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Effectiveness of Geo Gebra in Teaching Theorems and Postulates in Geometry

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Abstract
The development of technology has opened opportunities for both parties to use the tool as a means of supporting the educational process. The purpose of this article is to thoroughly assess GeoGebra's effectiveness as an information and communication technology (ICT) and as a digital technology integration in mathematics learning. Further, this paper is based on the results of a 1-week experiment in teaching and learning the initial postulate and theorems of geometry. The effectiveness of the ICT tool was explored through the use of a quasi-experimental approach with 46 students divided into two groups. A group of 20 students used the GeoGebra software, while another 20 students used the conventional method to learn mathematics. The data were collected, analyzed, and interpreted by using mean, standard deviation, and a t-test to determine the students' achievement in the initial postulates and theorems in geometry. The findings revealed that there was a higher mean score in achievement in mathematics for the experimental group (teaching with ICT) than for the control group (without using ICT). Thus, the use of ICT, particularly GeoGebra, is an effective tool to increase achievement, promote curiosity and creativity, make clear sense of concepts, and encourage the overall learning of students in mathematics.

Key term: GeoGebra, Theorems, Postulates, effectiveness, Geometry, Conventional

Introduction

Information and communication technology (ICT) refer to the use of new or modern technology in any field. ICT creates the environment for the learner to learn easily from difficulty. Worldwide research has shown that ICT can improve students' learning with the appropriate teaching methods. It provides a great opportunity for teachers and learners to improve their teaching and learning processes.

Mathematics education is the base for scientific development. The research on the mathematics subject discovered that it was weaker than another subject. This subject is widely regarded as the most difficult in the world, and many students are terrified of it.

Filipino students performed poorly in the 2019 Trends in International Mathematics and Science Study (TIMSS) international assessment for mathematics and science. In mathematics, only 19% of Filipino students met the low standard, indicating they had some fundamental mathematical understanding, whereas 81% did not even reach this level.

To avoid the perceived difficulty of this subject for students, there must be practice in mathematics using various ICT tools, and teaching and learning activities must be visualized by different mathematical software at the school level. GeoGebra, Mathematica, MATLAB, and other mathematical software programs are available for teaching mathematics. At the school level, many students struggled with geometrical content in mathematics. GeoGebra is the most important mathematical software that visualizes geometric concepts with figures. So, I chose this topic to investigate GeoGebra's effectiveness in teaching initial postulates and theorems in geometry at the secondary school level. I analyzed the result of this study after using GeoGebra in my research on this study.

Using ICT to teach mathematics can make the teaching process more efficient and improve students' ability to comprehend fundamental topics. However, adopting its usage in education is not without obstacles, since several obstacles may occur. The categories of obstacles have been determined through research. (Keong, Horani, & Daniel, 2005) This states that if we use different ICT tools in teaching mathematics, students have a clear concept of related content and can remember it for a long time. Also, the use of ICT in mathematics teaching makes it effective and increases student achievement.

The use of ICT materials in education has played an effective role. The teaching pedagogy has been changed to depend on ICT. There are multicultural learners at the school level. Because not all students have the same learning capacity, ICT tools help learners learn in different dimensions. ICT focuses on student achievement as it progresses from quantity to quality. The teaching and learning activity must be learner-centered, so ICT material creates an environment for the learner based on their viewpoint. As a result, ICT alters classroom instruction, and students learn the material with difficulty. Students require a variety of teaching skills to be successful in today's classrooms where ICT is used. This helps the learner with learning and memorization.

Purpose of the Study

This study was designed to ascertain whether

1. There was a significant difference in the mathematics performance of pupils in the pre-test between experimental and control group.
2. There was a significant difference in the mathematics performance of pupils in the mathematics post-test who were taught using GeoGebra (experimental group) and conventional method (control group).
3. There was a significant difference in the mathematics performance of pupils in their pre-test and post-test who were taught using GeoGebra and those who were taught using the conventional method.

Review of Related Literature

A review of the literature guides and assists the researcher in completing the study's objective. A literature review is a written summary of journal articles, books, and other documents that describes the past and current states of information on the topic of a research study. With so much information available, it can be difficult to find and locate reliable sources on the topic of a research study (Creswell, 2012). As a result, conducting a review of related literature entails systematically identifying, locating, and analyzing the literature on our chosen topic. This chapter represents the empirical and theoretical literature.

Empirical Review

According to the study of Paudel (2007) cited by Bohara, C. (2019) on the effectiveness of Geoboard in teaching geometry at the primary level, during the pre-test both groups, the control and experimental, had no significant difference, but after a month of exposure to GeoGebra, the experimental group had a higher and more favorable response compared to the control group.

In Acharya's (2015) study on the effectiveness of GeoGebra software on mathematics achievement, 53 students from two schools participated. There are 28 students in the experimental group and 25 in the control group. The respondents were exposed to GeoGebra's dynamic software tool for one week. According to the findings of that study, students in the experimental group outperformed those in the control group in terms of academic achievement.

The students in the experimental group were more motivated when taught using GeoGebra. Students are interested in learning, and they can remember for a long time what they have studied. According to these studies, ICT-based learning is superior to traditional methods. Bhandari, P. (2015).

Lamichhane, D.R. (2017) has further investigated the effectiveness of GeoGebra software on student achievement in parallelograms and circles of geometry at grade 10. Furthermore, Barai (2017) had done research in GeoGebra on the topic of student perceptions of the use of GeoGebra in geometry teaching and concluded that students have a positive perception of using GeoGebra in geometry teaching at the secondary level. Moreover, Bist, P.R. (2017), in his study of the use of GeoGebra in geometric construction analysis, found better student achievement in experimental groups than in control groups.

Theoretical framework

All studies are based on different theoretical concepts; therefore, learning theory provides us with a conceptual framework for the study. In the process of learning, which takes place between the teacher and a student while learners have different abilities in the classroom, teachers use different teaching methods that are anchored in different learning theories. This study is based on constructivist theory by Jean Piaget, where the constructivist approach to learning relates to how the learner constructs and processes their knowledge.

Methodology

Research Design

The quasi-experimental design was used because, unlike the true experimental design, it does not require randomization of samples. Randomization of samples for an experimental study is not practicable in a school system. Therefore, the quasi-experimental design was most appropriate for this study. Gay (2000) asserted that, with the exception of randomization, this design can meet all of the requirements of a true experimental design. This design will be composed of two groups: the control group, which is the group that will have conventional learning, and the experimental group, which will have the GeoGebra ICT tool integrated. This is to determine the effectiveness of GeoGebra in teaching theorems and postulates.

Sampling Technique

In this study, first-year BEED education students served as the population. The researcher selected 40 students out of a total of 59 populations. As a result, the researcher divided the students into two groups of 20 each: an experimental group and a control group. After the pre-test, the experimental

and control groups were selected by lottery. The researcher taught the same topic of postulates and theorems in geometry.

Research Instrument

The research instrument that was used to collect data for this study was a teacher-made test. Gay (2000) argued that the pretest and post-test instruments should be the same. For both the pretest and the post-test, the teacher-created test was used. The teacher made a test that consisted of twenty (20) objective items. The objective items were multiple-choice items on the initial postulates and theorems. According to Phye (1997), this type of question eliminates the possibility for subjectivity in scoring. The same test items were used for both the pretest and the post-test.

Reliability of instruments

The instrument was piloted by a second-year student who was not part of the sample for the study. A pilot test using the test–retest approach was carried out to determine the reliability of the research instrument. The Pearson product-moment correlation coefficient yielded a reliability coefficient of .768 to ensure that the instrument provides reliable data for the study. The correlation is significant at the.01 level, which is within the acceptable range given the sample size and length of the study.

Data Analysis

Descriptive statistics and inferential statistics were used to analyze the data for this study. The descriptive statistics were mean and standard deviation, whereas the inferential statistics were t tests.

The t test was used to analyze the research question because it involved the means of two groups. Shadish et al. (2002) and Schneider et al. (2007) noted that the t test can be used to determine whether there is any significant difference between the means of two groups.

Ethical Consideration

The British Educational Research Association (2011), under the Ethical Guidelines for Educational Research, Second Revision, stated that before the commencement of any study or primary research, the researcher needs to get the consent of a sample of the target population. In addition, if the researcher is conducting an experiment, which is the approach of this study, the participants must first agree to be a part of the study. The participants in this study were students, and the consent of the respondents and the relevant education authorities was sought. If after a participant has consented, he or she wishes to withdraw his or her responses and opt out of the study, this will be facilitated, and their pretestand post-test scores will be removed from the data analysis. The researcher followed all ethical principles guiding the conduct of an experiment. During the analysis, conclusions were reached, and the objective interpretation of the data was shared with all participants.

Result and Discussion

An independent sample t-test was used to determine whether any significant differences existed between the pre-test mean scores of both the control and experimental groups.

Table 1 Results of the independent sample*t*-test on the pre-test of both groups.

Group	mean	SD	t-value	sig. (2 tailed)
Control	6.40	1.536	.420	.507

Experimental	6.20	1.473

t-value significant at p < .05

Table 1 shows that the control group obtained a mean score of 6.4, while the experimental group obtained a mean score of 6.2. The mean scores for the standard deviation were 1.536 and 1.473, respectively, with a mean difference of 0.2. Nevertheless, the p value was 0.507 (p >.05), indicating that the difference between the two groups' mean scores was not statistically significant.

Before the treatment was given, the knowledge and skills of the students in the control group and the experimental group were about the same.

Table 2 Results of the independent sample*t*-test on the post - test of both groups.

Group	mean	SD	t-value	sig. (2 tailed)
Control	11.9	2.594	5.114	0.000*
Experimental	15.8	2.212		

t-value significant (*) at p < .05

An independent sample t-test was used to see if there were any significant differences in the post-test mean scores of the control and experiment groups.

Table 2 reveals that the mean score for the control group was 11.9, whereas the mean score for the experimental group was 15.8. The difference in mean scores across the groups was 4.22, and the t-value was 5.114. However, the p value was low (p.05), indicating that the difference between the two groups' mean scores was statistically significant. Post-test findings demonstrated that students in the experimental group did better using GeoGebra than students in the control group using the standard learning technique.

To determine whether any significant differences existed between the pre - test mean score of control groups and experimental group, a paired sample t-test was used.

Table 3 Results of the paired sample*t*-test on the pre - testand post - test of both control and experimental group.

Pair	pre and post-test	mean	SD	t	sig. (2 tailed)
1	control	5.5	2.565	9.59	0.000
2	Experimental	9.6	2.722	15.771	0.000

t-value significant at p < .05

To compare the pre-test and post-test scores for the experimental and control groups, a paired samples t-test was used. As shown in Table 3, the mean score difference between the post-test and the pre-test for the experimental group was 9.6 compared to 5.5 for the control group. The t-value for the experimental group was 15.771, and the p-value was low (p.05), indicating that the differences between pre- and post-test scores were significant. The t-value for the control group was -9.59, and the p-value was small (p.05), indicating that the differences between the pre- and post-test scores were significant. This revealed that the scores of both the experimental and control

groups improved significantly. From these results, it's clear that both approaches helped students, but it looks like the experimental group's scores changed or got better more than the control groups.

Conclusion

The use of GeoGebra as technology played a big part in teaching and learning mathematics. As a result of this research, it has already been concluded that GeoGebra is useful in teaching postulates and theorems because its visualization, aids in the understanding of concepts. It added more complexity and increased student creativity in learning. Using GeoGebra allows students to improve their skills and knowledge, promoting the student as the center of learning and allowing the teacher to act as a facilitator. This will encourage teachers to use GeoGebra as an alternative teaching strategy to harness students' potential.

As stated in (NCTM, 2000, p21) "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". Thus, in order to enhance their skills and knowledge in mathematics is to fully equipped of technology-enabled classroom.

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