Student Achievement*

To determine whether students in the experimental group using GeoGebra achieved significantly better results as compared to the students in the control group who learnt circles in the traditional learning environment, the mean scores of the experimental and control group were determined. Table 1 and 2 summarises the mean scores of the experimental and control groups.

Table 1
*Results of the paired t-test*

| | | Paired Differences | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 99% Confidence Interval of the Difference | | | | |
| | | **Mean** | **Sd** | **Std. Error Mean** | **Lower** | **Upper** | ***t*** | **df** | **Sig. (2-tailed)** |
| **Pair 1** | pretest score - posttest score (Control) | -4.3600 | 4.44277 | .88859 | -6.84534 | -1.87466 | -4.907 | 24 | .000 |
| **Pair 2** | pretest score - posttest score (Experimental) | -9.50000 | 2.88675 | .54554 | -11.01153 | -7.98847 | -17.414 | 27 | .000 |

Note: *significant at p ≤ 0.001

A paired samples *t*-test was conducted to compare the pre-test and post-test scores for experimental and control groups. The results in table 1 show that there was a significant difference in the pre-test and post-test scores for the experimental (mean is -9.50000, standard deviation is 2.88675 and *t*(27) is .000) and control group (mean is -9.50000, standard deviation is 4.44277 and *t*(24) is .000). This shows that there was a significant improvement in the scores of both the experimental and control groups.

Table 2
*Results of the independent t-test*

| | **Levene's Test for Equality of variance** | | **Experimental (28)** | | **Control (25)** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***F*** | **Sig.** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***t*** | **df** | **Sig. (2 tailed)** |
| Pretest scores | 1.055 | .309 | 6.9643 | 2.15135 | 7.8800 | 2.71293 | -1.368 | 51 | .177 |
| Posttest scores | 4.173 | .046 | 16.4643 | 3.28275 | 12.2400 | 4.39962 | 3.989 | 51 | .000 |

Note: *significant at $p \leq 0.001$

Table 2 shows the results of an independent *t*-test that was conducted to compare the pre-test scores of the experimental and control group and post-test scores of the experimental and control group. Levene's test for equality of variance was not significant for the pre-test scores of the experimental group (mean is 6.9643 and standard deviation is 2.15135) and control group (mean is 7.8800 and standard deviation is 2.71293), $t(51)$ is .177, indicating equal variances before the commencement of using GeoGebra and students were of equal ability. However, Levene's test for equality of variance showed a significance in the post-test scores of the experimental group (mean is 16.4643 and standard deviation is 3.28275) and control group (mean is 12.2400 and standard deviation is 4.39962), $t(51)$ is .000, indicating that the students' scores have increased significantly after using GeoGebra.

It can be concluded that the experimental students scored significantly higher than the control group in the post-test. Both the experimental and control group did better in the post-test.

## Discussion

The GeoGebra software can be used as an enabler in the teaching and learning of Mathematics, and more specifically of circles as there was a significant increase in experimental students' conceptual understanding of circles as compared to the control group.

The use of the GeoGebra software not only increased student scores, it was observed that the software enabled the realization of a vibrant classroom, a classroom whereby cooperative and collaborative principles of learning were also realised. This finding is supported by Bakar, Ayub and Tarzimi (2002) and Zengin, Furkan and Kutluca (2012), where a study was conducted with two groups using the pre-post test to learn mathematical concepts.

The above findings also corroborate other studies done to determine the effects of a technology-rich environment on students learning (Bennet, 1999; Idris, 2006; Dogan, 2010; Roberts, 2012; White, 2012). This improvement can be attributed to the design of the constructivist learning environment which was anchored on the twin concepts of scaffolds and zone of proximal development. Thus, it is equally important that the teacher as the main curator of the learning environment be

equally enlightened of the advantages of a technology-enabled classroom. Studies done by professional mathematics bodies should be constantly referred to when reviewing the impact of new learning technologies. In one report, the NCTM (Principles and Standards for School Mathematics) (2000), listed technology as one of their key principles to enhance the quality of mathematics, suggesting, "Teachers should use technology to enhance their students' learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently and well – graphing, visualizing and computing." (NCTM, 2000, p.25)

The findings also point to the fact that technology is a great motivational tool as especially it was noted that students' confidence increased when both the GeoGebra and videos were used to enhance students' learning process. This was especially beneficial for the lower ability students. Technology acted as a scaffold which enabled the learners to reach their zone of proximal development (Vygotsky, 1978). This finding is supported by Dogan, (2010) whereby it was observed that computer based activities encouraged higher order thinking skills, and had a positive effect in motivating students towards their learning.

## Conclusion

In this study, the GeoGebra software has proven to be an effective tool in enhancing the teaching and learning of Mathematics especially specifically in learning circles. Students were able to experience a hands-on method of learning which had a positive effect in enabling them to understand the concepts better rather than just being passive learners.

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