
EFFECT OF PHOTOMATH APP AND MATHWAY APP TOOLS ON UNDERGRADUATE UNIVERSITY STUDENTS' ACADEMIC PERFORMANCE IN INTRODUCTORY CALCULUS IN NASARAWA STATE, NIGERIA

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Abstract

This study investigated the effect of Photomath app and Mathway app tools on undergraduate university students' academic performance in introductory calculus in Nasarawa state, Nigeria. Three research questions and three null hypotheses were used for the study. Quasi experimental research design which made use of pretest and posttest was used. The study had two experimental groups and one control group. The experimental group 1 was taught higher order derivatives in calculus using Photomath App, the experimental group 2 was taught same concept with Mathway App, while the students in the control group were taught with traditional teaching method where no App was used. The census sampling technique was used to draw the sample for the study. A sample of one hundred and eighty three Level 100 undergraduate mathematics students were drawn from the population of one hundred and eighty three Level 100 undergraduate mathematics students. The name of the instrument used to collect data was Introductory Calculus Achievement Test "ICAT". This instrument was multiple-choice test and consisted of twenty five test items. The instrument was validated by experts in mathematics education. The Kuder Richardson formula 21 (KR-21) was used to obtain an internal stability of 0.84. The research questions were answered using mean and standard deviation while the hypotheses were tested at 0.05 significant level. The result showed that students in experimental group 1 that were taught higher order derivatives with

Photomath App performed better than those that were taught with traditional teaching method in the control group and there was a statistically significant difference between the two groups. The second result showed that students in experimental group 2 that were taught higher order derivatives with Mathway App performed better than those that were taught with traditional teaching method in the control group and there was also a statistically significant difference between the two groups. The third result showed that students in experimental group 1 that were taught higher order derivatives with Photomath App performed better than those that were taught with Mathway App and there was no statistically significant difference between the two experimental groups. It was concluded that the use of mathematics Apps (Photomath and Mathway) improved the academic performance of undergraduate mathematics students in introductory calculus better than the traditional teaching method. It was recommended amongst others that mathematics teacher should employ mathematics Apps to teach students introductory calculus.

Keywords: Higher Derivatives, Performance, Photomath App, Calculus, Undergraduates.

Introduction

Mathematics is often referred to as the language of the universe. It is a field that transcends cultural and linguistic barriers, providing a universal framework for understanding the world around us. From the simplest arithmetic operations to complex theorems that describe the nature of space and time, mathematics plays a crucial role in our daily lives, scientific advancements, and technological innovations. The importance of mathematics extends beyond academia and professional fields. It is intertwined with everyday experiences. Mathematics fosters critical thinking and analytical skills. Through mathematical problem-solving, students learn to approach challenges methodically, breaking them down into manageable chunks, and applying logical reasoning to arrive at solutions. This skill set is invaluable, not in academics and careers but also in navigating everyday problems (George & Charles-Ogan, 2023). At its core, mathematics is a study of patterns, structures, and relationships. It encompasses various branches such as algebra, geometry, statistics, calculus and more. Each of these branches has its peculiar principles and applications, yet all contribute to a comprehensive understanding of quantitative relationships.

Calculus emerges as a vital branch of mathematics that explores rate of change and motion. It can also be said to be the branch of mathematics that deals with continuous change, thus it is sometimes referred to as infinitesimal calculus. It is instrumental in fields such as physics, economics, finance, biology, chemistry, thus, allowing scientists, engineers and researchers to model dynamic systems and predict future outcomes. This may suggest why Wayne (2020) opined that calculus is used in real life to model, optimize, and predict the behavior of changing systems across many fields. The two major areas of calculus are differential and integral. The differential calculus, also referred to as derivatives is the measure of the rate of change of functions whereas integral calculus is the measure of the area under the curve. The rate of change is important in that it focuses on how functions change with respect to given variables. Higher order derivatives are found by the repeated differentiation of the functions. In Physics higher order derivatives describe changes in motion (Uchenna, 2021). Thus, the first derivative of position gives the velocity, the second derivative gives acceleration, and the third derivative gives jerk, while the fourth and fifth derivatives give jounce and crackling respectively.

Teaching mathematics could be challenging for educators as some students do not possess the logical and critical thinking skills. Ubalike (2020) opined that educators can integrate mathematical tools that can aid students to discover the relevance of mathematics and also improve their learning outcome. The advent of technology has amplified the role of mathematics in the society. In an era dominated by data and information, mathematical algorithms underpin everything from search engines, to social media platforms. The use of digital tools intrigues most students. Digital tools and application can therefore help educators during classroom teaching and learning of mathematics. The integration of mathematics software has made teaching and learning easy, improve students' grade, save time and energy during mathematics problem-solving and also increase their confidence and heuristics in mathematics.

There has been a paradigm shift from traditional teaching methods to the use of technology in the teaching and learning of mathematics in recent time. The use of technological applications (App) has been welcome by most stakeholders in education. Seeland (2024) opined that mobile apps have become indispensable resources in the educational realm over the past ten years. Mathematics software is a powerful digital tool for computations in algebra, calculus, geometry, and trigonometry (Joswig, 2021). They are used to model, analyze or calculate numeric, symbolic or geometric data. The use of mathematics software has become the trend of the present society. Mathematics software or App is software used for teaching and learning of various mathematics concepts. They are used for problem-solving, visualization of complex concepts, and compute complex calculations. The use of software makes students learn mathematics in a more interactive manner. Other features which students benefit from the use of mathematics software are the provision of personalized learning and checking of students work. The use of mathematics software in the classroom offers flexibility, adaptability, mastery-based learning, and interactive instructional sessions. To this end Umunna and Adegoke (2020) categorized mathematics software into general purpose software that are designed to perform a wide range of mathematical operations, specialized software, graphics, statistics, and online learning platforms.

It is crucial to note that the mobile and online learning Apps are integrated in the classroom teaching of mathematics to make mathematics learning interactive, practical, and engaging. Due to the advent of digital gadgets, there are Apps that can be used to solve problems in mathematics in smartphones and tablets. These math solver Apps help to track formula, solve the problem step by step with voice explanation. Mathematics Apps come in various forms and serve numerous purposes. Some focus on the teaching of foundational mathematics concepts while others focus on advance concepts. Tegutam (2020) asserted that the accessibility and ability of mathematics Apps to provide instant feedback transform the traditional learning experience, making mathematics more approachable and enjoyable for students. Mathematics Apps have revolutionized the way students engage with the subject, by transforming abstract concepts into interactive and enjoyable experiences. Several Apps have gained recognition for their effectiveness in teaching and engaging students. Some notable examples of mathematics software are GeoGebra, Geometer's Sketchpad, Symbolab, Prodigy, Photomath, Mathway, Cymath, Sage, Nearpod, Khan Academy Kids, Mathspace for students, Google classroom, Wolfram mathematica, Todo Math, Geometry Pad, Rocket Math, Sage, DoodleMath, Gauth, IXL, DragonBox etc.

Photomath is one of the mobile apps that has innovated the teaching and learning of mathematics in schools. Photomath App is a unique mobile app that is employed to solve mathematics problems of any difficult level. This innovative App allows users to take pictures of hand written or printed math problems. The App is usually downloaded into a

smart phone or a tablet as a free version. Photomath App is very useful to students that are ready to have a deeper understanding of the process behind the solution of the problem rather than just the answer. The Photomath app is ideal for solving a wide variety of mathematics topics such as arithmetic, geometry, trigonometry, algebra, and calculus. This App according to Amadi and Ogbuagu (2022) can also handle word problems, graphical and statistical problems. It has been verified that it renders a legitimate service which offers reliable and accurate solutions to mathematics problems. To use Photomath App, the problem needs to be clearly captured by snapping and cropping. Then, photomath AI will instantly analyze the scanned photo and identify the problem. Thereafter a step-by-step solution of the problem will be displayed accompanied with voice code explanation.

Kusi et al. (2021) stated that the impact of technology on mathematics education has gathered a global attention from well-meaning scholars. Zain et al. (2023) carried out a research on the use of Photomath applications to improve students' mathematical achievement in algebra and found that students' academic performance was improved upon. The result of Ahmad et al. (2025) revealed that the use of AI tools such as Photomath improved the mathematics learning of students. Obina et al. (2022) investigated the effect of Maths app utilization on students' academic performance and found that the app improved students' problem-solving skills, promoted the learning of mathematics concepts, as well as their academic performance.

Despite the positive impact which Photomath App has made on students' academic performance in mathematics, it has been questioned whether the use of Photomath App to teach and learn mathematics is a blessing or a curse (Kiara et al., 2021). This question was raised because some other studies have shown that the use of Photomath has made students to be cognitively lazy in their learning of mathematics. Students no more think critically nor reason logically due to the fact that the AI powered feature in Photomath does all of the solving for students. Thetatra (2023) asserted that one of the disadvantages of using Photomath for mathematics teaching and learning is that most students over rely on it and even use it for malpractices. Nevertheless, technology has come to stay. This may suggest why Haruna (2019) recommended that schools should endeavor to device means of discouraging students from using mathematics Apps to indulge in examination malpractices. The researchers have the belief that Photomath App can significantly enhance comprehension and engagement when used thoughtfully, promoting deeper conceptualization of mathematical facts and fostering independent learning. This study therefore, was embarked upon to investigate the effect of Photomath App on the academic performance of students in introductory calculus.

Statement of the Problem

The performance of students in mathematics has continued to be an issue of global concern due to the high rate at which students fail the subject. The present day students are all digital natives and as such have access to, and knowledge on the utilization of mobile apps. In an era where digital devices and internet play a central role, the learning of mathematics has become more accessible, easier and more engaging. The use of AI based apps has aided in the quick solving of both simple and complex math problem in an interactive way. Teaching students' mathematics concepts using the usual traditional teaching method has continued to pose challenges in the classroom. Traditional teaching method is neither engaging learner-centered nor activity-based. Students should therefore be taught mathematics concepts using that which they are naturally interest in. Calculus is a branch of mathematics that has a wide application in areas such as physics, statistics, economics, biology, computer science. Since students have interest in the use of technology in general and mobile Apps, integrating

Photomath App in the teaching and learning of Calculus might help improve their learning outcome in the concept. The question that arose was, can the integration of Photomath App improve the academic performance of undergraduate mathematics students in introductory Calculus? It was against this backdrop that this research was carried out.

Aim and Objectives of the Study

The aim of this study was to investigate the effectiveness of Photomath App on the academic performance of undergraduate mathematics students in introductory calculus. The objectives were to:

1. Determine if there is a difference in the mean score performance of undergraduate mathematics students taught introductory calculus with Photomath App and those taught with traditional teaching method.
2. Ascertain whether there is a difference in the mean score performance of undergraduate mathematics students taught introductory calculus with Mathway App and those taught with traditional teaching method.
3. Determine the difference in the mean score performance of undergraduate mathematics students taught introductory calculus with Photomath App and those taught with Mathway App.

Research Questions

The following three research questions were answered.

1. What is the difference between the mean score performance of undergraduate mathematics students taught introductory calculus course with Photomath App and those taught with traditional teaching method?
2. What is the difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Mathway App and those taught with traditional teaching method?
3. What is the difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Photomath App and those taught with Mathway App?

Hypotheses

Three null hypotheses were tested at 0.05 significant levels.

H₀₁: There is no significant difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Photomath App and those taught with traditional teaching method.

H₀₂: There is no significant difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Mathway App and those taught with traditional teaching method.

H₀₃: There is no significant difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Photomath App and those taught with Mathway App.

Research Design

Quasi experimental research design was used to carry out this investigation. The type of quasi experimental design was the pretest, and posttest that made use of non-equivalent, and non-

randomized intact classes. In this design two experimental groups and one control group were presented. Experimental group one was taught with Photomath App, experimental group two was taught with Mathway App while the control group was taught with traditional teaching method. Table 1 showed the study design.

Table 1: Study Design

Group	Pretest	Treatment	Posttest
EG 1	O ₁	X _{PMS}	O ₂
EG 2	O ₁	X _{MWS}	O ₂
CG	O ₁	X _{TTM}	O ₂

Where;

EG 1	=	Experimental Group 1
EG 2	=	Experimental Group 2
CG	=	Control Group
X _{PMS}	=	Taught with Photomath Software
X _{MWS}	=	Taught with Mathway Software
X _{TTM}	=	Treatment with Traditional Teaching Method
O ₁	=	Pretest for experimental and control groups
O ₂	=	Posttest for experimental and control groups

Population of the Study

The population of the study consisted of all one hundred and eighty three (183) Level 100 undergraduate mathematics students in the three universities in Nasarawa State.

Sample and Sampling Technique

The census sampling technique was used to select all the students in the population. The sample for the study therefore, was one hundred and eighty three (183) Level 100 undergraduate mathematics students.

Instrument

The instrument that was used to collect data was named Introductory Calculus Achievement Test 'ICAT'. The instrument had twenty five multiple-choice test questions on calculus. Each test item had four options and each was allotted 4 marks. The total mark for ICAT was 100 marks thus, it was marked in percentage. The test items measured both lower and higher order Bloom's cognitive learning outcome. A table of specification was prepared for the construction of ICAT.

Validity of the Instrument

The validity of the instrument, ICAT was carried out by three mathematics educators. The experts went through the initial instrument and made remarkable input that the research used to improve on the instrument. After the corrections were made, the instrument was administered to the sample students.

Reliability of the Instrument

The method used to conduct the reliability of the instrument was Kuder Richardson formula 21 (KR-21). The instrument was administered to a group of twenty undergraduate mathematics students in Level 100 that were not part of the sample students. The administration of the instrument was done once. An internal consistency of 0.84 was established for the instrument, ICAT.

Method of Data Collection

The three groups were first administered with a pretest of ICAT. After the pretest, the ICAT was collated and marked in percentage. Next was the teaching of the calculus topic to each of the groups by their respective course lecturers. The topic taught was higher order derivatives. The students in experimental group 1 were taught with Photomath App, the students in experimental group 2 were taught with MathwayApp, while the students in the control group were taught without any mathematics software but rather with the traditional teaching method. After the teaching session, a posttest of ICAT was administered to the three groups. The students' posttest scripts were also collated and marked in percentage. The raw scores for the pretest and posttest were subjected to statistical analysis.

Method of Data Analysis

The analyzed data was done with statistical package for Social Sciences (SPSS) version 25. The research questions were answered using mean and standard deviation, while the null hypotheses were tested using analysis of covariance (ANCOVA). The analysis was done at 0.05 significant level.

Results

Research Question 1: What is the difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Photomath App and those taught with traditional teaching method?

Table 2: Mean and standard deviation on the performance of students taught introductory calculus with Photomath App and traditional teaching method

Group	n	Pretest		Posttest		Performance	
		Mean	SD	Mean	SD	Mean Gain	Mean Diff.
Photomath App	55	48.93	10.52	72.83	12.63	23.90	13.17
TTM	60	51.74	12.58	62.47	11.65	10.73	

TTM = Traditional Teaching Method

Table 2 is the presentation of the mean and standard deviation on the performance of students that were taught introductory calculus with Photomath App in experimental group 1, and those taught with the traditional teaching method in the control group. From Table2, it can be deduced that the students who were taught with Photomath App in the experimental group 1, had a performance mean gain of 23.90, and those taught with the traditional teaching method in the control group had a performance mean gain of 10.73. This result indicated that the students that were taught with Photomath App performed better than those that were taught with the traditional teaching method. The mean difference between the two groups was 13.17.

Research Question 2: What is the difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Mathway App and those taught with traditional method?

Table 3: Mean and standard deviation on the performance of students taught introductory calculus with Mathway App and traditional teaching method

Group	n	Pretest		Posttest		Performance	
		Mean	SD	Mean	SD	Mean Gain	Mean Diff.
Mathway App	68	45.75	10.52	68.02	12.63	22.27	11.54
TTM	60	51.74	12.58	62.47	11.65	10.73	

TTM = Traditional Teaching Method

Table 3 is the presentation of the mean and standard deviation on the performance of students that were taught introductory calculus with Mathway App in the experimental group 2 and those taught with the traditional teaching method in the control group. From Table 3, it can be deduced that the students who were taught with Mathway App in the experimental group 2, had a performance mean gain of 22.27, and those taught with the traditional teaching method in the control group had a performance mean gain of 10.73. This result indicated that the students that were taught with Mathway App performed better than those that were taught with the traditional teaching method. The mean difference between the two groups was 11.54.

Research Question 3: What is the difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Photomath App and those taught with Mathway App?

Table 4: Mean and standard deviation on the performance of students taught introductory calculus with Photomath App and Mathway App

Group	n	Pretest		Posttest		Performance	
		Mean	SD	Mean	SD	Mean Gain	Mean Diff.
Photomath App	55	48.93	10.52	72.83	12.63	23.90	1.63
Mathway App	68	45.75	10.52	68.02	12.63	22.27	

TTM = Traditional Teaching Method

Table 4 is the presentation of the mean and standard deviation on the performance of students that were taught introductory calculus with Photomath App in experimental group 1, and those taught with Mathway App in experimental group 2. From Table 4, it can be deduced that the students who were taught with Photomath App in the experimental group 1, had a performance mean gain of 23.90, and those taught with Mathway App had a performance mean gain of 22.27. This result indicated that the students that were taught with Photomath App performed better than those that were taught with Mathway App. The mean difference between the two groups was 1.63.

H₀₁: There is no significant difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Photomath App and those taught with traditional teaching method.

Table 5: Summary of ANCOVA on the difference in the performance of undergraduate students taught introductory calculus with Photomath App and traditional teaching method

Source	Type III Sum of Squares	Df	Mean Square	F	p-value
Corrected Model	15917.616 ^a	2	7958.808	51.679	.000
Intercept	14880.985	1	14880.985	96.627	.000
Pretest	5215.051	1	5215.051	33.863	.000
Group	10098.471	1	10098.471	65.573	.000
Error	12782.384	112	154.005		
Total	288850.000	115			
Corrected Total	28700.000	114			

a. R Squared = .638 (Adjusted R Squared = .742)

Table 5 shows the summary of ANCOVA on the difference in the performance of undergraduate students taught introductory calculus with Photomath App and those taught with traditional teaching method. The result indicated an F-calculated value of 65.573, and p-value of 0.00. The result showed that there is a significant difference in the performance of undergraduate students taught introductory calculus with Photomath App and those taught with traditional teaching method ($F_{1, 112}=65.573$, $p = .000 < .05$). The null hypothesis one, H_{01} was rejected at 0.05 significant level.

H₀₂: There is no significant difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Mathway App and those taught with traditional teaching method.

Table 6: Summary of ANCOVA on the difference in the performance of undergraduate students taught introductory calculus with Mathway App and traditional teaching method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	5203.062 ^a	2	2601.531	57.371	.000
Intercept	5122.713	1	5122.713	112.969	.000
Pretest	1045.017	1	1045.017	23.045	.000
Group	3568.845	1	3568.845	78.702	.000
Error	3128.882	125	45.346		
Total	280900.000	128			
Corrected Total	8331.944	127			

a. R Squared = .624 (Adjusted R Squared = .614)

The analyzed data in Table 6 showed the summary of ANCOVA on the difference in the performance of undergraduate students taught introductory calculus with Mathway App in experimental group 2 and those taught with traditional teaching method in the control group. The result indicated an F-calculated value of 78.702, and p-value of 0.00. The result established that there is a significant difference in the performance of undergraduate students

taught introductory calculus with Mathway App and traditional teaching method ($F_{1, 125}=78.702$, $p=.00<.05$). The null hypothesis two was rejected at a .05 level of significance.

H₀₃: There is no significant difference between the mean score performance of undergraduate mathematics students taught introductory calculus with Photomath App and those taught with Mathway App.

Table 7: Summary of ANCOVA on the difference in the performance of undergraduate students taught introductory calculus with Photomath App and Mathway App

Type III					
Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	4847.40 ^a	2	2423.70	38.52	.00
Intercept	6772.02	1	6772.02	107.63	.00
Pretest	4662.46	1	4662.46	74.10	.00
Group	100.52	1	100.52	1.60	.08
Error	7613.38	120	62.92		
Total	461264.00	123			
Corrected Total	12460.77	122			

a.R Squared = .425 (Adjusted R Squared = .406)

The analyzed data in Table 7 showed the summary of ANCOVA on the difference in the performance of undergraduate students taught introductory calculus with Photomath App in experimental group 1 and those taught with Mathway App in experimental group 2. The result indicated an F-calculated value of 1.60, and p-value of .08. The result established that there is no significant difference in the performance of undergraduate students taught introductory calculus with Photomath App and Mathway App ($F_{1, 120}=1.60$, $p = .08>.05$). The null hypothesis three was retained at a .05 level of significance.

Discussion of Findings

Table 2 is the presentation of the mean and standard deviation on the performance of students that were taught introductory calculus with Photomath App in experimental group 1, and those taught with the traditional teaching method in the control group. From Table 2, it can be deduced that the students who were taught with Photomath App in the experimental group 1, had a performance mean gain of 23.90, and those taught with the traditional teaching method in the control group had a performance mean gain of 10.73. This result indicated that the students that were taught with Photomath App performed better than those that were taught with the traditional teaching method. The mean difference between the two groups was 13.17. When subjected to statistical analysis the result indicated an F-calculated value of 65.573, and p-value of 0.00. The result showed that there is a significant difference in the performance of undergraduate students taught introductory calculus with Photomath App and those taught with traditional teaching method ($F_{1, 112}=65.573$, $p = .000<.05$). The null hypothesis one, H_{01} was rejected at 0.05 significant level. The finding agrees with the findings of Ahmad et al. (2025) and also that of Amadi & Ogbugu (2022).

The second finding showed that the students who were taught with Mathway App in the experimental group 2, had a performance mean gain of 22.27, and those taught with the traditional teaching method in the control group had a performance mean gain of 10.73. This result indicated that the students that were taught with Mathway App performed better than those that were taught with the traditional teaching method. The mean difference between the two groups was 11.54. When subjected to statistical analysis the result indicated an F-calculated value of 78.702, and p-value of 0.00. The result established that there is a

significant difference in the performance of undergraduate students taught introductory calculus with Mathway App and traditional teaching method ($F_{1, 125}=78.702$, $p = .00 < .05$). The null hypothesis two was rejected at a .05 level of significance. This result agrees with the finding of Nnyigide (2025) which showed that mathway app improved the academic performance of students better than the lecture teaching method. The finding also agrees with the finding of Alqashanin and Faqihi (2022).

The third finding showed that the students who were taught with Photomath App in the experimental group 1, had a performance mean gain of 23.90, and those taught with Mathway App had a performance mean gain of 22.27. This result indicated that the students that were taught with Photomath App performed better than those that were taught with Mathway App. The mean difference between the two groups was 1.63. When subjected to statistical test the result indicated an F-calculated value of 1.60, and p-value of .08. The result established that there is no significant difference in the performance of undergraduate students taught introductory calculus with Photomath App and Mathway App ($F_{1, 120}=1.60$, $p = .08 > .05$). The null hypothesis three was retained at a .05 level of significance. This result agrees with the finding of George (2023) and Haruna (2019).

Conclusion

Based on the findings of this study it was concluded that the use of mathematics Apps improved the academic performance of undergraduate mathematics students in calculus better than the traditional teaching method. However, the use of Photomath App improved the academic performance of students in calculus better than the use of Mathway App.

Recommendations

The following recommendations were made based on the results of the study.

1. Teachers should use Photomath App to teach students Calculus.
2. Teachers should use Mathway App to teach students Calculus.
3. Students should be encouraged to harness the full potential of different mathematics Apps as a learning tool in mathematics.

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