



Effects of GeoGebra and Microsoft Mathematics Software on Students' Achievement in Calculus among Secondary School Students in Idah Education Zone

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Abstract

This study examines application of GeoGebra and Microsoft mathematics software in determining students' achievement in calculus. Two research questions and two null hypotheses guided the study. Factorial research design was used. Intact classes consisting of one hundred and sixty (160) students of SSS3 mathematics were purposively used in Kogi State Education Zone of Idah. Calculus Achievement Test (CAT) instrument was used for data collection. The CAT consisted of 30 multiple choice test items with five options (A-E) developed by the investigator to test the students' achievement in calculus. The CAT items were formed from differentiation and integration. The highest score that can be obtained on CAT is 30 and the lowest is 0. The data collected was analyzed using descriptive statistics of mean and standard deviation to answer the research questions, and the hypotheses were tested using Covariance Analysis (ANCOVA). The study found that senior secondary school students who learned calculus using GeoGebra and Microsoft Mathematics software achieved higher average scores with those taught using GeoGebra software having higher means gain, suggesting that these strategies effectively enhance student learning outcomes in calculus. Based on the results, it was recommended that mathematics educators introduce Microsoft mathematics software in their classes.

Keywords: GeoGebra software, Microsoft mathematics software, instructional strategies, and calculus

Introduction

In recent years, the integration of technology into mathematics instruction has gained significant attention as a means of improving students' understanding and performance. Despite this, many students still struggle with abstract concepts in calculus, which often leads to low achievement in the subject. Mathematics is an instructional subject that is mainly taught to develop thinking abilities, to reflect and to organize our own experiences for possible alternatives. Agwagah (2017) describes mathematics as science of counting patterns, reasoning, movement, change, shape, symmetry, regularity and position of communications. National Science Foundation (2015) opined that elementary and secondary school mathematics is the foundation of human capital that advances science and engineering research, technology

growth, innovation, and financially viable growth. Mathematics is studied under the following branches; algebra, geometry, number and numeration, statistics and calculus. Among the branches of mathematics, Calculus is a more complex branch of mathematics (Rahul, 2016). It revolves around human life, in various ways too numerous to mention. Calculus as a branch of mathematics deals with finding the properties of derivative and integral of functions by methods originally based on the summation of infinitesimal differences.

The purpose of studying calculus is simply to introduce the frame of mind to the scientific method of analysis. There are two types of calculus: differential calculus which deals with the mathematics of motion and change. Integral calculus is the branch of mathematics which

covers the accumulation of quantities such as areas under a curve (Stewart & James, 2012). Due to the relevance of calculus in achieving desired societal goals in education is presently taught as a unit in senior secondary school as directed by Nigeria Education Research Development Council (NERDC, 2007). Some of the widely used technologies in the classrooms are computers and their associated software, videos, and projectors, as they serve the purpose of instructional materials and instructional strategy for improving learning. Some of these mathematics teaching and learning software are Matlab/GNU Octave, Cantor software, Math Blaster, Geometer's sketchpad, SAGE-Free software (GPL), tux, math command, GeoGebra software and Microsoft mathematics software. Among the mathematics teaching and learning software, GeoGebra software and Microsoft mathematics software were recommended for teaching and learning of mathematics in secondary schools (Hohenwarter, 2007) and as such, necessitates their application in this study.

GeoGebra is a geometrie, algebra and calculus-integrating dynamic computer design. It has components of the Geometry Dynamics Software (DGS) and the Algebra Computer System (CAS) which operates any Java support platform. GeoGebra, available for free at www.geogebra.org, allows users to construct and animate points and functions (Dikovic, 2009). According to Thomas (2012), instructional strategy is a teaching plan outlining teacher and student roles to foster specific thought processes and achieve targeted learning goals. Instructional strategies are techniques teachers use to help students become independent strategic learners. Learning with the help of computers as instructional strategy will not only lead to development of skills and interest, but a sense of pleasure in the process of learning (Odili, 2012). Technology is highly recognized in the teaching of mathematics as an instrument and key element for supporting visualization and interactive reasoning representation, calculation, exploration and resolution of problems (Olurinola Oluwakemi, 2015). This can be done by applying the current software development that allows teachers and students to use computers without necessarily understanding the more technical hardware components. It is therefore within the purview of mathematics educators to develop and apply technological software that are more of instructional strategies. Also, innovative instructional strategies

like Microsoft mathematics software that can help students to understand the fundamental theorem of calculus.

Microsoft Mathematics software is one of the free software for teachers made by Microsoft Corporation that can be applied in mathematics teaching and learning. According to Microsoft Corporation (2016), using Microsoft Mathematics can help students both in visualizing and understanding the mathematics concepts and problems. Microsoft Mathematics program is free programming that has a representative processing framework and work dependent on scientific articulations. Studies; Williams, Charles, and Adesope (2017) showed that the GeoGebra group had significant performance compared to the Control group. Also, Rina and Yani (2014) that applying Microsoft Mathematics has the beneficial impact of educational technology to enrich the teaching of mathematics for students and to increase the achievement of students, and to become more engaged in learning activities in the classroom. Suh (2010) argued that technology is useful in helping students view mathematics less inactively and theoretically as a set of procedure that is more actively as reasoning exploring, solving problems, generating new information, and asking new questions. Microsoft Mathematics program is free programming that has a representative processing framework and work dependent on scientific articulations. Philip, Opoku, and Sampson (2016) reported that, there is a better relationship between algebraic and graphical representations with Microsoft mathematics, and that students using Microsoft mathematics are more likely to achieve higher when used as a supplementary instructional strategy to enhanced students' achievement in mathematics.

Achievement in mathematics is importantly associated with the measure of degree of passing or failing any assessment test or examination. Mathematics achievement also serves as an indicator of how well educational systems meet their objectives. High achievement rates reflect an effective educational infrastructure, capable teachers, and supportive learning environments, which are essential for developing a skilled workforce. Olatunde (2009) highlights that this impact goes beyond individual success—it influences the nation's socioeconomic future by preparing youth to participate in a globalized, technology-driven world. Thus, mathematics achievement is both a personal and societal asset, pointing to the broader health of a country's



educational and economic foundations. In contrast, Kung, and Lee (2016) posit that achievement in various disciplines, technology and mathematics is characterized by poor presentation of instruction in mathematics classroom irrespective of gender differences

Gender is a male and female sex that is socially constructed (Ewumi, 2013). Gender includes labor division, relationships between males and females, differences in positions, behaviors, and expectations. In its narrowest sense, Louis and Mistele (2012) describe gender as a social construct of being female or male. Ezeudu and Obi (2013) support the same view that gender can be used in different ways as a collection of features. Studies revealed that there exist gender gap in mathematics among males and females. Therefore, it becomes essential to involve gender, to verify gap in mathematics achievement as indicated in the 2023 and 2024 study of the WAEC Chief Examiner, by applying an innovative teaching distribution strategies that can assist close gender gap in calculus and enhanced achievement of students in mathematics.

It is usually acknowledged that one of the school system's main (if not the most significant) tasks is to create the pool of skilled labor that a country wants to develop. However, in Nigeria's secondary schools teaching and learning of mathematics has experienced a major setback from learners regardless of gender owing to poor achievement and absence of concern. This is evident in the WAEC chief examiner's report of students in Senior Secondary Certificate Examination 2023; and 2024, especially in calculus as a branch of mathematics. Therefore, it is necessary to determine how to enhance teaching and learning of calculus by applying more efficient and innovative strategies such as the use GeoGebra and Microsoft mathematics software. While these software tools have proven effective in plane geometry, algebra, and statistics, the question remains: can GeoGebra and Microsoft Mathematics also transform the teaching and learning of calculus.

Research questions

1. What are the mean achievement scores of students taught calculus using GeoGebra software and those taught using Microsoft mathematics software?
2. What are the mean achievement scores of male and female students in calculus?

Hypotheses

H0₁: The mean achievement scores of students taught calculus using GeoGebra software and those taught using Microsoft mathematics software do not differ significantly.

H0₂: The mean achievement scores of male and female students in calculus do not differ significantly using GeoGebra and Microsoft mathematics software.

Research Design

The study adopted factorial design. Specifically, a two-level complete factorial design 2×2 was employed. GeoGebra software (x_1) and Microsoft mathematics software (x_2), while gender as the moderating variable at two levels: Male (y_1) and Female (y_2). This research was carried out in Kogi State in Idah education zone. The choice of the area is due to persistent poor performance of students from WAEC chief examiner's report 2024, and 2025. The research population was 996 SSS3 mathematics students (523 male and 473 female) for the 2023/2024 academic session in the four Local Government Areas in Kogi State's Idah Education Zone. This study's sample consisted of 160 students of two intact classes of SSS3 mathematics class. Purposive sampling was used to sample two schools from Public secondary schools in the sampled Local Government Areas. This was done in order to avoid choosing schools that have no functional computers, because many schools have little or no workable and good number of computers. Mathematics teachers, one each teaching SSS3 students in the schools sampled were trained by the researcher for four days and administered pretest before the treatment began. At the end of the fourth week after the treatment, post CAT was administered at the same time. Calculus Achievement Test (CAT) was the instrument for data collection. The CAT consisted of 30 multiple choice test items with five options (A-E) developed by the investigator to test the students' achievement in calculus. The CAT items were formed from differentiation and integration. The highest score that can be obtained on CAT is 30 and the lowest is 0. The instrument was face validated by three experts in Department of Science Education, Faculty of Education, University of Nigeria, Nsukka. The reliability coefficient of CAT was determined using Kuder Richardson (K-R20) formula, the reliability index obtained was 0.93. The data collected was analyzed using descriptive statistics of mean and



standard deviation to answer the research questions, while the hypotheses were tested using Analysis of Covariance (ANCOVA) at .05 level of significance. Reject the null hypothesis if the p-value is less than

the significance level (alpha), which is typically set at 0.05. If the p-value is greater than alpha, you fail to reject the null hypothesis.

Results

Table 1: Mean and Standard Deviation of Pretest and Posttest of Students Learning Calculus with GeoGebra Software and Microsoft Math Software (n =160)

Software	N	Pretest		Posttest		Mean gain
		\bar{x}	SD	\bar{x}	SD	
GeoGebra Software	75	51.56	5.55	58.84	7.48	7.28
MS Maths Software	85	50.76	6.36	62.20	9.11	11.44

Result in Table 1 revealed that the group taught calculus using GeoGebra software had a 51.56 pretest mean score with a 5.55 standard deviation and a 58.84 posttest mean score with a 7.48 standard deviation. While their counterparts taught calculus using Microsoft mathematics software had 50.76

pretest mean score with 6.36 standard deviation and posttest mean score of 62.20 with 9.11. The mean gain for both (GeoGebra software and Microsoft mathematics software) was 7.28 and 11.44 respectively revealing that Microsoft mathematics software had higher mean gain.

Hypothesis one

The mean achievement scores of students taught calculus using GeoGebra software and those taught using Microsoft mathematics software do not differ significantly

Table3: Covariance Analysis (ANCOVA) of Mean Achievement Scores of Senior Secondary School Students Taught Calculus using Microsoft Math Software and GeoGebra Software(n=160)

Sources	Type II Sum of Squares	Df	Mean Square	F	Sig.	Dec.
Corrected Model	3818.783 ^a	4	954.696	19.082	0.00	
Intercept	8088.859	1	8088.859	161.679	0.00	
PretestAchi	26.813	1	26.813	.536	0.46	
Group	383.337	1	383.337	7.662	0.00	S
Gender	2665.836	1	2665.836	53.284	0.00	S
Error	7754.717	155	50.030			
Total	599636.000	160				
Corrected Total	11573.500	159				

$\alpha = 0.05$, S = Significant

s

The result in table 3 revealed an F-ratio of 7.66 with relative probability value of .00 was obtained with respect to the mean achievement scores of senior secondary school students taught calculus using Microsoft mathematics and those taught using GeoGebra software. Since the associated probability value of .00 was less than .05 set as meaning level, the null hypothesis (H_0) which stated that there was no significant difference in the mean achievement scores of senior secondary school students who were taught calculus using Microsoft mathematics software and

those taught using GeoGebra software is therefore rejected.

The mean achievement scores of male and female students in calculus do not differs significantly using GeoGebra and Microsoft mathematics software

Table 2: Mean and standard deviation of male and female achievement scores of students in calculus (n = 160)

Variable		Pretest		Posttest		
Gender	N	\bar{x}	SD	\bar{x}	SD	Mean gain
Male	85	52.66	5.84	64.60	8.02	11.94
Female	75	49.41	5.72	56.12	6.67	6.71

Result in Table 1 revealed that the group taught calculus using GeoGebra software, male had a 52.66 pretest mean score with a 5.84 standard deviation and a 64.60 posttest mean score with a 8.02 standard deviation. While their counterparts taught calculus using Microsoft mathematics software females had 49.41 pretest mean score with 5.72 standard deviation and posttest mean score of 56.12 with 6.67. The mean gain for both male and females (GeoGebra software and Microsoft mathematics software) was 11.94 and 6.71 respectively revealing that male students taught using Microsoft mathematics software had higher mean gain.

Discussion

The findings indicate that the use of technology, specifically GeoGebra and Microsoft Mathematics software, positively impacts the achievement scores of senior secondary school students in calculus. The higher mean gains observed in students taught with Microsoft Mathematics suggest that this software may be particularly effective in enhancing calculus achievement. However, both software programs contribute positively to learning outcomes, underscoring the potential of educational technology to enrich mathematical instruction. Furthermore, gender play a substantial role in achievement scores, suggesting that these educational tools might interact differently with students based on gender. The positive impact of GeoGebra and Microsoft Mathematics on students' achievement in calculus could be attributed to several factors. Both software programs provide interactive and visual learning environments that help students grasp abstract and complex calculus concepts such as limits, differentiation, and integration. These tools promote active learning, allowing students to manipulate variables, visualize functions dynamically, and receive immediate feedback features that enhance academic achievement compared to traditional lecture methods. The findings of this study align with numerous previous studies that emphasize the positive role of

technology in mathematics education. For instance: Hohenwarter and Fuchs (2004) found that using GeoGebra significantly improved students' understanding of mathematical concepts through visualization and exploration. Achor, Imoko, and Uloko (2009) also reported that computer-assisted instruction enhances students' performance and motivation in mathematics compared to traditional teaching methods. Binta (2017) observed that students exposed to Microsoft Mathematics performed better in algebra and calculus tasks than those taught conventionally, attributing the improvement to the software's interactive and supportive learning features. Similarly, Agyei and Voogt (2012) emphasized that integrating ICT tools in mathematics classrooms promotes deeper understanding and learner-centered instruction.

The result in Table 2 indicates that while both GeoGebra and Microsoft Mathematics software improved students' achievement in calculus, male students taught using Microsoft Mathematics software recorded higher mean gains than their female counterparts. Several factors may explain this outcome. Microsoft Mathematics provides step-by-step problem-solving features and automated computational support that favor procedural and analytical learners. Male students often demonstrate higher confidence and greater familiarity with technology-based learning tools. This confidence can lead to more active exploration and utilization of Microsoft Mathematics features, such as equation solving, graph plotting, and problem visualization. Studies (e.g., Yusuf & Afolabi, 2010) have shown that males tend to engage more readily with ICT tools, which enhances their learning experience and outcomes. This finding also aligns with the work of Williams, Charles, and Adescope (2017), who demonstrated that GeoGebra significantly improves achievement compared to a control group without such technological support. Similarly, Karim and Maryam (2018) found that GeoGebra positively affects academic achievement for both male and female

students in primary school, indicating that these benefits may extend across educational levels. Additionally, Rina and Yani (2014) showed that Microsoft Mathematics effectively enhances students' performance, reinforcing that well-implemented educational technology can support improved achievement in mathematics.

Together, these studies suggest that GeoGebra and Microsoft Mathematics software offer substantial advantages in mathematics instruction by fostering engagement and comprehension, leading to better academic outcomes. This evidence supports integrating technology in mathematics education to cater to diverse learning needs and capitalize on software's potential to bridge achievement gaps across different student demographics.

Conclusion

The findings reveal that both GeoGebra and Microsoft Mathematics software enhance senior secondary school students' calculus achievement, with Microsoft Mathematics showing particularly high effectiveness. Educational technology in mathematics supports learning outcomes, with a notable impact observed on gender-based differences in achievement. This aligns with previous studies, which show GeoGebra's benefits across educational levels and Microsoft Mathematics' ability to boost mathematics performance. Collectively, these studies highlight the value of integrating technology in mathematics education to improve engagement, comprehension, and academic performance, while also helping address achievement disparities among diverse student groups.

Recommendations

1. Based on the findings of this study, it was recommended that since GeoGebra and Microsoft software as teaching strategy is effective in learning calculus; teachers of mathematics should adopt these teaching strategies in order to improve the academic achievement of students in calculus.
2. Schools and educators should incorporate mathematics software, such as Microsoft Mathematics, into calculus curricula. This could involve dedicated lab sessions, class exercises, or assignments that leverage the software's capabilities to reinforce calculus concepts.
3. Since there is a significant gender influence on achievement scores, educators should explore

and implement gender-responsive teaching strategies. This may include providing targeted support, fostering an inclusive classroom environment, and encouraging participation from all students to ensure they feel comfortable using the software.

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