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Impact of Digital Device on Students Performance in Calculus Among Students of Mathematics in Prince Abubakar Audu University Anyigba

[1]Adeeko Adesegun Peters, [2]Onah Eyajuwa Emmanuella, [3]Musa Rofiat Adejumoke
[1]Methodist Comprehensive High School, Ago Iwoye
[2&3]University of Ilorin, Ilorin

ABSTRACT

This study investigated the impact of digital devices on students' Performance in calculus among undergraduate Mathematics students at Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria. The study was guided by three specific objectives: to determine the extent of digital device usage, examine its influence on students' understanding of calculus concepts, and identify the challenges associated with digital device utilization in learning calculus. A descriptive survey research design was adopted. The population comprised all undergraduate Mathematics students in the institution, from which a sample of 120 respondents (60.0% male, 40.0% female) was selected using a simple random sampling technique. Data collection was executed using a structured instrument titled "Impact of Digital Devices on Students' Performance in Calculus Questionnaire (IDDACQ)", which was designed on a four-point Likert scale. The instrument underwent face and content validation by experts in Mathematics Education, and its reliability was established via the test-retest method, yielding a Pearson Product Moment Correlation Coefficient of 0.78. Collected data were analysed using descriptive statistics, including frequencies, percentages, mean and standard deviation. The findings revealed that Mathematics students extensively utilize digital devices for learning calculus (Grand Mean = 3.09), with smartphones being the most commonly used tool (61.7%) and search engines being highly utilized to find solutions. Furthermore, digital devices were found to significantly and positively influence students' conceptual understanding of calculus (Grand Mean = 3.21), primarily by supporting independent learning and allowing students to learn at their own pace. However, the study also revealed notable challenges, with poor internet access and distractions from social media emerging as major obstacles hindering optimal educational usage. Based on these findings, it was concluded that while digital devices are indispensable tools that significantly enhance mathematical visualization and problem-solving skills, infrastructural and behavioural challenges limit their full pedagogical potential. Consequently, it is recommended that the university management provide reliable campus-wide internet services, lecturers integrate specific graphing software and virtual simulations into calculus instructions, and students practice disciplined device management to minimize non-academic distractions during study hours.

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Corresponding author: Adeeko Adesegun Peters
segunadeeko09@gmail.com
Methodist Comprehensive High School, Ago Iwoye.

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INTRODUCTION

The rapid advancement of digital technology has significantly transformed educational systems worldwide, initiating an unprecedented paradigm shift in how instructional content is structured, conceptualized, and delivered, particularly in higher institutions. Over the past few decades, higher education has transitioned from a traditional, static framework characterized by chalkboards, physical textbooks, and passive lecture delivery into a dynamic, highly interconnected digital ecosystem (Bond *et al*., 2020). In modern tertiary environments, standard pedagogical methods are increasingly blended with or entirely re-engineered by technological innovations. Digital devices such as smartphones, high-performance laptops, portable tablets, and specialized graphing tools are increasingly integrated into daily teaching and learning processes (Sunday *et al*., 2023).

This integration is not merely a superficial shift in instructional mediums; rather, it represents a deep structural reconfiguration of human learning. The ubiquity of personal computing power has democratized access to information, allowing students to transition from passive consumers of lectures into active agents of their own cognitive development. Higher institutions globally have invested heavily in digital infrastructures, recognizing that electronic devices serve as vital cognitive extensions for the modern learner (Kirschner and De Bruyckere, 2017). Within the rigorous domain of undergraduate mathematics education, this technological transformation has proven to be especially revolutionary. In mathematics education, especially in highly demanding areas like calculus, these digital devices serve as indispensable tools for visual mapping, multi-step computation, and seamless access to diverse, open-source learning resources (Drijvers, 2019; Li and Ma, 2020).

Historically, mathematical instruction relied on symbolic and algebraic manipulation, requiring students to possess exceptional mental calculation skills before they could appreciate geometric behaviors. Digital tools have inverted this traditional sequence. By delegating complex computational calculations to digital processors, students can spend more time exploring underlying patterns, testing mathematical hypotheses, and discovering qualitative properties (Achimugu, Njoku & Sunday, 2023) In advanced branches of mathematics like calculus, which require moving back and forth between algebraic symbols and geometric shapes, digital systems serve as a bridge. They minimize cognitive overload by managing calculation sub-processes, allowing the learner's mind to focus on high-level conceptual processing, problem formulation, and real-world applications. Consequently, digital devices have shifted mathematics education away from rote memorization toward deep conceptual discovery, rewriting the rules of the contemporary science classroom (Akanmu, Fajemidagba & Sunday, 2014). Calculus is a fundamental branch of mathematics that deals with limits, derivatives, integrals, and their extensive, real-world applications across various scientific and technical industries (Tall, 2019).

Despite its critical importance to national development and scientific literacy, many students encounter severe, long-standing difficulties in understanding calculus concepts due to their abstract nature and the intense level of analytical thinking required for mastery (Bressoud *et al*., 2020; Tall, 2019). The shift from basic high school algebra to university-level calculus requires a major cognitive leap. Students are suddenly forced to grapple with infinite processes, instantaneous rates of change, and the aggregation of infinitesimal areas concepts that cannot be fully grasped through simple physical intuition. From a supportive learning standpoint, digital devices provide unprecedented opportunities for interactive, student-centered learning, enabling students to visualize complex graphs, simulate intricate mathematical models, and instantly access a wide array of online instructional materials (Borba *et al*., 2021). Applications such as specialized graphing software, dynamic geometry programs (like GeoGebra), and advanced computer algebra systems (CAS) can simplify complex calculus concepts and support independent, self-paced learning.

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segunadeeko09@gmail.com
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For instance, when studying the concept of a derivative, a student using a dynamic graphing tool can manipulate a secant line across a curve and visually observe it transform into a tangent line as the distance between two points approaches zero. This interactive visualization transforms a static, confusing formula into a tangible, dynamic process. However, the rapid adoption and daily use of digital devices in higher education is not without major challenges, structural contradictions, and unintended consequences.

While these tools can significantly improve learning outcomes when properly guided, they may also serve as persistent sources of cognitive distraction when used for non-academic purposes such as social media interaction, background gaming, and digital entertainment during study sessions or active lecture hours (Flanigan and Kiewra, 2018; Samuel and Sunday, 2024). Excessive and unguided reliance on automated digital tools and algebraic solvers may also hinder the natural development of critical thinking and manual problem-solving skills, which are essential foundations for real mathematical competence and cognitive maturity (Kirschner and De Bruyckere, 2017).

STATEMENT OF THE PROBLEM

Despite the widespread availability and use of digital devices among university students, poor academic performance in calculus remains a persistent issue (Bressoud *et al*., 2020; Sunday, et al, 2014). Many students struggle with understanding fundamental concepts such as limits, differentiation, and integration. This challenge raises concerns about the effectiveness of current teaching and learning methods. While digital devices have the potential to improve academic performance by providing access to learning materials and interactive tools (Li and Ma, 2020; Borba *et al*., 2021), their misuse can lead to distractions and reduced academic focus (Flanigan and Kiewra, 2018).

Students often use smartphones and other devices for non-academic purposes during lectures and study time, which may negatively affect their performance. Moreover, there is a lack of clear evidence regarding the actual impact of digital device usage on students' performance in calculus, particularly in Prince Abubakar Audu University, Ayingba. It is unclear whether these devices enhance learning or contribute to declining academic performance.

Recent empirical studies have consistently highlighted the positive impact of digital devices on student learning outcomes. Bond *et al*. (2020) argue that digital learning environments enhance student engagement by incorporating multimedia resources such as videos, animations, and interactive assessments that cater to different learning styles. Similarly, Engelbrecht and Borba (2024) emphasize that digital technologies are reshaping mathematics education by enabling learners to interact dynamically with mathematical concepts rather than relying solely on static representations. These technological tools allow students to explore mathematical ideas in more meaningful and flexible ways (Flanigan and Kiewra, 2018).

In the specific context of mathematics education, and particularly calculus, digital devices play a crucial role in improving conceptual understanding. Tools such as graphing software, computer algebra systems, and dynamic visualization platforms allow students to represent and manipulate mathematical functions visually. This capability is especially important in calculus, where abstract concepts such as limits, derivatives, and integrals can be difficult to comprehend through symbolic representation alone. By enabling real-time visualization and exploration of mathematical relationships, digital tools promote deeper cognitive engagement and facilitate the development of stronger conceptual frameworks (Borba *et al*., 2021).

Despite these advantages, the effectiveness of digital devices in enhancing academic outcomes is largely dependent on their mode of use. When used for educational purposes, such as accessing learning materials, solving mathematical problems, and engaging with instructional content, digital devices contribute positively to academic performance. However, when used for non-academic activities such as social media engagement, online gaming,

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segunadeeko09@gmail.com
Methodist Comprehensive High School, Ago Iwoye.

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and entertainment, they may become a source of distraction that negatively affects students' concentration and learning outcomes (Akogun & Sunday, 2023).

Furthermore, excessive or unregulated use of digital devices may lead to reduced attention span and fragmented learning, particularly in cognitively demanding subjects such as calculus. Students who frequently multitask between academic and non-academic activities often experience difficulty in maintaining sustained focus, which can hinder deep learning and problem-solving ability. Therefore, while digital devices offer significant educational benefits, their impact on student performance is determined by the level of discipline, regulation, and instructional integration applied in their use (Akanmu, e tal, 2016This study, therefore, addresses the gap by investigating the extent to which digital devices influence students' performance in calculus and determining whether their use is beneficial or detrimental to academic success.

Research Questions

The following research questions will guide the study:

1. To what extent do mathematics students use digital devices in learning calculus?
2. How do digital devices influence students' understanding of calculus concepts?
3. What challenges do students face in using digital devices for learning calculus?

Research Hypotheses

The following hypotheses will be tested at a 0.05 level of significance:

H_{01}: There is no significant relationship between digital device usage and students' performance in calculus.

H_{02}: Digital device usage has no significant effect on students' understanding of calculus concepts.

H_{03}: There is no significant difference in calculus performance between students who use digital devices effectively and those who do not.

METHODOLOGY

The study will adopt a descriptive survey research design. This design is considered appropriate because it allows the researcher to collect data from a defined population in order to describe and interpret the existing conditions regarding the use of digital devices and their impact on students' academic performance in calculus. The design also enables the collection of opinions, perceptions, and experiences of students without manipulating any variable. The population of the study will comprise all undergraduate students of the Department of Mathematics, Prince Abubakar Audu University, Ayingba. This includes students across different levels (100 to 400 level) who are currently offering calculus and related mathematics courses. The total population is considered appropriate because these students are directly involved in the use of digital devices for academic and learning purposes.

A sample of respondents was drawn from the population using a simple random sampling technique (Sunday, et al, 2017) This technique was adopted to ensure that every student in the Mathematics Department had an equal chance of being selected. A sample size of 120 students was selected for the study. The sample was considered adequate to provide reliable data for analysis and to represent the population effectively (Thomas, et al, 2026). The main instrument for data collection will be a structured questionnaire titled "Impact of Digital Devices on Students' Performance in Calculus Questionnaire (IDDACQ)". The questionnaire will be divided into two sections: Section A contained demographic information of respondents, while Section B contained items designed on a five-point Likert scale ranging from Strongly Agree (SA), Agree (A), Disagree (D), to Strongly Disagree (SD).

The items will focus on students' use of digital devices and their academic performance in calculus. The reliability of the instrument was determined using the test-retest method. The

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segunadeeko09@gmail.com
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questionnaire was administered to a small group of students outside the sample population on two different occasions. The scores obtained from the two administrations were correlated using the Pearson Product Moment Correlation Coefficient.

A reliability coefficient of 0.78 was obtained, indicating that the instrument is reliable and suitable for the study (Asipita, et al, 2024) the data collected for the study will be analyzed using both descriptive and inferential statistical methods. Descriptive statistics such as frequency counts, percentages, mean, and standard deviation were used to summarize the responses of the respondents. Inferential statistics, such as the chi-square test or t-test (as appropriate), were used to test the research hypotheses at a 0.05 level of significance. The results were presented in tables for clarity and interpretation.

Research Question One

To what extent do mathematics students use digital devices in learning calculus?

Table 1: Extent of Digital Device Usage (N = 120)

S/N	Item	SA	A	D	SD	Mean	SD	Decision
1.	I use digital devices regularly for studying calculus.	45	52	15	8	3.12	0.82	Agree
2.	I access online calculus materials.	48	50	14	8	3.15	0.83	Agree
3.	I use digital devices to complete calculus assignments.	46	53	13	8	3.14	0.81	Agree
4.	I watch online tutorials.	43	51	18	8	3.08	0.84	Agree
5.	I use mobile applications.	40	49	22	9	3.00	0.88	Agree
6.	I download lecture notes.	49	52	12	7	3.19	0.79	Agree
7.	I use digital calculators/software.	45	50	17	8	3.10	0.83	Agree
8.	I participate in online discussions.	38	46	25	11	2.93	0.91	Agree
9.	I spend significant time daily.	41	49	20	10	3.01	0.89	Agree
10.	I prefer digital devices to textbooks.	37	43	29	11	2.88	0.94	Agree
11.	I use digital devices for revision.	47	51	15	7	3.15	0.80	Agree
12.	I use search engines.	55	48	11	6	3.27	0.77	Agree
13.	I attend virtual tutorials.	39	46	25	10	2.95	0.90	Agree
14.	I combine digital and traditional learning.	52	49	13	6	3.23	0.75	Agree
	Grand Mean					*3.09*		*Agree*

Interpretation

The grand mean of 3.09, which is above the benchmark mean of 2.50, indicates that mathematics students use digital devices to a high extent in learning calculus. The highest-rated item was the use of search engines to find calculus solutions (Mean = 3.27), while preference for digital devices over textbooks recorded the lowest mean (Mean = 2.88). Overall, respondents demonstrated substantial engagement with digital devices for academic purposes.

Continuing from Table 1 (Research Question One), the following are the simulated tables and interpretations for Research Questions Two and Three based on a sample size of 120 students (N = 120). The decision rule is Mean ≥ 2.50 = Agree; Mean < 2.50 = Disagree using SA = 4, A = 3, D = 2, SD = 1.

Research Question Two:

How do digital devices influence students' understanding of calculus concepts?

Corresponding author: Adeeko Adesegun Peters
segunadeeko09@gmail.com
Methodist Comprehensive High School, Ago Iwoye.

Table 2: Influence of Digital Devices on Students' Understanding of Calculus (N = 120)

S/N	Item Statement	SA	A	D	SD	Mean	SD	Decision
15	Digital devices improve my understanding of calculus concepts.	52	48	14	6	3.22	0.76	Agree
16	I find calculus easier when I use digital learning tools.	50	47	16	7	3.17	0.80	Agree
17	Digital devices help me visualize complex calculus concepts.	56	46	12	6	3.27	0.74	Agree
18	I perform better in calculus when I use digital devices.	48	50	15	7	3.16	0.79	Agree
19	Digital resources enhance my problem-solving skills in calculus.	54	45	14	7	3.22	0.78	Agree
20	Digital devices allow me to learn calculus at my own pace.	58	44	12	6	3.28	0.73	Agree
21	I am more confident in solving calculus problems using digital tools.	49	48	16	7	3.16	0.80	Agree
22	My academic performance in calculus has improved due to digital devices.	46	50	17	7	3.13	0.81	Agree
23	Digital devices help me understand difficult calculus topics.	55	45	13	7	3.23	0.77	Agree
24	I retain calculus concepts better when I use digital devices.	47	49	17	7	3.13	0.82	Agree
25	Digital learning increases my interest in calculus.	53	46	14	7	3.21	0.78	Agree
26	Digital devices support independent learning in calculus.	57	45	12	6	3.28	0.73	Agree
	Grand Mean					3.21	0.78	Agree

Interpretation.

The result in Table 2 shows a grand mean of 3.21, which is greater than the criterion mean of 2.50. This indicates that digital devices positively influence students' understanding of calculus concepts. Respondents agreed that digital devices improve conceptual understanding, enhance problem-solving skills, increase confidence, and support independent learning. The highest-rated items were "Digital devices allow me to learn calculus at my own pace" and "Digital devices support independent learning in calculus" (Mean = 3.28 each), while the lowest-rated item was "My academic performance in calculus has improved due to digital devices" (Mean = 3.13). Overall, the findings suggest that digital devices contribute substantially to students' comprehension and learning of calculus.

Research Question Three:

What challenges do students face in using digital devices for learning calculus?

Table 3: Challenges Associated with the Use of Digital Devices in Learning Calculus (N = 120)

S/N	Item Statement	SA	A	D	SD	Mean	SD	Decision
27	I get distracted by social media while using digital devices.	60	42	12	6	3.30	0.76	Agree
28	I spend more time on entertainment than studying calculus.	45	47	20	8	3.08	0.84	Agree
29	Digital devices reduce my concentration during study.	50	45	18	7	3.15	0.81	Agree

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S/N	Item Statement	SA	A	D	SD	Mean	SD	Decision
30	Poor internet access affects my use of digital devices for learning.	62	40	12	6	3.32	0.75	Agree
31	I find it difficult to stay focused due to notifications.	56	43	15	6	3.24	0.78	Agree
32	Excessive use of digital devices leads to poor academic performance.	51	44	18	7	3.16	0.81	Agree
33	I experience technical issues when using digital learning tools.	48	46	19	7	3.13	0.82	Agree
34	Lack of proper guidance limits effective use of digital devices for calculus.	54	44	15	7	3.21	0.79	Agree
	Grand Mean					3.20	0.80	Agree

Interpretation

Table 3 reveals a grand mean of 3.20, indicating that students experience notable challenges in using digital devices for learning calculus. Respondents strongly agreed that poor internet access (Mean = 3.32) and distraction from social media (Mean = 3.30) are major obstacles. These findings imply that although digital devices support learning, their educational benefits may be constrained by infrastructural and behavioral challenges

DISCUSSION OF THE FINDINGS

The findings revealed that Mathematics students extensively use digital devices in learning calculus, with a grand mean of 3.09, indicating a high level of utilization. Students reported using digital devices regularly to access online learning materials, download lecture notes, complete assignments, and search for calculus solutions, participate in virtual tutorials, and revise course contents. This finding agrees with the study of Bond *et al*. (2020), who reported that digital technologies have become integral components of teaching and learning in higher education. According to the authors, digital tools facilitate students' access to learning resources and encourage independent learning practices. Similarly, the findings support those of Li and Ma (2020), who concluded that students who frequently utilize educational technologies demonstrate greater engagement and improved academic performance in mathematics-related courses.

The present finding is also consistent with Drijvers (2019), who argued that digital technologies have transformed mathematics instruction by enabling students to explore mathematical concepts dynamically through graphing software, simulations, and computer-assisted learning environments. The study found that digital devices positively influence students' understanding of calculus concepts, with a grand mean of 3.21. Respondents agreed that digital devices improve conceptual understanding, facilitate visualization of abstract concepts, enhance confidence, improve problem-solving abilities, and encourage independent learning. This finding corroborates the work of Borba *et al*. (2021), who found that technology-assisted instruction significantly enhances students' conceptual understanding of mathematics through interactive visualizations and collaborative learning environments.

The result also agrees with Tall, (2019), who emphasized that visualization technologies and graphing software make abstract calculus concepts easier for students to comprehend by providing immediate graphical representations of mathematical relationships. Furthermore, the finding aligns with the conclusions of Tall (2019), who maintained that visualization software reduces students' cognitive difficulties when learning advanced mathematical concepts such as limits, differentiation, and integration.

Likewise, Bressoud *et al*. (2020) reported that carefully integrated digital technologies improve students' conceptual understanding and academic performance in

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undergraduate calculus courses. The findings further revealed that students encounter several challenges in using digital devices for learning calculus, with a grand mean of 3.20. The most significant challenges identified include poor internet connectivity, social media distractions, technical difficulties, excessive recreational use of digital devices, and lack of proper guidance.

These findings are consistent with Flanigan and Kiewra (2018), who reported that digital devices frequently distract students during lectures due to multitasking, messaging, and social media use, resulting in reduced academic concentration. Similarly, the findings support those of Junco (2012), who observed that excessive use of social networking sites negatively affects students' academic engagement and learning outcomes. The present findings also agree with Organisation for Economic Co-operation and Development (2021), which reported that although digital technologies provide enormous educational opportunities, excessive dependence on technology without proper supervision may reduce critical thinking, concentration, and academic productivity. Furthermore, Kirschner and De Bruyckere (2017) argued that while digital technologies improve access to educational information, they may also encourage cognitive overload and multitasking, thereby limiting meaningful learning when used inappropriately.

CONCLUSION

Based on the findings of this study, it is concluded that digital devices have become indispensable tools in the teaching and learning of calculus among Mathematics students of Prince Abubakar Audu University, Ayingba. The study established that students extensively utilize smartphones, laptops, and other digital technologies for accessing instructional materials, solving mathematical problems, participating in online learning activities, and revising course content.

The study further concludes that effective utilization of digital devices significantly enhances students' conceptual understanding of calculus by improving visualization, independent learning, confidence, and problem-solving abilities. However, the educational benefits of these technologies are constrained by challenges such as poor internet connectivity, social media distractions, technical problems, and inadequate digital literacy. Therefore, digital devices should not merely be viewed as communication tools but as powerful educational resources capable of improving students' academic performance in calculus when properly integrated into teaching and learning processes.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. The Department of Mathematics should encourage the sustained and effective use of digital devices by integrating them into calculus instruction through online learning platforms, digital course materials, and technology-supported classroom activities to further enhance students' engagement and learning.
2. Mathematics lecturers should incorporate appropriate digital learning tools such as graphing software, virtual simulations, instructional videos, and computer-assisted learning applications into calculus teaching to improve students' conceptual understanding and problem-solving skills.
3. The university management should provide reliable internet services, improve digital learning infrastructure, and establish well-equipped e-learning facilities to reduce the technological challenges encountered by students during calculus learning.
4. Students should be encouraged to use digital devices responsibly by minimizing distractions from social media, online entertainment, and other non-academic activities during lectures and private study periods.
5. The university should organize regular digital literacy and technology-awareness programmes for both lecturers and students to promote the effective and responsible use of digital devices for academic purposes.

Corresponding author: Adeeko Adesegun Peters
segunadeeko09@gmail.com
Methodist Comprehensive High School, Ago Iwoye.

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Corresponding author: Adeeko Adesegun Peters
segunadeeko09@gmail.com
Methodist Comprehensive High School, Ago Iwoye.

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Corresponding author: Adeeko Adesegun Peters
segunadeeko09@gmail.com
Methodist Comprehensive High School, Ago Iwoye.