

USES OF GEOGEBRA SOFTWARE TO IMPROVE GEOMETRY LEARNING OUTCOME AMONG UPPER PRIMARY SCHOOL PUPILS' IN MINNA, NIGER STATE.

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ABSTRACT: This study employs a quasi-experimental research design of pre-test and post-test within group on the uses of GeoGebra software to improve Geometry learning outcome among upper primary school pupils in Minna, Niger State. An intact class of Basic 5 pupils participated in the study which comprises of 15 pupils. Three instruments were used in this study; the treatment instrument, Geometry Achievement Test (GAT) and the Pupils' Motivation Questionnaire (PMQ) which were validated by experts in Mathematics education from the department of Science Education, Abubakar Tafawa Balewa University, Bauchi, Bauchi State. The Geometry Achievement Test (GAT) yielded a reliability coefficient of 0.73 and the Pupils' Motivation Questionnaire (PMQ) yielded a reliability coefficient of 0.78 which was established through split half and Cronbach Alpha formulas. Data was collected in three phases; before, during and after the GeoGebra intervention. The GAT measured pupils' performance before and after the lessons, while the PMQ assessed their motivation immediately after the intervention. Mean, standard deviation and pairwise t- test was used to analyze the data. The findings revealed that uses of GeoGebra software in teaching geometry improves pupils' geometry achievement and motivation. Pupils were highly motivated while using GeoGebra software to solve geometry. They solve different problems in geometry and requested to try more using the software. The study concluded that GeoGebra software enhanced the pupil's enthusiasm in learning geometry. Therefore, mathematics teachers should integrate GeoGebra software in teaching and learning of Mathematics in primary schools.

KEYWORDS: Uses of GeoGebra, Geometry, Primary Pupils, Achievement, Motivation.

I. INTRODUCTION

Mathematics is a compulsory subject in Nigerian primary schools and serves as a fundamental tool for human and national development (Yeh et al., 2019). However, pupils' achievement in mathematics has remained a major concern for decades. Many primary school pupils perceive mathematics as a difficult subject, a challenge often attributed to conventional teacher-centered methods of instruction (Chinn, 2020). With the emergence of technology in education, several studies have shown that digital tools can enhance students' understanding, engagement, and motivation in learning mathematics (Kelley et al., 2020; Rashidov, 2020). Among various technological innovations, GeoGebra has gained recognition as a dynamic mathematics software designed to link geometry and algebra for effective conceptual understanding. GeoGebra software was developed by Markus Hohenwarter in 2001. It provides an interactive environment for modeling, visualization, and problem-solving in mathematics (Hohenwarter & Fuchs, 2004; Majerek, 2014). Geometry, one of the most visual and practical branches of mathematics, remains difficult for many pupils to grasp due to its abstract nature and the limitations of traditional instructional methods (Surynkova, 2011). GeoGebra provides a platform for pupils to explore geometric shapes dynamically, test ideas, and visualize relationships, thereby deepening conceptual understanding and encouraging active participation.

Despite these advantages, the use of GeoGebra in teaching geometry at the upper primary school level in Nigeria remains limited due to lack of awareness, training, and resources. In response, this study investigates the use of GeoGebra software to improve geometry learning outcomes among upper primary school pupils in Minna, Niger State. Specifically, it examines pupils' mean achievement scores before and after using GeoGebra and explores how the software influences their motivation toward learning geometry. The study focuses on Basic 5 pupils and selected topics such as types of angles, triangles, quadrilaterals, perimeter, and area of plane shapes, all aligned with the Nigerian primary mathematics curriculum. It is expected to guide teachers, school administrators, and policymakers in adopting technology-driven teaching approaches that enhance pupils' understanding, engagement, and overall performance in mathematics.

II. LITERATURE REVIEW

This study reviewed relevant studies on the uses of GeoGebra software to improve geometry learning outcomes among upper primary school pupils in Minna, Niger State. For instance, the work of Udofia and Uko (2018) investigated the effectiveness of GeoGebra instructional package on students' performance in secondary school mathematics. The study was guided by six research questions and six null hypotheses. The research design was quasi experimental, specifically the pre –test, post-test non-randomized control groups design was used. They found that GeoGebra Mathematics software enhanced more and significantly the performances of students in Mathematics than demonstration method in Akwa Ibom state. In another study, Ajaegba and Ekwueme (2019) found that there is significant difference in the mean performance scores of pupils who use GeoGebra in learning geometry and conventional method. In a cyclic geometry, Gamage and Charles-Ogan (2019) investigated the application of GeoGebra software and students' performance. The study was guided by two objectives, two research questions and two null hypotheses which were tested at .05 alpha level. The pretest-posttest quasi-experimental research design was employed for the study. The result further showed that there was a significant difference between the mean performance of students taught circle geometry using GeoGebra and those taught using the traditional method. Also, Ibibo and Tubona (2019) investigated Students' Perception and Performance across ability levels on GeoGebra Software usage in Learning of Circle Geometry. The study was guided by two research questions and two null hypotheses which were tested at .05 alpha level. Descriptive and quasi-experimental research design was used. The study revealed that students of all ability levels benefitted from the use of GeoGebra software in the teaching and learning of circle geometry and that they had a positive perception on the use of GeoGebra software for the teaching and learning of circle geometry. Mamman and Surajo (2021) investigated the effect of GeoGebra software on attitude and achievement in circle geometry among first year students of Kano University of Science and Technology Wudil, Kano state – Nigeria. The results of the study revealed that students taught with GeoGebra software (experimental group) performed better than students taught with traditional teaching method. It was also discovered that within the experimental group, the attitude of the students was found to be enhanced significantly. Also, Adelabu et al (2022) investigated the use of GeoGebra software in teaching and learning circle geometry enhancing Grade 11 learners' academic achievement in South Africa. The result of the study showed that between the experimental and control groups, that there were statistically significant differences after using GeoGebra software to teach.

Furthermore, Hamzeh (2020) investigated the impact of using GeoGebra software on the level and type of student engagement in learning Geometry. This study adopted a mixed-method research design. The research findings strongly suggest that GeoGebra positively impacted eighth-graders' engagement in learning geometry. Prajapati (2021) researched on the effectiveness of GeoGebra in teaching and learning Geometry. The result of the research shows that students gave positive feedback or view toward the GeoGebra software in teaching geometry. In another study, Narh-Kert and Sabtiwu (2022) researched on the use GeoGebra in the teaching and learning of Geometry among mathematics education students as well as in-service teachers, using an action research approach. The purposive sampling technique was used to

select two public tertiary institutions for the study. The finding showed that there is a statistically significant improvement in the students' scores and interest in the learning, as well as the teaching of Geometry. Tetteh et al. (2022) researched on the impact of using GeoGebra software in teaching and learning transformation (Rigid motion) on senior high school student's achievement. A mixed method approach using both qualitative and quantitative research approaches was used for this study. The study's findings made it abundantly evident that GeoGebra had improved students' knowledge of transformation principles and, consequently, their performance. Ekwue et al (2023) also investigated the effectiveness of GeoGebra application on geometrical mathematics among secondary school students in Delta state. The result of the findings showed that GeoGebra makes the teaching and learning of mathematics fun and enjoyable. Despite the identified benefits of GeoGebra software in teaching mathematics, the concentration was majorly on secondary school and preservice students. Thereby creating a gap on the area of primary pupils' mathematics education. Traditional teaching methods, which are often limited to textbook illustrations and teacher-centered instruction, have not been effective in stimulating pupils' engagement or improving their achievement in geometry among primary school pupils. As a result, pupils frequently exhibit low motivation, poor spatial reasoning, and limited engagement during geometry lessons. Therefore, this study contributed to knowledge to investigate the uses of GeoGebra software to improve geometry learning outcome among upper primary school pupils in Minna, Niger state.

III. METHODOLOGY

This study adopted a quasi-experimental research design involving a pretest-posttest experimental group. The design was selected to determine the effect of using GeoGebra software on Basic 5 pupils' learning outcome in geometry. The quasi-experimental approach is suitable since the pupils could not be randomly assigned to the group, an intact class of basic 5 pupils was used. This enables the researcher to compare the learning outcome of the pupils before and after. The pupils were exposed to basic geometry concepts such as plane shapes, angles, Triangles, Polygons, as prescribed in the National Mathematics Curriculum. Sixteen pupils participated in the study. They were informed that they could be removed from this study if they do not want to participate or discontinue at any time. Purposive sampling was used to ensure a better match between the sample and the aims and objectives of the research, thus improving the rigour of the study and trustworthiness of the data and results. The selection of the school and participants were purposively selected due to the availability of basic ICT facilities, the co-educational nature of the school, cooperation from the school administration, and access to a functional computer laboratory and the participants. Two instruments were developed and used for data collection:

(a). Geometry Achievement Test (GAT)

A 20-item multiple-choice test was developed by researchers from Primary 5 mathematics curriculum, focusing on geometry topics such as types of Angles, Measuring angles, types of Triangles, Properties of Quadrilaterals, and polygons. The test was administered before and after the intervention to measure pupils' academic achievement.

(b). Pupils' Motivation Questionnaire (PMQ)

A 15-item structured questionnaire on a 4-point Likert scale (Strongly Agree to Strongly Disagree) designed to assess pupils' motivation such as interest, engagement, enjoyment, and willingness to use GeoGebra software in mathematics learning.

The two instruments used for this study were validated by two experts in science education and research methodology to ensure that the items are relevant, appropriate for Basic 5 pupils, and aligned with the objectives of the study. The feedback received from the experts led to necessary modifications in the structure and content of the test and questionnaire to improve clarity, age-appropriateness, and content coverage. This validation process ensured that the instruments are relevant for the study. The reliability of the instruments; the Geometry Achievement Test (GAT) and the Pupils' Motivation Questionnaire (PMQ) was established through internal consistency measures. A 0.69 reliability coefficient was obtained using Kuder-Richardson 21

Similarly, the Pupils’ Motivation Questionnaire, designed using a 4-point Likert scale, was adapted from Aybek and Toraman (2022). They have demonstrated acceptable reliability of 0.78 using Cronbach’s Alpha. Mean and standard deviation was used to answer the research questions. The decision rule was an average mean value of 4 points modified Likert-scale, any mean score above 2.50 was considered High Motivation and any mean score below 2.50 was considered Low motivation. While paired sample t-test was used to test the formulated null hypothesis at 0.05 Alpha level of significance.

IV. RESULTS AND DISCUSSION

Table 1 shows that pupils had a mean score of 11.00 with a standard deviation of 2.449 before using GeoGebra software. However, after they used GeoGebra software, their mean score increased to 18.00 with a standard deviation of 0.000. This result indicates a substantial improvement in pupils’ academic achievement after the use GeoGebra with a mean gain of 7.0. The standard deviation of 0.000 further suggests that pupils’ scores were highly consistent, meaning that most of them performed at a similar and improved level after using GeoGebra.

Table 1: Descriptive Statistics of Geometry Achievement Test Before and After Treatment

Categories	Mean	Std. Deviation
BEFORE	11.00	2.449
AFTER	18.00	.000

To understand the mean gain among the pupils taught geometry before and after using GeoGebra Software, paired sample t-test was computed as presented in table 2.

Table 2: Summary of Paired Sample t- Test before and after Treatment.

Categories	T	df	Paired Mean gain	Std. Deviation	p- value	Decision
AFTER BEFORE	11.068	14	7.000	2.449	.000	Reject

From the table, it can be understood that there is an improvement in the pupils learning of Geometry after using GeoGebra software with (mean = 7.0, t-value = 11.068, p- value = 0.00). This shows that there is a significant mean gain before and after the pupils were subjected to learning of geometry using GeoGebra software. The null hypothesis, which stated that there is no significant mean gain before and after was rejected. How does the use of GeoGebra software motivate upper primary school pupils to learn geometry in Minna Niger State?

Table 3: Descriptive Statistics on Pupils’ Motivation towards Learning Geometry Using GeoGebra Software

S/N	STATEMENT	Mean	Std. Deviation	Remarks
1.	I participated actively during the use of GeoGebra software in geometry lessons.	3.75	.447	High
2.	I enjoy learning geometry using GeoGebra software.	3.44	.814	High
3.	I feel confident when solving geometry problems while using the GeoGebra.	3.00	1.095	High
4.	Using GeoGebra makes learning geometry more interesting.	3.31	1.014	High

5. Using GeoGebra make me feel eager to attend mathematics classes.	3.07	1.335	High
6. I prefer using GeoGebra software because it involves activities and visual demonstrations.	3.25	.856	High
7. I pay more attention when my teacher uses teaching aids like GeoGebra.	3.56	.512	High
8. I like working with shapes and figures in mathematics.	3.33	.900	High
9. I solve geometry problems using GeoGebra.	3.38	.719	High
10. Uses of GeoGebra software motivate me to study mathematics using GeoGebra software.	3.19	.834	High
11. I would like to learn and practice more topics in mathematics using GeoGebra software.	3.44	.892	High
12. I believe uses of GeoGebra will enhance my performance in mathematics.	3.38	1.025	High
Grand Mean	3.34		Highly Motivated

Table 3 presents the mean and standard deviation of pupils' responses on how GeoGebra software motivated them to learn geometry. The mean scores range from 3.00 to 3.75, indicating that the pupils generally agreed that the use of GeoGebra software highly influenced their motivation toward learning geometry. The pupils participated actively during the use of GeoGebra software in geometry lessons with a grand mean score of 3.34, suggesting that most pupils strongly agreed that GeoGebra made learning geometry more interesting and engaging. The standard deviation values, which range between 0.447 and 1.335, indicate moderate variability in pupils' responses. This finding concurs with Ukaigwe (2022), who reported that computer-assisted instruction significantly improved students' mathematics achievement by enhancing visualization and providing immediate feedback that increased engagements. The interactive nature of the software made learning more practical, student-centered, and engaging. Contrarily, Mustafa (2014) in his study found that the Dynamic Geometry Software-assisted instruction had no significant effect on students' attitudes toward mathematics and technology in his study of transformation geometry and Etcuban (2025) reported that while GeoGebra improved performance, students' attitudes and motivations did not show a significant relationship with pre or post-performance. Therefore, these findings reaffirm the importance of integrating technology in mathematics classrooms to enhance both cognitive and affective learning outcomes. This finding is consistent with the studies of Mamman (2021), who reported that the use of interactive software such as GeoGebra enhances pupils' understanding of mathematical concepts and promotes active engagement in learning activities. Contrary to the above studies is the study of Agbo (2021) who reported no significant difference in the mean achievement scores between students taught geometry using GeoGebra and those taught using conventional method and Wonu (2023) who revealed that while some positive effects were found, the study includes hypotheses or tests where no significant difference in interest/achievement between students taught using GeoGebra-aided instruction and those taught using the traditional method.

V. CONCLUSION

Based on the findings of this study, it was established that the use of GeoGebra software significantly improves pupils' learning outcomes in geometry at the upper primary school level. GeoGebra enhances pupils' academic achievement by providing opportunities for visualization, exploration, and discovery learning. It also boosts pupils' motivation and interest in learning geometry through its interactive and

dynamic features. Therefore, integrating GeoGebra into classroom instruction offers a powerful means of addressing pupils' learning difficulties in geometry and improving their overall performance in mathematics. This study is part of undergraduate project research work and was limited to some selected primary school and pupils in Minna, Niger State. Approval for the study was obtained from the head of the department of Science Education, School of Science and Technology Education, Federal University of Technology Minna, Niger State. Informed consent was attached to the introductory section of the two instruments. The study Was conducted in a way that did not disrupt regular school activities.

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