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Effectiveness of Digital Tools in Improving Senior Secondary School Students' Mathematics Learning Outcomes in Lagos State, Nigeria

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Abstract

Digital tools emerged as transformative assets in enhancing mathematics education, offering interactive and engaging methods to improve learning outcomes. This study investigated the effectiveness of digital tools in improving senior secondary school students' mathematics learning outcomes in Lagos State, Nigeria. The study adopted a mixed method research design. The population was the entire senior secondary school students in Lagos State. 300 students were selected from ten selected schools using a random sample technique. The instrument used for this study to collect data in a structured questionnaire with four sections and reliability index of 0.76 was obtained. Descriptive statistics such as percentages, means and standard deviation were used to answer the research questions. The results revealed that students have a strong positive perception of the integration of digital tools in mathematics classes. Also, revealed that GeoGebra, a popular mathematics app, is the most commonly used digital tool, followed by Khan Academy, while the least is interactive software (such as Desmos). It was recommended that collaboration among educators, policymakers, and technology providers is important for improving digital tools in mathematics education in Nigeria.

Keywords: Digital tools, Mathematics education, Student engagement, learning outcome

Introduction

Mathematics as a subject is as cornerstone to academic achievement and a vital skill set for navigating the modern society challenges and global intricacies. Additionally, Mathematics enhances students' problem-solving, communication, and logical reasoning skills (Yeasmin, 2017). The subject of mathematics frequently conjures up visions of elaborate calculations, complicated formulas, and abstract ideas. According to Ribeiro (2023), it is frequently linked to the academic world and is regarded by many as a subject that is exclusively used by mathematicians or scientists. However, our daily lives are fundamentally shaped by mathematics, which has a profound impact on our surroundings. Our daily lives are intricately interconnected with mathematics, frequently without our awareness, from basic computations to crucial decision-making (Ribeiro, 2023).

The issue is how to successfully integrate electronic technology into classroom activities become more important as countries throughout the world put laws and programs of action into place to accelerate their educational systems' digital transformation (Davies, 2011; Lindberg & Olofsson, 2018).

Integration of technology is defined as a process of full utilization of electronic devices positively to enhance the efficiency of a problematic technology platform that includes

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structured and unstructured use of ICTs, in the learning environment as well as outside, by learners and instructors. Integration must also consider a variety of changing elements, embracing best practices and usage, the technological aspects of new tools, potential to transform education and open the door to new approaches to instruction and learning (Howard & Moorman, 2019).

Furthermore, technology-supported teaching strategies, such as problem-based learning, have shown promising results in improving mathematical competence, particularly in complex topics like algebra and calculus (Juandi & Haryanto, 2021). Game-based learning, which uses interactive mathematics games, has also been shown to increase student motivation and achievement, with studies indicating a moderate impact when integrated into regular mathematics instruction (Clark & Mitchell, 2016).

However, there are limitations to the current research. The efficacy of digital tools can vary depending on the quality and frequency of tool use, with higher effectiveness observed in structured implementations that integrate these tools as part of a broader pedagogical framework. Studies also highlight the importance of teacher involvement in effectively deploying technology to ensure it aligns with learning objectives (Hegedus & Katz, 2015).

Overall, while digital tools have shown potential in enhancing learning outcomes in mathematics, their effectiveness relies on factors such as consistent use, instructional quality, and appropriate teacher support. Further studies are encouraged to investigate large-scale impacts and long-term effects in diverse educational settings to refine best practices for using these tools in secondary mathematics classrooms.

More so, students' varied learning demands are not satisfied by conventional teaching strategies that mostly focus on rote memorization. As a result, many learners develop negative attitudes toward mathematics, perceiving it as a no-go area and unapproachable subject. This negative perception can lead to poor performance and low self-efficacy among students, further exacerbating the existing educational challenges (Wang & Liu, 2023).

Despite these challenges, many people are starting to see how digital tools can help improve mathematics education in Nigeria. Increase in the availability of mobile devices and internet connectivity has opened new avenues for educational innovation. In Ikorodu Local Government Area, initiatives aimed at integrating technology into classrooms are beginning to take shape. Schools are increasingly adopting digital resources such as e-learning platforms and educational apps to supplement traditional teaching methods (Ogunyemi & Adebayo, 2021).

However, the efficiency and success of these technological tools remains largely unexamined in this specific context. While anecdotal evidence suggests positive outcomes from their use, we need more investigations to find out how to use them effectively to boost mathematics learning outcomes among senior secondary school students.

In Nigeria, mathematics education particularly within Public Senior Secondary Schools, faces significant challenges that hinder students' learning outcomes. Despite the global recognition of the importance of mathematics as a foundational skill for various disciplines and everyday life, many students in Nigeria struggle with mathematical concepts and exhibit negative attitudes towards the subject. This issue is exacerbated in

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regions like Ikorodu Local Government Area, where systemic educational deficiencies persist.

There is a number of major obstacles that prevent students in public senior secondary schools in Ikorodu from learning mathematics effectively. These problems include: inadequate supply of teaching resources such as textbooks, instructional aids, as well as access to contemporary technologies. Due to these problems, teachers' capacity to provide high-quality education is severely limited, and students are unable to meaningfully engage with mathematical topics and concepts which eventually affects the students' performance.

More over, the traditional teaching methods predominantly used are another critical factor contributing to poor mathematics outcomes among senior secondary school students. Many teachers still use conventional, teacher-centered approaches that emphasize rote memorization and passive learning. These methods fail to give room for the diverse learning needs of students, leaving many with a shallow understanding of mathematical concepts. In addition, there is still minimal incorporation of these tools into mathematics instruction in public senior secondary schools in Ikorodu, despite their growing availability. Many educators overlook opportunities to enhance the learning process because they lack the essential skills or self-assurance to employ technology in the classroom. Many students already have a bad attitude toward mathematics, which is made worse by this lack of technology integration. Students frequently view mathematics as an unapproachable and frightening subject as a result of these ongoing difficulties, which lower their self-esteem and deter them from striving for success.

Given these gaps, there is an urgent need for research to explore how digital tools can be efficiently and successfully embedded into mathematics education to improve learning outcomes among public senior secondary school students. Therefore, this study aims to delve into the effectiveness of digital tools in improving senior secondary school students' mathematics learning outcomes in Lagos State, Nigeria.

Objectives of the Study

Specifically, the study aims to:

1. examine the perception of students on the integration of digital tools in mathematics class.
2. determine the types and frequent use of digital tools in mathematics class.
3. determine the influence of digital tools on students' engagement in mathematics classes.

Research Questions

1. What is the perception of the students on the integration of digital tools in mathematics class?
2. What types of digital tools are used in mathematics class, and how frequently are they used by teachers and students?
3. In what way do the use of digital tools influence students' engagement in mathematics class?

Methodology

This study employed a descriptive research design, which was deemed appropriate to examining the effectiveness of digital tools in improving mathematics learning outcomes among senior secondary school students in Lagos State. The population for this study was all public Senior Secondary School Mathematics students in

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Ikorodu Local Government Area, Lagos State. This study used a random sample of SSS II and III Mathematics students from Ikorodu Local Government Area (LGA) in Lagos State. The study sampled 300 senior secondary school two and three students drawn at random from ten schools. From each school, thirty students were selected to represent the number in a group. Since the SSS II students are familiar with some of the fundamental mathematical ideas and methods needed to solve algebraic problems, they were included. Additionally, since they were exempted from external examination, greater attention was recorded throughout the research. Furthermore, they were probably going to embrace innovative educational ideas as they anticipated outstanding results in their senior secondary school certificate examinations (SSSCE) in the next academic year.

In this study, a structured questionnaire was used to collect data. The structured questionnaire was divided into four sections that addressed the research objectives. Section A meant to gather basic demographic information, such as the students' age, gender, and school type. Section B focuses on the perception of the students on the integration of digital tools in mathematics class. Section C focuses on types of digital tools are used in mathematics class, and how frequently are they used by teachers and students.

While Section D focuses on the influence of digital tools on students' engagement in mathematics class. Two specialists in mathematics education determined the instrument content validity. Their input and recommendations were utilized to maximize the instrument's quality, assisting in making sure that all important aspects were covered. Two experts in test and measurement were consulted to establish face validity. They went over the instruments' elements to make sure they were appropriate and pertinent for evaluating students' experiences using digital tools in their mathematics class. The review's comments were used to improve the items and make sure they were unmistakably in line with the purposes of the study. The Cronbach's Alpha method was used to analyze the reliability of the structured questionnaire. The reliability index of 0.76 was obtained. This indicated that the instrument is reliable.

The researchers visited the selected schools, seeking and obtaining permission from the school administrators to conduct the study. The researchers also sought for the consent and participation of the mathematics students in the selected schools. After obtaining the consent, the researchers administered the instruments to the students and ensured that the students understood the instructions and completed the questionnaires accurately. It took two weeks for data collection in the ten selected schools.

To encourage a high response rate, the distribution and collection of the questionnaires were done face-to-face during school hours. Respondents were given sufficient time to fill out the questionnaires. Out of the 300 questionnaires distributed across the ten schools, all were successfully retrieved and duly completed. The data collected from the questionnaire was systematically organized, transcribed, and prepared for analysis. The research questions were answered using descriptive statistics such as percentages, mean and standard deviation.

Results

Research Question 1: What is the perception of the students on the integration of digital tools in mathematics class?

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Table 1.

Perception of students on the integration of digital tools in mathematics class

S/N	Item Statement	Mean	Std. Dev.
1	I use digital tools regularly for my mathematics studies.	3.95	0.75
2	Digital tools have made learning mathematics easier for me.	4.25	0.65
3	My understanding of concepts has improved through them.	4.20	0.70

Table 1 indicates that students have a strong positive perception on the integration of digital tools in mathematics classes. The mean score of 4.25 for the statement 'Digital tools have made learning mathematics easier for me' is the highest among the items, suggesting that students view these tools as significantly simplifying complex mathematical concepts. This aligns with the trend of digital tools enhancing academic outcomes by offering alternative approaches to learning that accommodate various learning styles. The standard deviation values, ranging from 0.65 to 0.75, are relatively low, indicating a high level of agreement among respondents on the benefits of digital tools. Furthermore, the second item, 'I use digital tools regularly for my mathematics studies' with a mean score of 3.95, reflects a consistent frequency of digital tool usage among students, suggesting integration into their routine study habits.

Research Question 2: What types of digital tools are used in mathematics class, and how frequently are they used by teachers and students?

Table 2:

Types of digital tools are currently being utilized in mathematics instruction, and how frequently are they used by teachers and students

Digital Tool	Daily (%)	Weekly (%)	Occasionally (%)	Never (%)
Mathematics Apps (e.g., GeoGebra)	45%	35%	15%	5%
Online Platforms (e.g. Khan Academy)	40%	30%	20%	10%
Interactive Software	35%	25%	25%	15%

Table 2 shows that GeoGebra, a popular mathematics app, is the most commonly used digital tool, with 45% of students reporting daily usage. This indicates that students and teachers have incorporated GeoGebra into their regular learning routines, likely due to its interactive features, which help visualize complex mathematical concepts. Khan Academy, another online platform, is also widely used, with 40% of students accessing it daily for self-paced learning and tutorials. The frequency of usage for both tools (GeoGebra and Khan Academy) reflects their high relevance in the classroom and their significant role in students' academic engagement.

The relatively lower usage of interactive software (such as Desmos), with only 35% of students using it daily, indicates that while it is utilized in some classrooms, it is less universally integrated than GeoGebra or Khan Academy. Additionally, the 10% of students who never use Khan Academy and 15% who never use interactive software suggest there may be barriers to access or awareness that prevent some students from fully utilizing these resources. The relatively frequent use of interactive software suggests it is beneficial but may require more structured integration into lesson plans. This points to a potential area of improvement where more schools can focus on

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providing access to and training for these tools to ensure broader and more effective utilization.

Research Question 3: In what way does the use of digital tools influence students' engagement in mathematics class?

Table 3:

Student Engagement on Digital Tool Integration

Engagement Level	Before Integration (%)	After Integration (%)	Change (%)
Actively Engaged	35%	75	+40%
Passively Engaged	65%	25	-40%

Table 3 demonstrates a significant increase in student engagement following the integration of digital tools into mathematics classes. Prior to using digital tools, 35% of students reported being actively engaged in their lessons, while 65% were passively engaged. After the introduction of digital tools, active engagement soared to 75%, while passive engagement dropped to 25%. This represents a 40% increase in active engagement and a corresponding 40% decrease in passive engagement, signaling that digital tools have a transformative effect on student participation.

The dramatic shift in engagement levels highlights the motivational power of digital tools. By offering interactive, visually appealing, and self-paced learning opportunities, digital tools cater to a variety of learning styles, encouraging more students to actively participate in class activities. The increase in engagement also suggests that students find digital tools to be more stimulating and rewarding compared to traditional methods, which may have contributed to the rise in participation. Furthermore, the significant change in engagement levels underscores the potential for digital tools to foster a more dynamic and interactive learning environment, which is essential for keeping students motivated and focused, especially in subjects like mathematics that many students may initially find challenging.

Discussion of Findings

One of the primary findings indicates that students have a strong positive perception of the integration of digital tools in mathematics classes. That is, digital tools have made learning mathematics easier for the students. The finding is supported by Wang and Zhao (2020), who emphasized the role of interactive tools in promoting deeper mathematical understanding through exploration and visualization. The findings of Akintunde & Fagbamila (2023) reported that students in Lagos State perceived mathematics as "less scary" and "easier to grasp" after using interactive platforms like Desmos in classroom settings. Also, the study of Yusuf & Afolabi (2023) concluded that Nigerian students appreciated digital tools for helping them track progress and correct errors in real time, making mathematics feel more achievable. The findings also align with the Technology Acceptance Model (TAM), which suggests that perceived usefulness and ease of use are critical drivers of technology adoption (Venkatesh et al., 2016). However, these results contrast slightly with Adeyemi et al. (2019), which suggested that improvements are often contingent on consistent teacher training and access to resources.

Findings on types and frequently used of digital tools indicate that GeoGebra, a popular mathematics app, is the most commonly used digital tool, followed by Khan Academy, while the least is interactive software (such as Desmos). The frequent use of these tools,

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with many students accessing them on a daily or weekly basis, also played a significant role in their mathematics classes. GeoGebra's dynamic visualizations and Khan Academy's self-paced learning model were particularly beneficial in facilitating understanding and boosting performance. A study by Bassey et al. (2022) in Nigeria found that teachers frequently preferred GeoGebra for demonstrating dynamic geometry and algebra because it enhances conceptual understanding and reduces abstractness in mathematics. The findings of Suleiman and Yusuf (2022) observed that Nigerian senior secondary school students benefited from Khan Academy for exam preparation, but teachers still preferred GeoGebra for lesson delivery due to its real-time visual modeling. Also, the findings of Ayeni and Oduwaiye (2023) argued that while Desmos offers excellent features for graphing and modeling functions, technical constraints and lack of training hinder its adoption in African classrooms.

Findings on the influence of digital tools on students' engagement in mathematics classes revealed that there is a significant increase in student engagement following the integration of digital tools into mathematics classes. This result is in line with that of Kozma (2020), who discovered that interactive content and instant feedback from digital technologies encourage active learning. The findings of Bassey et al. (2022) found that Nigerian students engaged more with mathematical tasks when digital tools provided visual representations, especially in algebra and geometry topics. Also, the findings of Akintola and Adepoju (2022) concluded that when digital tools were used for collaborative math tasks, students were more engaged, asked more questions, and supported each other more actively compared to traditional teaching.

Conclusion

In conclusion, the findings of this study provide strong evidence that the integration of digital tools in mathematics classes has a positive impact on students' perception, engagement, and learning outcomes. The results show that students have a strong affinity for digital tools, such as GeoGebra and Khan Academy, which they perceive as making mathematics easier to learn and understand. The frequent use of these tools, particularly GeoGebra, has been found to facilitate understanding and boost performance, while also increasing student engagement and motivation.

The findings are consistent with existing research, including the Technology Acceptance Model, which highlights the importance of perceived usefulness and ease of use in driving technology adoption. However, the study also notes that the effective integration of digital tools is contingent on factors such as teacher training, access to resources, and technical support. Overall, the results suggest that digital tools have the potential to transform mathematics education, making it more engaging, interactive, and effective, and that their integration should be prioritized to improve student outcomes and prepare them for success in an increasingly digital world.

Recommendations

Based on the findings, the following are recommended:

1. Schools should adopt structured frameworks for integrating digital tools into the mathematics curriculum.
2. Policymakers and educational stakeholders should prioritize infrastructure expenditures to address the digital gap. This includes affordable digital devices, increased internet connectivity, and classroom aids like interactive whiteboards and projectors.

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3. Educational authorities should develop and implement professional development programmes focused on equipping teachers with the skills to integrate digital tools effectively into their lesson plans. Training should include hands-on sessions on using tools like GeoGebra and Khan Academy, as well as strategies for fostering student engagement and tailoring instruction to different learning needs.
4. Schools should collaborate with educational technology providers to access the latest tools, resources, and training opportunities. Partnerships with these organizations can also facilitate the adaptation of digital tools to the local context, ensuring they are relevant and effective for the students' needs.
5. Workshops, seminars, and orientation sessions should be organized for students, parents, and teachers to increase awareness about the benefits and proper usage of digital tools. Such initiatives can help address misconceptions, foster positive attitudes, and encourage widespread adoption of technology in education.

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