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Effect of GeoGebra Computer Package on Performance in Concept Integral Calculus among Colleges of Education Students in Borno State

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Abstract
This study investigated the effect of the GeoGebra computer package on performance in concept integral calculus among colleges of education students in Borno State. The study was guided by three objectives, research questions, and corresponding hypotheses, respectively. The population of the study was made up of 478 mathematics students in the department of mathematics from the two (2) colleges of education in Borno State during the 2021/2022 academic session. Purposive sampling techniques were used to select one college of education. Thus, gave a sample size of sixty (60) students. A quasi-experimental design specifically, pre-test, post-test, and non-randomized control group was used for this study. The instruments used for data collection is Integral Performance Test Items (IPTIs) developed by the researcher and validated by three experts. The reliability coefficient of the instrument was 0.81 using the Cronbach alpha reliability test. In answering research questions descriptive statistics of mean, standard deviation and mean difference was used and t-test was used to test the null hypotheses. Findings revealed that the GeoGebra computer application package has significant effects on the performance of students taught integral calculus when compared with students exposed to the Lecture teaching method. Moreover, male students perform better than female students taught concept integral calculus using the GeoGebra computer package. The study recommends that teachers and students should be encouraged to explore the GeoGebra computer application package in solving problems related to integral calculus.
Keywords: GeoGebra, Computer application Package, Integral Calculus, Academic performance.

Introduction
Mathematical concepts that are introduced to students are more directly defined using formal definitions without regard to the concept of images or visuals (Sari et al., 2018). Some learners' ability to depict images is still lacking (Septian, et al., 2021). Visual abilities rely more on memorization abilities, especially through rote learning strategies, which usually lead to their low proficiency in algebraic and graphical representations and their effects on analytic abilities. This is a serious problem in solving problems related to integral and differential calculus in mathematics. It also contributes to the weaknesses in problem-solving caused by difficulties drawing graphics in calculus (Septian, et al., 2021; Rojas Suarez et al., 2019). However, there are some similarities in differential calculus difficulties, such as drawing graphs of incorrect functions (Haciomeroglu et al., 2020).

The options for the use of ICT are varied, ranging from the use of graphing calculators, digital whiteboards, applets, cellular automata, data shows, and software. GeoGebra was chosen for this paper because of its user-friendly interface, which allows you to enter items such as points, lines, and functions into a graphical window and manipulate those using basic tools and commands (Nobre et al., 2016). The software also includes several tools for working with statistical and mathematical data, making it appropriate for solving mathematical problems. GeoGebra (https://www.geogebra.org/) is dynamic mathematics software that allows you to build and explore geometric and algebraic constructions interactively. One of the computer programs that can be utilized in learning mathematics is GeoGebra software, which is a simple, dynamic computer application package that can be used in solving problems related to calculus, algebra, geometry, statistics, numbers and numeration, probability, and many other areas of mathematics (Nobre et al., 2016).

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As the demand for possible alternatives for solving problems in mathematics has grown to the extent that researchers have tried heavily to explore various ways of tackling challenges in mathematics, the software called GeoGebra was introduced in 2001 by one Marcus Hohenwater as his master's thesis, and now its impact has spread all over the globe to help mathematics educators, teachers, and lecturers solve various problems in mathematics. With that, students can discover the world of mathematics in a wider context and become better equipped to think critically and creatively (Arbain & Shukor, 2015). One of the important things about the dynamic application computer package (GeoGebra) is that it has been translated into more than 100 different major languages around the globe today. The GeoGebra computer application package solves many problems in mathematics when properly utilised, especially problems related to geometry, calculus, trigonometry, algebra, statistics, and many areas of mathematics, engineering, and applied sciences (Amoo & Disu, 2012).

One of the major areas of mathematics that students mostly experience problems solving using lecture methods is calculus (differential and integral calculus). However, this study is limited to the use of the GeoGebra computer application package in solving problems related to calculus in mathematics. As we know, Calculus is one of the fields of mathematics that influences the basis of mathematical thinking. Calculus can be seen from two perspectives: differential calculus and integral calculus, where the integral is the reverse of the differential and vice versa. Problems related to differential and integral calculus experienced by students include the visual ability in drawing graphics and effective ways of illustrating the solution steps to arrive at the final answers (Grossfield, 2014). In terms of differential and integral calculus, we emphasized materials focused on graphs of equations and functions. Functions and equations are important and fundamental mathematical concepts in differential and integral calculus (Sudihartinih & Purniati, 2018).

In the recent industrial revolution era, the development of the technological world is growing rapidly (Nafea & Toplu, 2019; Septian et al., 2019). Some applications of software and other related ICT, as well as computer-assisted instruction (CAI), in the world of education, have been widely used by lecturers (Hendriawan & Septian, 2019; Septian, et al., 2021). Also, to effectively handle these packages, it is up to the ability of teachers and lecturers to master technology and the ways of operating it so that, in the end, it will adjust to the conditions of the times (Zaheer et al., 2018). The challenge for the future is how an educator can master technological literacy in this current industrial revolution, which also matters (Kazimirov, 2018; Maskur et al., 2020). Recent technological advances are needed, according to the times. Educators must utilize technology in their teaching processes to influence students' progress in schools, so they can adjust to the needs of using CAI in teaching and learning mathematics.

In mathematics, a variety of technology-based tools are frequently utilized (Korenova, 2017; Majerek, 2014). According to Hohenwarter et al., technology-based tools are frequently utilized (Korenova, 2017; Majerek, 2014). According to Hohenwarter et al. (2008), the GeoGebra program is very beneficial for teachers and students in terms of solving numerous mathematics problems. Unlike profit-making software that frequently can only be used at school, GeoGebra can be installed on personal computers and used anytime and anywhere by students and teachers; thus, it is completely free computer application software. GeoGebra provides teachers with a powerful tool for creating an interactive online learning environment in which students can study a variety of mathematical ideas. Matlab and Mathematica are two more mathematical software programs that have benefits in the creation of graphs of functions of mathematical equations (in algebra), as well as 2D and 3D views. On the other hand, Matlab and Mathematica software are more difficult to use than GeoGebra if you need to employ computer programming language syntax. GeoGebra is preferred for its practicality and ease of usage. That is one of the reasons the researchers chose to use the GeoGebra computer application package for this study.

The requirement for the production of teaching materials for differential and integral calculus courses that are tailored to student's abilities is one way for lecturers to address challenges that arise (Zilinskiene & Demirbilek, 2015). Calculus is a course that is similar to algebra and geometry. Calculus teaching resources are still rarely technologically oriented. Usually, a manual module and textbooks are the only traditional materials used in teaching and learning calculus. However, the use of the GeoGebra application package in the teaching and learning of mathematics by lecturers is still very limited. Also, manual modules or textbooks have weaknesses in terms of visualizing 2-dimensional and 3-dimensional shapes. And the replica included with GeoGebra teaching materials is incredibly versatile and practical, making it simple for students and lecturers to utilize. According to Jacobson and Kozma, (2012), the advanced GeoGebra computer application package is one of the innovative software packages in mathematics education that enables students to appreciate electronic teaching and learning of integral calculus and differential equations, which improves students' mathematical performance when used properly.

Learning differential and integral calculus with GeoGebra could make students pay more attention to the materials (Haciomeroglu et al., 2010 cited in Septian, et al., 2021; Machromah et al., 2019; Takaci et al., 2015 as cited in Ondes, 2021).

Therefore, there is a need to make and develop teaching materials using GeoGebra, and this can complement the efforts of mathematics teachers in the improvisation of some instructional materials for teaching and learning mathematics (Kasti & Jurdak, 2017; Tamam & Dasari, 2020). The problem related to differential and integral calculus experienced by students is their visual ability when drawing graphics. Focusing on the solution of integral calculus and students' performance based on gender, Septian, et al. (2021) found in their study titled "Development of Calculus Teaching Materials using GeoGebra at the Universitas Suryakancana", illustrated that the male students' performance was higher over the performance of female students based on the finding of the research study.

Some studies indicate that there is difficulty experienced by students and teachers while solving problems related to integral calculus in colleges of education using lecture methods (Surya et al., 2013; Grossfield, 2014). It has been a long time since mathematics students have faced a lot of challenges through the process of solving problems related to calculus, especially those related to integral (definite and indefinite) and differential calculus. As we all know, calculus is one of the mathematical concepts that students of mathematics must have a vast knowledge of to have the requisite and advanced knowledge for pure and applied mathematics at the university level. Integral calculus is a part of calculus where students face the most problems while solving them with ordinary lecture methods. In this computer age, the integration of computers and technological tools into the teaching and learning of mathematics at various levels of education is paramount.

Most of the lecture methods of solving mathematical problems are gradually becoming obsolete due to their peculiar difficulties. With this in mind, researchers and scholars all over the globe have advocated and made lots of recommendations that computer-assisted instruction should be integrated into the teaching and learning of mathematics. Regarding the findings of many research studies, students usually perform badly, especially in problems related to integral calculus at the tertiary education level. With all these in mind, the researchers deployed the use of one dynamic computer application package in the teaching and learning of integral calculus called GeoGebra to test its effect of GeoGebra computer package on performance in concept integral calculus among colleges of education students in Borno State

Objectives of the study

The objectives of the study are to determine;

1. The effect of the GeoGebra computer package on Performance in concept integral Calculus and those exposed to lecture teaching methods among Colleges of Education students in Borno State.
2. The effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between male and female students in Borno State.
3. The effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between pre-test and post-test scores of students in experimental and control groups.

Research Questions

The following research questions guided the study:

1. What is the effect of the GeoGebra computer package on Performance in concept integral Calculus and those exposed to lecture teaching methods among Colleges of Education students in Borno State?
2. What is the effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between male and female students in Borno State?
3. What is the effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between pre-test and post-test scores of students in experimental and control groups?

Hypotheses

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

1. There is no significant effect between the GeoGebra computer package on Performance in concept integral Calculus and those exposed to lecture teaching methods among Colleges of Education students in Borno State.
2. There is no significant effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between male and female students in Borno State.
3. There is no significant effects of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between pre-test and post-test scores of students in experimental and control groups.

Methodology

This study adopted a quasi-experimental design with pre-test and post-test experimental and control design. The total population of the study includes all NCE II mathematics students of the two colleges of education in Borno State in the

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2021/2022 academic session made up of 478 students of which 127 are female and 351 are male students. Purposive sampling was used to select one college of education for the study and a sample of 60 NCE II mathematics students was selected (30 male and 30 female) an intact class was used. The instrument used for data collection in this study was Integral Performance Test Items (IPTIs), which were developed by the researchers and were subjected to both face and content validation. The instrument was validated by three experts at the university. Test-retest methods were used, and the reliability coefficient was found to be 0.81 with the aid of Cronbach Alpha. The IPTIs contain fifteen (15) test items, of which eight are on definite integral problems and seven are on indefinite integral problems. The experimental group was taught the concept of integral calculus using the GeoGebra computer application while the control group was taught using the lecture teaching method. In answering research questions, descriptive statistics of mean, standard deviation and mean difference was used and Inferential statistics was used to test the null hypothesis at a 0.05 level of significance

Results

Research Question 1:
What is the effect of the GeoGebra computer package on Performance in concept integral Calculus and those exposed to lecture teaching methods among Colleges of Education students in Borno State?

Table 1: **shows the descriptive statistics of the effect of the GeoGebra computer package on performance in concept integral calculus and those exposed to lecture method among colleges of education students in Borno State**

Groups	N	Mean	Std. Deviation	Mean Difference
Experimental Group	30	52.53	2.85	18.30
Control Group	30	34.23	4.95	

(Field work, 2023)

Table 1 shows the performance scores of the experimental and control groups $\bar{X}$(52.53, 34.23), SD (2.85, 4.95), respectively. This indicates that the mean scores of the experimental groups supersede that of the control group with the me Table 1 shows the performance scores of the experimental and control groups (52.53, 34.23), SD (2.85, 4.95), respectively. This indicates that the mean scores of the experimental groups supersede those of the control group, with a mean difference of 18.30. This signifies that the experimental group performed better than the control group.

Research Question 2
What is the effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between male and female students in Borno State?

Table 2: shows the descriptive analysis of the effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between male and female students in Borno State.

Gender	N	Mean	Std. Deviation	Mean Difference
Male	15	72.53	9.191	15.20
Female	15	57.33	5.158	

(Field work, 2023)

Table 2 shows the performance scores of the students exposed to the GeoGebra application in solving problems in concept integral calculus based on gender (72.53, 57.33), SD (9.191, 5.158), respectively. This indicates that the mean scores of the male students supersede those of the female students, with a mean difference of 15.20. This signifies that the male students performed better than the female students in concept integral calculus.

Research Question 3
What is the effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between pre-test and post-test scores of students in experimental and control groups?

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Table 3: shows the descriptive analysis of the effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between pre-test and post-test scores of students in experimental and control groups.

Groups	N	Mean	Std. Deviation	Mean Difference
Pre-test for experimental Group	60	38.6	6.92	
				4.80
Pre-test for lecture Group	60	33.8	4.76	

(Field work, 2023)

Table 3 shows the pre-test mean scores of the experimental and control groups (38.6, 33.8), SD (6.92, 4.76), respectively. This indicates that the mean scores of the students in the pre-test for the experimental Group supersede those of the students in the Pre-test for the lecture group, with a mean difference of 4.8. Thus, the mean performance difference is minimal.

Hypothesis 1

There is no significant effect between the GeoGebra computer package on Performance in concept integral Calculus and those exposed to lecture teaching methods among Colleges of Education students in Borno State.

Table 4: t-test analysis of the significant effect between the GeoGebra computer package on Performance in concept integral Calculus and those exposed to lecture teaching methods among Colleges of Education students in Borno State.

	N	$\bar{X}$	SD	df	MD	t	P
Experimental Group	30	52.53	2.85				
				58	18.30	3.205	0.0021
Control Group	30	34.23	4.95				

(Field work, 2023)

Table 4 showed the performance scores of the experimental and control groups $\bar{X}$(52.53, 34.23), SD (2.85, 4.95), at $\alpha = 0.05 \; and \; df = 58$. Since the P-value is less than the 0.05 significance level, therefore, the null hypothesis is rejected in favour of the alternative hypothesis. Hence, there is a significant difference between the performance of students taught concept integral Calculus using GeoGebra Computer Package and those exposed to the lecture teaching method.

Hypothesis 2

There is no significant effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between male and female students in Borno State.

Table 5: t-test analysis of the significant effect of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between male and female students in Borno State.

	N	$\bar{X}$	SD	df	MD	t	P
Male	15	72.53	9.191				
				28	15.20	2.007	**0.0001**
Female	15	57.33	5.158				

(Field work, 2023)

Table 5 shows the mean score of the gender exposed to the GeoGebra application in solving problems in integral calculus $\bar{X}$ (72.53, 57.33), **SD** (9.191, 5.158), at α=0.05 and df=28. Since the P-value is less than 0.05, therefore, the null hypothesis 2 is rejected. Implies that there is a significant difference in gender performance in the application of GeoGebra in solving problems in concept integral calculus. By implication, male students perform better than their female counterparts in solving problems in integral calculus using the GeoGebra application package.

Hypothesis 3

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There is no significant effects of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between pre-test and post-test scores of students in experimental and control groups.

Table 6: t-test analysis of the significant effects of the GeoGebra Computer Package on Performance in concept integral Calculus in colleges of Education between pre-test and post-test scores of students in experimental and control groups.

	N	$\overline{X}$	SD	df	MD	t	P
Pre-test for experimental	60	38.6	6.92				
				118	4.80	1.58	0.0641
Pre-test for lecture	60	33.8	4.76				

Source: Field work (2023)

Table 6 shows the pre-test mean scores of the experimental and control groups $\overline{X}$ (38.6, 33.8), SD (6.92, 4.76), at an alpha level of 0.05 and $df = 118$. Since the P value is greater than 0.05 then, null hypothesis 3 is retained; hence, there is no significant difference in the mean performance of students in pre-test scores of students in the experimental and control groups. By implication, there was homogeneity in the performance of the two groups before the treatment.

Discussion of Findings

The results revealed that there is a significant difference in the performance of students exposed to the teaching of concept integral calculus using the GeoGebra package compared to the lecture method. The result is in favour of the students taught concept integral calculus with the GeoGebra computer package. Regarding the findings obtained in Table 4, it can be seen that the null hypothesis has been rejected since the P-value is less than the 0.05 level of significance. This finding is in line with the findings of Jacobson and Kozma, (2012) that the advanced GeoGebra application package is one of the innovations in mathematics education that enables students to appreciate electronic teaching and learning of integral calculus and differential equations, which improves students' performance in mathematics when properly applied. The finding conforms to the experiment carried out by Owolabi and Oginni (2014), which showed that the use of the GeoGebra package in teaching geometry has produced greater academic performance in the post-test.

However, Amoo and Disu, (2012) confirm the earlier findings that only professionals who are ICT compliance and mathematically certified are allowed to teach mathematics at any level, and those who do not yet have pedagogical knowledge of the subject matter should be encouraged to do so. Therefore, there is a significant difference in the performance of students exposed to the teaching of concept integral calculus using the GeoGebra package and those taught using the lecture method. The result is in favour of the experimental group. The result from Table 5 shows that there is a significant difference in the performance of students taught integral calculus using GeoGebra based on their gender. This implies that male students perform better than female students while using the GeoGebra computer package to teach concept integral calculus; the result of their post-test revealed that female students' performance was less than that of their male counterparts.

The results of the finding in Table 5 are in line with the findings of Septian et al. (2021), who found in their study titled The Development of Calculus Teaching Materials Using Geogebra at the Universitas Suryakancana that the male students' performance was higher than the performance of female students based on the findings of the research study. Moreover, the finding in the last table on the performance of students in pre-test scores for both the experimental and the control groups The results show that there is no significant difference in the performance of students in their pre-test scores between the two groups (control and experimental) in the study. This finding shows that since the test was conducted before the deployment of the GeoGebra and lecture teaching exercises for both the experimental and control groups, this finding has justified the claim that the application of the computer package is paramount to increasing students' performance in integral calculus.

Conclusion

This study investigated the effect of the GeoGebra computer application package on students' performance in integral calculus in colleges of education in Borno State. As a result, it is pertinent to believe that technology plays an important role in the teaching and learning of mathematics at all levels of learning. The study portrayed and employed the use of computer software in the teaching and learning of integral calculus, which provides a significant improvement in the performance of students, and it produced a huge aspect that mathematics educators should take into consideration for the advancement of their

teaching and learning processes in schools. The use of technology in teaching mathematical concepts, especially at the tertiary institution level, should be highly encouraged.

Recommendations

Based on the findings of this study, it is important that

1. Teachers and lecturers should make use of the GeoGebra package in their day-to-day lesson delivery as it is one of the computer packages that are easy to use by both teachers and students since GeoGebra is friendly-oriented software that is easy to use.
2. This study suggests that since teaching and learning processes are gradually moving from traditional to technological bases, governments, and non-governmental organizations should supply enough computers to schools so that students have full access to the system whenever they desire. This may reduce the wide gap that exists between the performances of male and female students in mathematics.
3. The use of the GeoGebra computer application software should be adopted by schools to bridge the gaps between mass student failure in mathematics at both the internal and external examinations conducted by the examination body. By doing so, the students' academic performance or achievement in mathematics can be improved to an advanced level.

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