Effectiveness of Mobile Apps in Enhancing Secondary School Students' Understanding of Algebra in Katsina State, Nigeria

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Abstract
This study investigates the effectiveness of mobile applications in enhancing secondary school students' understanding of algebra in Katsina State, Nigeria. Despite the increasing integration of technology in education globally, many Nigerian classrooms still rely heavily on traditional, teacher-centered methods, especially in mathematics instruction. Algebra, a core component of the mathematics curriculum, poses considerable challenges for students due to its abstract nature. With the growing accessibility of mobile devices in Northern Nigeria, this study explores how educational apps can serve as innovative tools to support conceptual understanding and improve academic performance. Adopting a quasi-experimental design, the study involved JSS 2 students from selected public secondary schools in Katsina State. Participants were divided into experimental and control groups. The experimental group received instruction supplemented with mobile apps such as GeoGebra and Photomath, while the control group was taught using conventional methods. Data were collected through pre-tests, post-tests, and student attitude questionnaires. Statistical analysis, including paired and independent samples t-tests, was employed to evaluate the impact of the intervention. Findings revealed that students exposed to mobile apps showed significantly greater improvement in their understanding of algebraic concepts compared to those in the control group. Additionally, learners expressed positive attitudes toward the use of mobile technology in learning mathematics. The study concludes that mobile apps can be effective pedagogical tools for enhancing mathematics instruction in resource-constrained contexts and recommends their integration into classroom practices across Katsina State and similar settings.

Keywords:MobileApps,Algebra, MathematicsEducation,Technology Integration.

Introduction

Background of the Study

The teaching and learning of mathematics, particularly algebra, continues to present challenges to students and educators alike in many parts of the world, including Nigeria. Algebra, as a foundational concept in secondary mathematics, is essential for logical thinking, problem-solving, and further studies in science, technology, engineering, and mathematics (STEM) disciplines (Akinsola & Awofala, 2020).

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However, many Nigerian students exhibit poor performance in algebraic tasks due to the abstract nature of the subject and the limitations of traditional teaching methods (Ugwuegbulam & Ezeugo, 2018).

With the rise in mobile technology usage across Africa, including Northern Nigeria, mobile applications have emerged as promising tools for delivering interactive and engaging learning experiences. Educational apps such as GeoGebra, Khan Academy, and Photomath offer dynamic, visual representations of algebraic concepts, allowing students to manipulate variables and receive instant feedback (Sung, Chang, & Liu, 2016). Such technologies have the potential to support constructivist learning by enabling students to build understanding through exploration and active participation (Vygotsky, 1978; Jonassen, 1991).

Katsina State, located in the North-Western region of Nigeria, is experiencing gradual increases in digital penetration and smartphone usage among students and teachers. Despite this development, there remains limited empirical evidence on how mobile apps impact student learning outcomes in core subjects like mathematics, especially in public secondary schools. This gap highlights the need for localized studies that evaluate the effectiveness of educational technologies within the cultural and infrastructural realities of Northern Nigeria.

Statement of the Problem

Despite efforts by the government and educationalstakeholderstoimprovemathematicseducationinNigeria, students' performance in algebra remains unsatisfactory. The traditional chalk-and-talk teaching approach often lacks interactivity, leading to low student engagement and poor conceptual understanding. Mobile apps offer an innovative alternative, yet there is insufficient research investigating their effectiveness in real classroom settings in Katsina State. This study aims to fill this gap by examining how the use of mobile algebra apps influences students' understanding and performance.

Objectives of the Study

The main objective of this study is to determine the effectiveness of mobile apps in enhancing students' understanding of algebra in selected secondary schools in Katsina State. Specifically, the study aims to:

1. Compare the performance of students taught algebra using mobile apps with those taught using traditional methods.
2. Assess students' attitudes and engagement toward algebra after using mobile learning tools.
3. Identify challenges faced in implementing mobile apps in mathematics instruction.

Research Questions

1. What is the difference in algebra performance between students taught using mobile apps and those taught with traditional methods?
2. How does the use of mobile apps influence students' engagement and interest in algebra?
3. What are the challenges associated with using mobile apps in teaching algebra in secondary schools in Katsina State?

Significance of the Study

The findings from this study will provide insights for educators, curriculum developers, and policymakers into the benefits and limitations of integrating mobile technologies in mathematics instruction. It will also inform future teacher

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training and infrastructure planning needed to support digital learning in the region.

Scope and Delimitation

This study will focus on public junior secondary schools in Katsina State, targeting JSS2 students who are currently being introduced to algebra. The research will evaluate the use of selected mobile applications and will not cover other areas of mathematics or other forms of technology-enhanced learning.

Literature Review

2.1.TheRoleofTechnology in Mathematics Education

Theintegration of technology in mathematics education has been widely acknowledged for its potential to enhance teaching and learning outcomes. Digital tools provide visualizations, simulations, and interactive tasks that can deepen students' conceptual understanding, particularly in abstract areas like algebra (Kaput, 1992). As global educational systems move toward 21st-century skills, there is a growing emphasis on digital literacy and the need to leverage mobile and web-based tools in classroom practice (UNESCO, 2020). In Nigeria, the Federal Ministry of Education has recognized the importance of ICT in improving education quality, but implementation remains inconsistent, especially in rural regions (Yusuf & Afolabi, 2010).

2.2. Mobile Learning and Mathematics Applications

Mobile learning (m-learning) is an emerging approach that enables students to access educational content anytime and anywhere via smartphones, tablets, and other portable devices (Crompton & Burke, 2018). In mathematics, mobile apps like GeoGebra, Khan Academy, and Photomath have been praised for their interactivity, adaptability, and real-time feedback features, which can support student-centered learning (Baya'a & Daher, 2013). GeoGebra, for instance, allows students to manipulate algebraic and geometric representations dynamically, fostering exploration and deeper comprehension.

Several empirical studies have examined the use of these tools in secondary education. For instance, Kay et al. (2017) found that the use of mobile apps significantly improved students' mathematics achievement and engagement. In Nigeria, however, such studies are limited. One notable exception is the work of Okafor and Edokpolor (2021), who found that mobile app use in teaching quadratic equations significantly improved student performance compared to traditional methods.

2.3 Challenges in Algebra Instruction

Algebra is often seen as a gateway to advanced mathematics but also as a stumbling block for many learners due to its symbolic language and abstract structures (Kieran, 2007). Traditional teaching methods in Nigerian classrooms—often dominated by rote memorization and passive learning—fail to address these cognitive demands (Agwagah, 2001). As a result, students struggle with basic concepts such as variables, expressions, and equations.

The cognitive load theory suggests that abstract mathematical content should be delivered in ways that reduce mental effort and enhance comprehension (Sweller, 1994). Mobile applications, through visual and interactive content, can help reduce cognitive overload and support gradual internalization of complex concepts.

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2.4 Theoretical Framework

This study is guided by the **constructivist learning theory**, particularly the work of Vygotsky (1978), who emphasized the role of tools and social interaction in the development of higher-order thinking skills. Mobile apps can serve as "mediating tools" that scaffold students' understanding by allowing them to explore, make mistakes, and receive immediate feedback. Additionally, Bruner's (1966) theory of instruction highlights the importance of discovery learning and representation, both of which are supported by interactive mobile environments.

3. Methodology

3.1 Research Design

This study adopted a **quasi-experimental, pretest-posttest control group design** to evaluate the effectiveness of mobile applications in enhancing students' understanding of algebra. This design was chosen because it allows for the comparison of outcomes between a treatment group and a control group without random assignment, which is often impractical in school-based settings (Creswell & Creswell, 2018).

3.2 Population and Sample

The population of the study comprised all Junior Secondary School Two (JSS2) students in public secondary schools in Katsina State, Nigeria. Two schools were purposively selected based on the availability of mobile learning infrastructure (e.g., smartphones, stable electricity, and basic digital literacy among teachers) and the schools are Family Support Secondary School, Katsina and Government Day Secondary School Kofar Yandaka, Katsina. From each school, one intact class was selected: one as the **experimental group** (taught using mobile apps) and the school under this group is Family Support Secondary School, Katsina, and the other as the **control group** (taught using traditional methods) and the school is Government Day Secondary School Kofar Yandaka, Katsina.

A total of **100 students** participated in the study, with 56 and 44 students in the groups respectively. Intact classes were used to ensure ecological validity while minimizing classroom disruptions.

3.3 Instruments for Data Collection

Three instruments were used for data collection:

1. **Algebra Achievement Test (AAT):** A 30-item multiple-choice test covering algebraic concepts such as expressions, equations, and word problems. The test was validated by mathematics education experts and had a reliability coefficient of 0.83 using the Kuder-Richardson Formula 20 (KR-20).
2. **Student Attitude Questionnaire (SAQ):** A Likert-scale questionnaire adapted from previous studies (e.g., Kay et al., 2017), used to assess students' attitudes toward the use of mobile apps in learning mathematics.

3.4 Procedure for Data Collection

The study was conducted over **six weeks**:

- **Week 1:** Pre-test (AAT) administered to both groups.
- **Weeks 2–5:** The experimental group received instruction using selected mobile apps (GeoGebra and Photomath), while the control group was taught using conventional chalk-and-board methods. Lessonsfocused on algebraic expressions, solvingequations,andapplication problems. Teachers were trained prior to implementation to ensure competence in app usage.
- **Week 6:** Post-test administered to both groups using the same AAT instrument.

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The SAQ was also distributed to the experimental group to assess their perceptions and attitudes.

3.5 Data Analysis Techniques

Data collected were analyzed using **descriptive and inferential statistics**:

- **Mean and standard deviation** were used to describe students' performance and attitude scores.
- **Analysis of Covariance (ANCOVA)** was used to determine the difference in post-test scores between the experimental and control groups because the students from experimental and control groups were having different abilities as displayed by their pre-test results and also intact classes were used for the study.
- **Paired samples t-test** was used to assess within-group improvement from pre-test to post-test.
- **Qualitative comments** from open-ended items in the SAQ were thematically analyzed to capture students' perceptions of mobile app usage.

All statistical tests were conducted at a **0.05 level of significance** using SPSS version 25.

4. Results and Discussion

4.1.PerformanceofStudentsin Experimental and Control Groups

The pretest and posttest mean scores for both the experimental and control groups were analyzed to assess the impact of mobile apps on algebra achievement.

Table 1: Mean and Standard Deviation of

Test Comparison	T	df	p-value
Pretest vs Posttest	14.03	49	< 0.001

Pretest and Posttest Scores

The mean posttest score of the experimental group (38.90) was significantly higher than that of the control group (28.62), indicating that students taught with mobile apps performed better in algebra than those taught with traditional methods.

Table 2: Independent Samples t-Test on Posttest Scores

Group Comparison	T	df	p-value
Experimental vs Control	7.89	98	< 0.001

The independent samples t-test revealed a statistically significant difference in posttest scores between the two groups ($p < 0.001$). This supports the hypothesis that mobile appssignificantlyenhancestudents'understanding of algebra.

4.2.Within-GroupPerformance

Group	N	Pretest Mean (SD)	Posttest Mean (SD)
Experimental	44	23.14 (5.82)	38.90 (6.25)
Control	56	22.76 (5.71)	28.62 (6.13)

Comparison

Table 3: Paired Samples t-Test for Experimental Group

Thepairedsamples t-test for the experimental group showed a statistically significant improvement in algebra achievement after the mobile app intervention.

4.3. Students' Attitudes toward Mobile Apps

The Student Attitude Questionnaire (SAQ) revealed that:

- **84%** of students found mobile apps helpful in understanding difficult concepts.

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- **78%** reported increased interest and motivation in learning algebra.
- **92%** preferred continued use of mobile tools for mathematics learning.

Students noted that mobile apps made learning "fun," "interactive," and ―easier to understand.‖ These responses support earlier findings by Baya'a and Daher (2013), who reported that students perceived mobile learning as both engaging and effective.

4.4 Discussion of Findings

The significant difference in academic performance between the experimental and control groups aligns with findings from Okafor and Edokpolor (2021), who found that mobile-assisted instruction enhanced achievement in algebra. The increase in student interest and engagement supports the idea that digital tools offer more personalized and responsive learning environments (Sung, Chang, & Liu, 2016).

From a theoretical perspective, the results affirm the principles of constructivist learning, where learners actively construct knowledge through interaction with tools and context (Vygotsky, 1978). The mobile apps used in this study provided scaffolding that enabled students to explore algebraic concepts at their own pace, visualize mathematical relationships, and receive immediate feedback, all of which contributed to better understanding and performance.

4.5 Challenges Observed

Despite the positive outcomes, a few challenges were observed:

- Some students lacked prior experience with mobile learning, requiring extra time for orientation.
- Occasional power outages and device-sharing constraints limited full utilization in some sessions.
- Teachers required training to effectively integrate the technology into their pedagogy.

These findings underscore the need for supportive infrastructure, teacher professional development, and thoughtful curriculum alignment when introducing mobile technology into Nigerian classrooms.

5. Conclusion and Recommendations

5.1 Conclusion

This study examined the impact of mobile applications on the teaching and learning of algebra among Junior Secondary School students in Katsina State. The findings demonstrate that the use of mobile apps such as GeoGebra and Photomath significantly improved students' understanding and performance in algebra compared to traditional teaching methods. Moreover, the students exhibited positive attitudes toward the use of technology in mathematics learning, citing enhanced engagement, interest, and conceptual clarity.

The study concludes that mobile learning tools, when effectively implemented, can bridge the gap between abstract mathematical concepts and learners' comprehension. These tools serve as dynamic instructional aids that support active learning, immediate feedback, and personalized pacing—features that are often missing in traditional classroom settings.

5.2 Recommendations

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

1. **Integration of Mobile Technology in Mathematics Curriculum**

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Educational policymakers in Katsina State and beyond should consider integrating mobile learning tools into the secondary school mathematics curriculum, especially for abstract topics like algebra.

2. TeacherTrainingandCapacity Building
Continuous professional development programs should be organized to equip mathematics teachers with the necessary skills to integrate mobile apps effectively in their instructional delivery.

3. Provision of Infrastructure and Devices
The government, NGOs, and school administrators should provide adequate infrastructure, such as solar-powered charging stations, affordable devices, and internet access, particularly in underserved rural schools.

4. Further Research and Scalability
More extensive studies should be conducted across different senatorial zones in Katsina State and other parts of Northern Nigeria to validate and scale the results. Comparative studies between different types of educational apps could also provide deeper insights into what works best for specific topics.

5. Localized App Development
Indigenous developers should be encouraged to design culturally and linguistically relevant math apps tailored to the Nigerian educational context, particularly in Hausa language, to enhance inclusivity.

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