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GEOGEBRA-AIDED INSTRUCTION AND GEOMETRY LEARNING ACHIEVEMENT AMONG UNDERGRADUATE STUDENTS IN COLLEGES OF EDUCATION, GHANA

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Abstract
In colleges of education in the Volta Region of Ghana, the study looked at how well GeoGebra-assisted lessons advanced undergraduate students' learning achievement in geometry. The study used a non-equivalent control group pre-test post-test quasi-experimental research design. It was based on two study questions and two hypotheses, and it involved two intact classes. A simple random selection method was used to choose a sample size of 73 undergraduate students. Geometry Achievement Test (GAT), a validated instrument, was used to gather data on student learning achievement. The reliability coefficient of GAT was calculated using the Kuder-Richardson formula 21 and was found to be 0.87. The analysis of covariance (ANCOVA) was used to test the hypotheses at the 0.05 level of significance and the mean and standard deviation were utilised to answer the study's questions. The results of the study showed that undergraduate students who learnt geometry through diagram-aided instruction (DAI) fared less well than those who did so with GeoGebra-aided instruction (GAI). The study's findings confirmed that there is no significant difference in learning achievement between undergraduate male and female students in GAI. As a result, it is advised, among other things, that the GAI be used to teach geometry to students in Ghanaian educational institutions.

Keywords: GeoGebra-aided instruction, Diagram-Aided Instruction, Undergraduate, Students, Achievement

Introduction

Geometry is a discipline of mathematics that encourages people to appreciate the world around them. The ancient Greeks referred to geometry as 'earth measure.' Geometry was known to the ancient Greeks as 'geometreo,' with 'geo' standing for 'earth' and 'metreo' standing for 'measure.' Geometry is seen as a field of reflection that supports a variety of approaches to solving mathematics problems and understanding the world in both natural and artificial settings (Gamboa & Ballestero, 2009). It also plays a significant role in daily life because it naturally occurs in the solar system's architecture, as well as in plants, flowers, and animals as well as in geological formations like rocks and crystals (Lie & Hafizah, 2008). Furthermore, according to Jones (2002), students' ability to visualise, think critically, anticipate, solve problems, generate hypotheses, use deductive reasoning, and make logical arguments throughout testing and demonstration processes is facilitated by geometry. Geometry, as a part of mathematics, is also important for improving students' spatial awareness, intuition, visualization, and problem-solving ability. The National Council of Teachers of Mathematics (2000) also emphasized the importance of geometry as a fundamental component of mathematics education, claiming that every student needs a basic understanding of geometry to succeed in school and in real-life situations because it allows people to interpret and reflect on their surroundings.

Despite the prominence of Geometry as a part of mathematics, both teachers and students find it difficult to teach and study (National Council of Teachers of Mathematics, 2009). Concerns concerning pupils' geometric thinking levels in Ghanaian schools and institutions were raised by research findings (Baffoe & Mereku, 2010). The student teachers' presentations of solutions to the majority of geometrical problems were subpar, according to the annual reports of the Chief Examiners for the End-of-Second-Semester Mathematics Examination in geometry at the College of Education level in 2011 and 2012 (the University of Cape Coast, Institute of Education, 2011; 2012). Similarly, according to the Chief Examiners' findings from 2013 and 2014 candidates lacked sufficient knowledge of geometry and the application of geometric concepts (the University of Cape Coast, Institute of Education, 2013; the University of Cape Coast, Institute of Education, 2014),. Most students failed to develop geometric problem-solving skills and build the required comprehension of geometric ideas, resulting in poor performance in geometry. Students' poor performance in geometry is related to teachers' failure to use efficient and appropriate instructional approaches that would interest students and assist them develop their geometric thinking (Alex & Mammen, 2012). Most Ghanaian student-teachers, according to researchers (Armah et al., 2017), have a poor knowledge of geometry, and students' poor academic performance in geometry may be related to their belief that geometry is a challenging topic to study (Bikic et al., 2016). Other issues with teaching and learning geometry have also been identified by research, including issues with teachers' pedagogy, students' lack of enthusiasm in geometry, their lack of comprehension of geometrical concepts, and their lack of use of technology (Dinayusadewi & Agutika, 2020; Ngirishi, 2015). Students' geometry academic performance was also rated as bad due to their lack of comprehension of geometric concepts, failure to recognize the interrelationships between geometric qualities, shapes, and procedural and conceptual understanding (Ngirishi, 2015). The notion of students' performance in geometry is also described as unsatisfactory, as the Chief Examiners' Reports from May/June (WAEC, 2010, 2011) demonstrated that students' performance in geometry is not satisfactory. Lack of background knowledge, poor geometric reasoning abilities, difficulty understanding geometric language, difficulty visualising, teachers' teaching strategies, lack of instructional materials, and other factors are some of the causes of students having trouble learning geometry, according to researchers. (Aysen, 2012; Noraini, 2006)

According to research findings, gender has an impact on students' ability to understand geometry. Ominrin (2009) contends that female students outperformed male students in geometry, despite research finding that male students outperformed female students (Baharvand, 2001; Uduosoro, 2011). In accordance with a related study, male and female students demonstrate equal proficiency in geometry (Gbodi & Olaleye, 2006; Adegun & Adegun, 2013). Learning geometry is a difficult cognitive task for students. According to Royati et al. (2010) and the Chief Examiners' Reports of the West African Examination Council (WAEC) from 2014 and 2015, most students performed poorly on tasks relating to geometry. Correspondingly, the concept of students' learning achievement in geometry was rated as very low, as Telima (2012) hypothesized that students failed to grasp key concepts in geometry, and likewise indicated that the learning of geometry is assumed to be difficult due to geometric language, visualizing abilities, and the teacher's instructional strategy (Aysen, 2012; Noraini, 2006).

At St. Teresa's College in Hohoe, Ghana, Kumah and Wonu (2020) investigated how the GeoGebra-Plus-Lecture model affected students' performance in basic algebra. The researchers only utilised a post-test quasi-experimental study design and a sample size of 58 pupils. The children were given a 13-item Elementary Algebra Test (EAT), which was used to gather the data. Using Kuder-Richardson KR-21, the EAT's dependability was examined; the resultant coefficient was 0.81. The study's findings revealed that the GeoGebra-Plus-Lecture Model had a significant impact on students' elementary algebra achievement in favour of the experimental group. In a parallel study, Oti and George (2020) looked at the effects of the GeoGebra software suite on senior secondary pupils with dyscalculia in Bayelsa State, Nigeria. The quasi-experimental pre-test and post-test research were used. The students' data was collected using an achievement test. The validity of the instrument was guaranteed by exposing the items to specialists in mathematics education. Kuder-Richardson (KR-21) was used to determine the instrument's reliability and achieve a reliability coefficient of 0.80. Thirty-eight (38) public senior secondary students with dyscalculia were chosen using the purposive sample technique. The mean, standard deviation and analysis of covariance at 0.05 significant level were used for data analysis. The study found that using the GeoGebra software package enhanced dyscalculic learners' trigonometry proficiency compared to those who were taught using the deductive teaching method.

Mukamba and Makamure (2020) looked into how the GeoGebra software program could be used to teach and learn geometric transformations at a basic level in Zimbabwe. The researchers utilized a mixed-technique approach to their investigation. Two (2) mathematics teachers and fifty-four (54) students were chosen using the purposive sampling technique. For data collection, tests (pre-and post-test) were used, as well as semi-structured interviews. Inferential (t-test) and descriptive statistics were used to analyze the data. The study found that, while the traditional method increased learners' performance in Geometric Transformations, the usage of the GeoGebra software package enhanced their performance even more.

Ihechukwu and Chidi (2020) looked into how GeoGebra software affected pupils' achievement in geometry. In this quasi-experimental study, a pre-test post-test non-equivalent control design was employed. A total of 114 senior secondary two (2) students were selected for the study utilising simple random sampling and selective sampling methods. Purposive sampling was used to select two (2) intact SS2 classes, and simple random selection was used to assign the experimental and control groups at random. Data were collected through tests, and the reliability of the equipment was assessed using Kuder-(KR-20) Richardson's formula. The reliability coefficient for the research tool was 0.80. With the help of descriptive statistics (mean and standard deviation) and inferential statistics (ANCOVA), the hypotheses were tested at the 0.05 level of significance. The study discovered that GeoGebra software improved students' academic achievement in geometry regardless of gender when compared to conventional teaching techniques. Similar to this, Hamzeh (2020) examined the impact of using the GeoGebra software to teach geometry lessons on the degree and kind of three-dimensional engagement of students at Mount Lebanon Governate. A sample size of thirty-four (34) eighth-graders was chosen using a purposive sampling procedure for this quasi-experimental mixed-method study. Data were gathered using research instruments, achievement tests (pre- and post-tests), and semi-structured interviews. Calculated Cronbach's alpha coefficients for internal consistency and dependability showed that inter-item reliability was adequate. In Statistical Package for Social Sciences, descriptive and inferential statistics (independent sample t-test at 0.05 level of significance) were used to evaluate the data. In comparison to the traditional method of instruction, the investigation demonstrated that GeeoGebra software package instruction influenced students' involvement in Geometry lessons.

Asare (2019) looked into the possibility of using GeoGebra software to enhance rigid motion instruction and learning in Ghanaian senior high schools. It was conducted using a mixed-methods study approach that combined qualitative and quantitative information. The forty-five (45) participating students were chosen from the two (2) form two (2) science courses using simple random sampling approaches. Two research instruments, test items and interviews were used to collect data. The pre-test and post-test were administered to the same group of forty-five students in order to reduce any further intervening influences between the control and experimental groups. The data were examined using descriptive statistics (percentages, mean, and standard deviation) and inferential statistics (t-test) of the test results using a statistical package for social sciences (SPSS) programme. Students' interview replies were transcribed and analyzed using SPSS. Test-retest was also used to ensure the dependability of test items. The Pearson Correlation analysis of the pilot test data revealed a positive Pearson Product Moment Correlation Coefficient of 0.825, indicating a significant association, and thus the instrument was deemed dependable. By explaining the research tools to professional colleagues and supervisors, the construct and content validity of the test items and interviews were ensured. The study found that using the GeoGebra program improved students' knowledge of arithmetic concepts and improved their performance when compared to traditional teaching methods.

The effect of dynamic geometry computer software (GeoGebra) on learners' performance in geometry was examined by Adelabu et al. (2019) in Tshwane South, Gauteng Province, South Africa. Pre-posttesting and a non-equivalent quasi-experimental control group design were utilised in the study. Eighty-seven ordinary grade nine pupils were chosen for the study using convenience and purposive sampling procedures. The Geometry Mathematics Achievement Test (GMAT) was used to collect the data. Cronbach's alpha was used to gauge the reliability of the GMAT, and it was found to be 0.9. Microsoft Excel 2016 was used to analyse the data using descriptive statistics and a statistical t-test independent sample at the 0.05 level of significance. The study found that using the GeoGebra software package improved female students' learning achievement more than male students. The effect of GeoGebra software on secondary school pupils' Geometry achievement in Kenya's Kajiado County was also examined by Mukiri (2016). A mixed-methods strategy was adopted for the study, which combined qualitative and quantitative research. Seven secondary school students were chosen as the sample size through the use of purposeful sampling. Data were gathered using a questionnaire, an achievement exam (pre-posttest), and three research instruments: observation and testing. The reliability of the pre-posttest was assessed using a split-half reliability index, which produced a reliability coefficient of 0.84. The reliability of the instrument was confirmed using the Cronbach test, and an alpha value of 0.79 was discovered. The validity of the instruments

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was established using triangulation. The data was examined using split-plot analysis of variance, or ANOVA, to test the hypotheses at a statistically significant threshold of 0.05. The study's conclusions show that using GeoGebra software had no discernible impact on gender differences in students' performance in geometry.

Gamage and Charles-Ogan (2019) looked into pupils' abilities to learn and understand circular geometry using GeoGebra software in Yenagoa Local Government Area, Bayelsa State. Pre-post tests and a quasi-experimental research design were employed in the study. Using the purposive sampling technique, a sample size of 117 students from the second year of secondary school (SS. Data was gathered using the Geometry Performance Test (GPT). The instrument's reliability was calculated using the test-retest method to be 0.75. The data were analysed using the mean, standard deviation, and analysis of covariance. The findings showed that utilising GeoGebra to teach circle geometry to pupils did not significantly differ in mean performance between male and female students. The effect of the GeoGebra software package on students' performance in Geometric Transformations and attitudes towards learning mathematics through technology in Zambia was examined by Bwalya (2019). Bwalya used a 66-person sample size and a random sampling technique in a quasi-experimental research design. The Geometric Transformations Pre-Test (GTPreT), Geometric Transformations Post-Test (GTPT), and Mathematics and Technology Attitude Scale (MTAS) were employed by the researchers to gather their data. Based on the Zambian Mathematics Syllabus under geometric transformation, the researcher designed a pre-test and post-test that included knowledge, understanding, and application levels. A scale measuring attitudes towards mathematics and technology was also employed. The data were evaluated using descriptive statistics and independent samples t-test statistics. The results showed that male and female students in the experimental group performed comparably. The effects of GeoGebra software on Malaysian students' conceptual and procedural understanding as they studied the function topic in mathematics were also examined by Zulnaidi et al. (2017). A quasi-experimental research approach was adopted for the investigation. A total of 345 students were selected for the study utilising random and purposive sampling techniques with complete classes. The data was gathered via achievement examinations. The Conceptual Knowledge Test items' reliability was 0.82, and the Procedural Knowledge Test questions' reliability was 0.833. The data were analysed using Multivariate Analysis of Variance (MANOVA). The results showed that both male and female students had an equal level of conceptual and procedural understanding.

Statement of the Problem

The learning achievement of students in geometry appears to be dwindling despite different interventions put in place by varied researchers in mathematics education to improve student-learning achievement. The substandard learning achievement of students had been attributed to factors such as students' discernment that geometry is difficult, teachers' use of passive instructional method which fails to support students' learning style, and students' lack of interest in geometry among others (Dinayusadewi & Agutika, 2020; West African Examination Council Chief Examiners' Report, 2010; 2017; 2018).

Aim and objectives of the study

The study aimed to investigate the effect of GeoGebra-aided instruction on students' learning achievement in geometry. The study was specifically intended to;

1. Examine the difference in the learning achievement between the students taught Geometry using the GeoGebra-aided instruction (GAI) and those taught using diagram-aided instruction (DAI).
2. Find out the difference in the learning achievement between the male and female students taught Geometry using the GeoGebra-aided instruction.

Research Questions

The study was guided by the following research questions;

1. What is the difference in the learning achievement between the students taught Geometry using the GeoGebra-aided instruction and those taught using diagram-aided instruction?
2. What is the difference in the learning achievement between the male and female students taught Geometry using GeoGebra-aided instruction?

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Hypotheses

The following hypotheses were tested at a 0.05 level of significance;

H_{01}: There is no significant difference in the learning achievement between the students taught Geometry using the GeoGebra-aided instruction and those taught using diagram-aided instruction.

H_{02}: There is no significant difference in the learning achievement between the male and female students taught Geometry using GeoGebra-aided instruction.

Methodology

In a quasi-experimental pre-test post-test non-equivalent control group research design, two intact classes were used in the investigation. A sample size of 73 mathematics students was established using easy random sampling techniques with a purpose. The tool used to collect the data was the Geometry Achievement Test (GAT). The GAT had 20 multiple-choice questions with answers from A to D covering the fundamentals of geometry that were covered in class, as well as a closed-ended question to gauge the gender of undergraduate students. There was just one correct answer and several distracting possibilities for each of the 20 multiple-choice questions' components. Each right response received five (5) points, while a wrong response received zero (0) points. Experts determined the validity of the instruments, and the Kuder-Richardson formula 21 (KR-21) was used to calculate the reliability coefficient of GAI, which was 0.87. Additionally, information regarding the sample's learning progress in geometry was gathered utilising a modified four-phase instrument administration method. Table 1 displays the research approach.

Table 1: Quasi-experimental design

Group	Pre-test	Treatment	Post-test
E	Q_1	X_{GAI}	Q_2
C	Q_1	X_{DAI}	Q_2

Where;

E = Experimental Group, X_{GAI} = GeoGebra-Aided Instruction

C = Control Group, X_{DAI} = Diagram-Aided Instruction

Q_1 = Pre- (GAT) Q_2 = Post- (GAT)

Data collection procedure

The data collection procedure involved orientation of research assistants, pre-test, GeoGebra-aided Instruction, Diagram-aided Instruction, and post-test as shown in Table 2

Table 2: shows the data collection procedure

S/N	Experimental Group	Control Group	Treatment
1.	+	+	Pre-test (GAI)
2.	+	-	GeoGebra-aided Instruction
3.	-	+	Diagram-aided Instruction
4.	+	+	Post-test (GAI)

The data collection procedure involved orientation for the research assistant, pre-test, GeoGebra-aided instruction, diagram-aided instruction, and post-test. For effective and efficient data collection, the research assistant was thoroughly briefed on the research design, the GeoGebra-aided instruction and the diagram-aided instruction. The orientation was followed by the pre-test (GAI) administration to both the experimental and the control groups which were collected for marking after 35 minutes. The experimental group was then given a three-week course in geometry using GeoGebra. The control group acquired the same Geometry content over the course of three weeks via diagrams, much like the experimental group. As a result, the post-test (GAI) was administered to both the experimental and control groups. The scripts were also collected for marking after 35 minutes of task. To address the study difficulties, the data was analysed using mean and standard deviations while the hypotheses were evaluated using Analysis of Covariance (ANCOVA) at the 0.05 level of significance.

Results

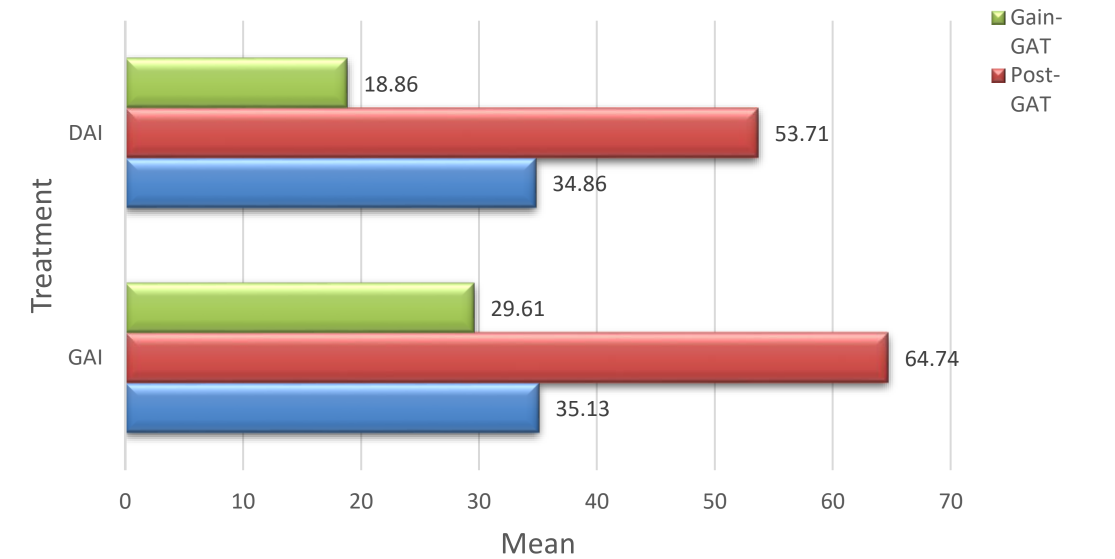

Fig. 1: Mean variations in the GAT scores based on treatments

Figure 1 and Table 3 (appendices) display the summary of descriptive statistics on the learning achievement gap between undergraduate students taught geometry using diagram-aided instruction (DAI) and those taught using GeoGebra-assisted instruction (GAI). It shows that the Pre-GAT mean score of students who learned using the GeoGebra-aided instruction was 35.13, SD=7.75 whereas their mean Post-GAT was 64.74, SD=7.25 and their mean Gain-GAT score was 29.61, SD=10.49. On the other hand, the Pre-GAT mean score of students who taught using the diagram-aided instruction (DAI) was 34.86, SD=7.22 whereas their mean Post-GAT was 53.71, SD=5.60 and their mean Gain-GAT score was 18.86, SD=5.30.

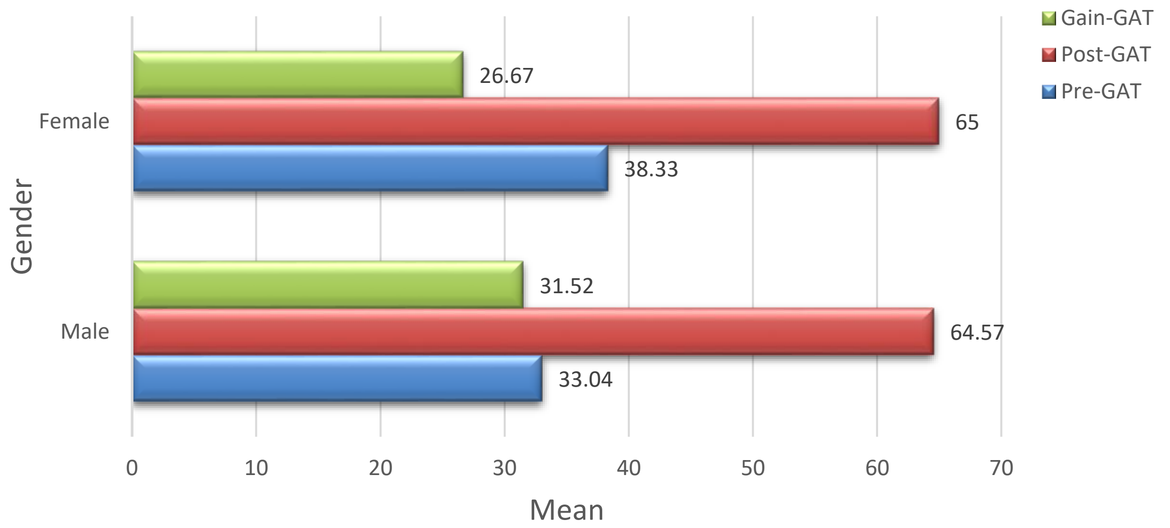

Fig. 2: Mean variations in the GAT scores for the experimental group based on gender

When undergraduate students were taught geometry using GeoGebra-assisted teaching, the results from Table 4(appendices) and Figure 2 provide the summary of descriptive statistics on the difference in learning achievement between the male and female students. It demonstrates that male students who learnt using GeoGebra-assisted instruction had a mean Pre-GAT score of 33.04, SD=6.87, a mean Post-GAT score of 64.57, SD=8.52, and a mean Gain-GAT score of 31.52, SD=11.12. On the other hand, the Pre-GAT mean score of female students who taught using the same method was 38.33, SD=8.16 whereas their mean Post-GAT was 65.00, SD=5.00 and their mean Gain-GAT score was 26.67, SD=9.00.

Table 5: Summary of Analysis of Covariance (ANCOVA) on the difference in the learning achievement between undergraduate students taught Geometry using the GAI and those taught with the DAI

Source	SS	df	MS	F	Sig.	η^2
Corrected Model	2461.106[a]	2	1230.553	31.131	.000	.471
Intercept	7975.983	1	7975.983	201.779	.000	.742
Pre-GAT	247.535	1	247.535	6.262	.015	.082
Treatment	2185.481	1	2185.481	55.289	.000	.441
Error	2766.976	70	39.528			
Total	263250.000	73				
Corrected Total	5228.082	72				

a. R Squared = .471 (Adjusted R Squared = .456)

Table 5's result displays an ANCOVA summary of the learning achievement gap between undergraduate students who received Geometry education using GeoGebra and those who received diagram-based instruction. The result indicated an F-calculated value of 55.289, a p-value of 0.00 and η^2 =0.441. This shows a moderate Partial Eta effect-size value of 44.1%. The findings showed that undergraduate students who were taught geometry using diagram-aided teaching and those who were taught using GeoGebra had significantly different learning performance($F_{1, 70}$=55.289, p=0.00). At a significance level of.05, the null hypothesis one was rejected.

Table 6: Summary of ANCOVA on the difference in the learning achievement between the male and the female undergraduate students taught using GAI

Source	SS	df	MS	F	Sig.	η^2
Corrected Model	2.186[b]	2	1.093	.020	.981	.001
Intercept	6121.434	1	6121.434	110.144	.000	.759
Pre-GAT	.470	1	.470	.008	.927	.000
Gender	1.003	1	1.003	.018	.894	.001
Error	1945.182	35	55.577			
Total	161200.000	38				
Corrected Total	1947.368	37				

a. Treatment = GAI

b. R Squared = .001 (Adjusted R Squared = -.056)

Table 6's outcome displays an ANCOVA summary of the learning achievement gap between male and female undergraduate students who were taught geometry using GeoGebra-assisted instruction. The result indicated an F-calculated value of 0.018, a p-value of 0.894 and η^2 =0.001. This shows a very low Partial Eta effect-size value of 0.1%. The findings showed that there is no statistically significant difference in the learning performance of undergraduate students who were taught geometry using GeoGebra ($F_{1, 35}$=0.018, p=0.894). The null hypothesis, two was retained at a 0.05 level of significance.

Discussion of findings

According to Table 3, there was a mean-GAT score difference of 10.75 in favour of the GAI among students who were taught using the GAI against those who were taught using the DAI. The ANCOVA result in Table 5 demonstrated a moderate Partial Eta effect-size value of 44.1% when put to the test statistically. This demonstrated a significant learning achievement difference between undergraduate students taught geometry using GeoGebra-aided instruction and those taught using diagram-aided instruction ($F_{1, 70}$=55.289, p=0.00), favouring the undergraduate students taught using GeoGebra-aided instruction. At a significance level of 0.05, the null hypothesis one was rejected. This finding is consistent with some earlier findings that showed that students who were taught mathematics using GeoGebra-aided instruction and those who were taught using diagram-aided instruction had significantly higher learning achievement in the experimental group. (Tay & Mensah-Wonkyi, 2018; Asare, 2019; Ajaegba & Ekwume, 2019; Aliyu, 2019; Kumah & Wonu,2020; Oti & George, 2020; Mukamba & Makamure, 2020; Ihechukwu & Chidi, 2020; Salifu, 2020; Hamzeh, 2020; Salihu et al., 2020)

The results from Table 4indicated that male undergraduate students who learnt using the GAI had a mean gain-GAT score fluctuation that was 4.85 points higher than that of female undergraduate students. The data in Table 6 exhibited a very small Partial Eta effect-size value of 0.1% when put to statistical test using the ANCOVA. The results showed that male and female undergraduate students showed similar interest in learning geometry when taught using GeoGebra-aided instruction ($F_{1, 35}$=0.018, p=0.894), indicating that there is no significant difference in learning achievement between the genders when taught geometry using GeoGebra-aided instruction. The second null hypothesis was retained at a 0.05 level of significance. This finding is in agreement with earlier findings which established that there is no significant difference in the learning achievement between the male and the female students in Mathematics(Emaikwu et al., 2015; Mukiri, 2016; Onaifoh & Ekwueme, 2017; Zulnaidi et al., 2017; Bwalya, 2019; Gamage & Charles-Ogan, 2019; Abari et al., 2019; Ihechukwu & Chidi, 2020; Oti & George, 2020). The results are in contrast to a previous study which indicated a significant difference between male and female students' learning achievement in mathematics (Adelabu et al., 2019).

Conclusion

The learning achievement of students in geometry needs much to be desired following its effect on their overall academic performance in mathematics. Findings from researchers in mathematics education have established students' appalling learning achievement in geometry as a result of the abstract nature of geometry, students' enmity towards the study of geometry and their perception that the study of geometry is difficult among other factors. The researchers employed GeoGebra-aided instruction to potentially improve students' learning achievement in geometry as a result of the variables working against geometry learning achievement. The study's findings showed that GeoGebra, regardless of gender, had a favourable impact on undergraduate students' learning achievement in geometry. Besides, the effective use of the GeoGebra-aided instruction also showed that students' learning achievement in geometry fails to depend on gender. The study's results also highlighted the lack of a statistically significant gender difference in acquiring geometry abilities. Similarly, the result of the study as well indicated that GeoGebra-aided instruction is capable of reducing the abstract nature of geometry to promote student-learning outcomes, eradicating students' perceived difficulties of the subject, minimising teacher's challenges of explaining abstract geometric concepts, stimulating students' active involvement in the learning process and enhances students' ability to create. It is reasonable to conclude that using GeoGebra effectively to teach geometry to students improved their learning achievement and eliminated gender disparities in geometry learning achievement.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Mathematics educators may embrace the use of GeoGebra-aided instruction in facilitating geometry teaching in Colleges of Education, Senior/Junior High and primary schools.
2. Mathematics educationalists may accept the use of GeoGebra-aided instruction in geometry teaching to avoid gender discrimination in learning achievement among students of mathematics.

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Appendices

Table 3: Summary of descriptive statistics on the difference in the learning achievement between undergraduate students taught Geometry using the GAI and those taught using DAI

		Pre-GAT		**Post-GAT**		**Gain-GAT**	
Treatment	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
GAI	38	35.13	7.75	64.74	7.25	29.61	10.49
DAI	35	34.86	7.22	53.71	5.60	18.86	5.30

Table 4 Summary of descriptive statistics on the difference in the learning achievement between the male and the female undergraduate students taught Geometry using GeoGebra-aided instruction (GAI)

		Pre-GAT		**Post-GAT**		**Gain-GAT**	
Gender	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Male	23	33.04	6.87	64.57	8.52	31.52	11.12
Female	15	38.33	8.16	65.00	5.00	26.67	9.00