International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE)
www.ijasvote-fce.com
Volume 3; Issue 2; August 2026; Page No. 148-162.

PERCEIVED EFFECT OF ONLINE MATHEMATICS TEACHING APPS ON STUDENTS' ACHIEVEMENT AND RETENTION IN MATHEMATICS AMONG SECONDARY SCHOOL STUDENTS IN ENUGU STATE, NIGERIA

Uguru, Ndubuisi Okon[1]; Onwunali, Amarachukwu[1]; Udaeni, Gloria Chinyere[2]
1 Department of Mathematics, Federal College of Education,
Eha-Amufu, Enugu State, Nigeria
2 Department of Mathematics, Federal College of Education, Odugbo, Benue State, Nigeria
***Corresponding Author*:** Ugurundubuisi1202@gmail.com,

Abstract

This study investigated the perceived effect of online mathematics teaching applications (apps) on students' achievement and retention in mathematics among secondary school students in Enugu State, Nigeria. Anchored on the Technology Acceptance Model (TAM) and the Constructivist Learning Theory, the study adopted a descriptive survey design. A stratified random sample of 500 secondary school students drawn from five local government areas of Enugu State served as participants. Data were collected using a validated researcher-developed instrument, the Online Mathematics App Perception Scale (OMAPS), alongside a Mathematics Achievement Test (MAT) and a Mathematics Retention Test (MRT). Data were analysed using descriptive statistics, Pearson product-moment correlation, independent samples t-test, multiple linear regression, and two-way ANOVA. Results revealed a significant positive relationship between the perceived usefulness of online mathematics apps and students' achievement ($r = .612$, $p < .001$) and retention ($r = .574$, $p < .001$). Students with high app-use frequency recorded significantly higher achievement ($M = 68.47$) and retention ($M = 61.23$) scores compared to low-frequency users ($M = 53.41$ and $M = 47.61$, respectively). Multiple regression analysis indicated that app usefulness, frequency of use, ease of navigation, and app interactivity jointly accounted for 61.2% of the variance in mathematics achievement. Gender was found to moderate the relationship between app usage and retention. The study recommends the strategic integration of quality mathematics apps into the secondary school curriculum in Enugu State and across Nigeria.

Keywords: online mathematics apps, mathematics achievement, mathematics retention, secondary school students, Enugu State, technology-enhanced learning

Introduction

The rapid proliferation of digital technology in the twenty-first century has transformed virtually every sector of human endeavour, and education is no exception. Across the globe, education stakeholders governments, curriculum developers, classroom teachers, and learners

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

alike -are increasingly embracing technology-enhanced learning environments as instruments for improving educational outcomes. In Nigeria, this trend has been reinforced by the federal government's commitment to integrating technology into the educational system, as reflected in the National Policy on Education (Federal Republic of Nigeria, 2023) and the Digital Economy Policy and Strategy (DEPS) framework. Mathematics occupies a central position in the Nigerian educational system: it is a compulsory subject for all secondary school students, a prerequisite for entry into science and technology programmes in tertiary institutions, and a cornerstone of national development (Agbo & Usman, 2022). Yet, persistent evidence from the West African Examinations Council (WAEC) and the National Examinations Council (NECO) shows that a large proportion of Nigerian students consistently perform below the minimum acceptable standard in mathematics (WAEC, 2023). In Enugu State, the challenge is particularly pronounced, with students in many secondary schools demonstrating poor conceptual understanding, computational skills, and retention of mathematical knowledge beyond the examination period (Okeke & Eze, 2021).

In response to these persistent challenges, educational technology researchers have explored a variety of digital interventions, among which online mathematics teaching applications (apps) have emerged as particularly promising. These apps — including platforms such as Khan Academy, Photomath, Geo Gebra, Mathway, Desmos, Socratic, and numerous locally developed solutions — offer interactive, gamified, and self-paced learning experiences that traditional classroom instruction often cannot provide (Eze & Obiora, 2022; Adeleke & Hassan, 2023). They afford students the opportunity to receive immediate feedback, access worked examples at any time, visualise abstract mathematical concepts, and track their own learning progress. Given the widespread ownership of smartphones among Nigerian youths (Obi, Chukwuemeka & Onah, 2024), the potential of mathematics apps as supplementary instructional tools is considerable.

Despite the growing enthusiasm for mathematics apps, empirical research on their specific effects on achievement and retention among secondary school students in Enugu State remains limited. Most available Nigerian studies focus on Information and Communication Technology (ICT) in general, computer-assisted instruction, or specific software without distinguishing the unique attributes of mobile mathematics apps (Ugwuanyi & Okeke, 2021; Ibrahim & Abdullahi, 2022). Moreover, the Technology Acceptance Model (TAM), which posits that users' perceptions of usefulness and ease of use are the primary drivers of technology adoption, has rarely been applied in the context of mathematics app use among Nigerian secondary school students. There is therefore a research gap that the present study seeks to address.

This study was guided by two theoretical frameworks: Davis's (1989) Technology Acceptance Model and Vygotsky's (1978) Social Constructivist Theory. TAM provides a lens

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

for understanding how students' perceptions of online mathematics apps influence their willingness to engage with these tools and, by extension, their academic outcomes. The constructivist framework, on the other hand, highlights the importance of active, meaningful learning — a feature that well-designed mathematics apps are engineered to support through interactivity, problem-solving scaffolding, and contextualized feedback.

The study investigated the following research questions: (1) What is the relationship between students' perceived usefulness of online mathematics apps and their achievement in mathematics? (2) Is there a significant difference in mathematics achievement between high-frequency and low-frequency users of online mathematics apps? (3) To what extent do perceived app usefulness, frequency of use, ease of navigation, and interactivity jointly predict mathematics achievement? (4) What is the relationship between app-use frequency and mathematics retention? (5) Is there a significant difference in mathematics retention scores based on app-usage level and gender?

Literature Review

Conceptual Framework

Online mathematics teaching apps are defined in this study as mobile or web-based digital applications specifically designed to support the learning and teaching of mathematics through interactive problem sets, step-by-step explanations, visualisation tools, gamified exercises, and instant feedback mechanisms (Adeleke & Hassan, 2023). These apps exist on a spectrum from simple drill-and-practice platforms to sophisticated intelligent tutoring systems. Their growing popularity in developing countries is attributable to the increased accessibility of affordable smartphones, expanded mobile internet coverage, and the global acceleration of e-learning infrastructure following the COVID-19 pandemic (Obi et al., 2024).

Mathematics achievement, for the purposes of this study, refers to students' scores on a standardised mathematics test covering topics from the secondary school curriculum (Ugwuanyi & Okeke, 2021). Mathematics retention, by contrast, refers to the ability of students to recall and apply mathematical knowledge after a specified interval following instruction, measured in this study four weeks after the achievement test. These two constructs — achievement and retention — are analytically distinct but empirically related: a student who achieves a high score immediately after instruction does not necessarily retain that knowledge at the same level over time (Okeke & Eze, 2021).

Theoretical Framework

Technology Acceptance Model (TAM)

Developed by Davis (1989) and subsequently extended by Venkatesh and Bala (2008), the Technology Acceptance Model proposes that technology adoption is primarily determined by

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

two psychological beliefs: perceived usefulness (PU) — the degree to which a user believes the technology will enhance performance — and perceived ease of use (PEOU) — the degree to which use of the technology is expected to be effort-free. When applied to the educational technology context, TAM suggests that students who perceive a mathematics app as useful and easy to navigate are more likely to engage with it consistently, and that this engagement in turn produces positive learning outcomes (Ibrahim & Abdullahi, 2022). Several studies have confirmed the relevance of TAM in predicting students' acceptance and use of educational technology in Nigerian contexts (Agbo & Usman, 2022; Eze & Obiora, 2022).

Social Constructivist Theory

Vygotsky's (1978) Social Constructivist Theory emphasises that learning is an active, social process facilitated by tools, language, and more knowledgeable others within the learner's Zone of Proximal Development (ZPD). Well-designed mathematics apps function as cognitive tools that scaffold student learning by providing hints, adapting difficulty levels to individual performance, and offering explanations that bridge the gap between what students already know and what they are capable of knowing with appropriate support (Adeleke & Hassan, 2023). This theoretical alignment suggests that the most effective mathematics apps are those that not only deliver content but also model problem-solving processes and respond dynamically to learner input.

Empirical Review

A growing body of international and Nigerian research has examined the effects of technology-mediated instruction on mathematics learning. Internationally, Bhagat and Chang (2020) conducted a meta-analysis of 47 studies and found that technology-enhanced mathematics instruction produced a significant positive effect on student achievement ($d = 0.67$) compared to conventional instruction. Similarly, Hwang and Chen (2022) demonstrated, in a quasi-experimental study involving 312 Taiwanese senior secondary students, that GeoGebra-enhanced instruction significantly improved both achievement and geometric reasoning skills relative to a control group.

In the Nigerian context, Eze and Obiora (2022) investigated the effect of mathematics apps on the academic performance of senior secondary students in Anambra State and found that app-assisted instruction led to significantly higher mean scores than conventional chalk-and-talk methods. Adeleke and Hassan (2023) similarly reported that secondary school students in Lagos State who regularly used Photomath and Khan Academy demonstrated significantly better performance on algebra tasks than their counterparts who did not use any apps. Ugwuanyi and Okeke (2021) examined technology integration and mathematics achievement in Enugu State and observed that students exposed to computer-assisted instruction outperformed those in traditional settings. However, their study did not specifically focus on mobile apps or address the dimension of retention.

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

On the subject of mathematics retention, Obi et al. (2024) found that students who used gamified mathematics apps over a six-week period retained mathematical content significantly better than those who did not. The gamification elements — leaderboards, badges, and immediate reward systems — were identified as key motivators that enhanced long-term memory encoding. Okeke and Eze (2021) established, in a study conducted in Nsukka LGA of Enugu State, that students exposed to e-learning platforms demonstrated higher retention of algebraic content after a four-week interval compared to students taught using traditional methods, noting that interactivity and visual representation were the most influential app features for retention.

Gender differences in technology use and mathematics achievement have also attracted scholarly attention. Ibrahim and Abdullahi (2022) found no statistically significant gender difference in mathematics achievement when technology was employed as an instructional aid, suggesting that well-designed technology may serve as an equaliser. Agbo and Usman (2022), however, reported a marginal but significant advantage for male students in terms of technology-use frequency, attributing this to sociocultural factors that restrict females' access to digital devices in some northern Nigerian communities. These mixed findings underscore the importance of examining the moderating role of gender in the present study, which is set in the south-eastern context of Enugu State.

Gap in the Literature

Despite the growing body of literature on technology and mathematics education in Nigeria, specific empirical studies on the perceived effects of online mathematics apps on both achievement and retention — using TAM as a framework, and drawing participants from the secondary schools of Enugu State — remain scarce. Most existing studies focus on one outcome variable (achievement or retention), employ broad ICT constructs rather than app-specific measures, or are set in contexts other than Enugu State. This study addresses these gaps simultaneously.

Methodology

Research Design

This study adopted a descriptive survey research design with correlational and comparative components. The descriptive survey design was considered appropriate because the study sought to elicit students' perceptions of online mathematics apps and examine the relationship between those perceptions and measurable academic outcomes (achievement and retention), without manipulating the independent variable (Eze & Obiora, 2022).

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

Population and Sample

The target population comprised all SS1–SS3 (Senior Secondary School 1–3) students and JS1–JS3 (Junior Secondary School 1–3) students in public secondary schools in Enugu State, Nigeria. Based on the Enugu State Secondary Education Management Board (ESEMB) 2024/2025 register, the accessible population comprised 127,430 students across 312 public secondary schools. Using Krejcie and Morgan's (1970) table for determining sample size, a minimum sample of 384 was indicated for a population of this magnitude. However, to improve statistical power and account for potential attrition and non-response, a sample of 500 students was drawn using stratified random sampling. Five Local Government Areas (LGAs) — Enugu North, Enugu South, Igbo-Eze North, Oji River, and Udi — were purposively selected to represent urban, peri-urban, and rural school settings. Within each LGA, one secondary school was randomly selected, and 100 students (across both senior and junior classes) were randomly selected within each school. Table 1 presents the demographic distribution of the sample.

Table 1

Demographic Distribution of Study Sample

School	Male	Female	Senior	Junior	Total
School A	52	48	58	42	100
School B	45	55	50	50	100
School C	49	51	54	46	100
School D	53	47	60	40	100
School E	50	50	55	45	100
Total	**249**	**251**	**277**	**223**	**500**

Instrumentation

Three instruments were used for data collection:

i. Online Mathematics App Perception Scale (OMAPS): A 30-item, five-point Likert-type scale (Strongly Agree = 5 to Strongly Disagree = 1) developed by the researchers to measure students' perceptions of online mathematics apps across four dimensions: perceived usefulness (10 items), ease of navigation (8 items), frequency of use (6 items), and perceived interactivity (6 items).

ii. Mathematics Achievement Test (MAT): A 50-item multiple-choice test constructed from WAEC/NECO past questions spanning topics in the secondary mathematics curriculum, including algebra, geometry, statistics, and number theory.

iii. Mathematics Retention Test (MRT): A parallel form of the MAT, administered four weeks after the MAT to measure the degree to which students retained previously tested mathematical knowledge.

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

Validity and Reliability

The face and content validity of all three instruments were established through expert review by five specialists in mathematics education at the University of Nigeria, Nsukka. Items rated as irrelevant or ambiguous by three or more experts were revised or deleted. The instruments were pilot-tested on 40 SS2 students in a school not included in the main study. Cronbach's alpha coefficients obtained were: OMAPS (α = .87), MAT (α = .84), and MRT (α = .82), all exceeding the 0.70 threshold recommended by Nunnally and Bernstein (1994).

Data Collection Procedure

After obtaining institutional approval from the Enugu State Ministry of Education and informed consent from school principals, class teachers, and students (and parents where applicable), data were collected over a four-week period in the second term of the 2024/2025 academic session. The OMAPS and MAT were administered in one session under the supervision of trained research assistants. The MRT was administered four weeks later by the same assistants. Completed instruments were retrieved on the spot to ensure a 100% response rate.

Data Analysis

Data were analysed using the Statistical Package for Social Sciences (SPSS), version 27. Descriptive statistics (means and standard deviations) were used to characterise the sample and the study variables. Pearson product-moment correlation was used to address research questions on the relationship between app perceptions and achievement/retention. An independent samples t-test was used to compare achievement and retention scores between high-frequency and low-frequency app users. Multiple linear regression analysis was employed to determine the joint predictive power of app-related perception variables on mathematics achievement. Two-way ANOVA was used to examine the interactive effect of app-usage level and gender on mathematics retention. The level of significance was set at α = .05.

Results

Descriptive Statistics

Table 2 presents the means and standard deviations of the major study variables. The overall mean for perceived app usefulness (M = 3.87) indicates a moderately high positive perception among students. The mean score for mathematics achievement (M = 61.34) and retention (M = 54.82) suggest that while students perform above a chance level, substantial room for improvement exists, and a notable decline in scores occurs between achievement and retention measurement points.

Table 2

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

Descriptive Statistics of Major Study Variables (N = 500)

Variable	N	Mean	Std. Dev.	Min	Max
Perceived App Usefulness	500	3.87	0.72	1.00	5.00
App Frequency of Use	500	3.54	0.81	1.00	5.00
Ease of Navigation	500	3.68	0.74	1.00	5.00
Mathematics Achievement Score	500	61.34	12.41	25.00	95.00
Mathematics Retention Score	500	54.82	13.07	18.00	94.00

Research Question 1: Correlation Between App Perceptions and Academic Outcomes

Table 3 presents the Pearson product-moment correlation coefficients among app-use frequency, mathematics achievement, and mathematics retention. There was a significant positive correlation between app-use frequency and mathematics achievement ($r = .612$, $p < .001$) and between app-use frequency and mathematics retention ($r = .574$, $p < .001$). Achievement and retention were also significantly correlated ($r = .689$, $p < .001$).

Table 3

Pearson Correlation Matrix: App Use, Achievement, and Retention

Variable	App Use Frequency	Achievement	Retention	p-value
App Use Frequency	1.000	0.612**	0.574**	.000
Achievement	0.612**	1.000	0.689**	.000
Retention	0.574**	0.689**	1.000	.000

*** Correlation is significant at the 0.01 level (2-tailed).*

Research Question 2: Achievement Differences by App-Use Frequency

Students were classified as high-frequency users (using an app ≥ 4 times per week; n = 263) or low-frequency users (< 4 times per week; n = 237) based on their OMAPS frequency subscale scores. Table 4 shows the results of independent samples t-tests comparing achievement and retention scores between the two groups. High-frequency users achieved significantly higher mathematics achievement scores ($M = 68.47$, $SD = 10.32$) than low-frequency users ($M = 53.41$, $SD = 11.89$), $t(498) = 12.84$, $p < .001$. Similarly, high-frequency users had significantly higher retention scores ($M = 61.23$, $SD = 11.44$) compared to low-frequency users ($M = 47.61$, $SD = 12.73$), $t(498) = 11.16$, $p < .001$.

Table 4

Independent Samples t-test: Achievement and Retention by App-Use Frequency

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

Variable	Group	N	Mean	SD	t	df	p
Achievement	High Users	263	68.47	10.32	12.84	498	.000
	Low Users	237	53.41	11.89			
Retention	High Users	263	61.23	11.44	11.16	498	.000
	Low Users	237	47.61	12.73			

Research Question 3: Multiple Regression of App Perceptions on Achievement

A multiple linear regression analysis was conducted to determine the joint predictive power of four app-related variables — perceived usefulness, frequency of use, ease of navigation, and perceived interactivity — on students' mathematics achievement. Prior to the analysis, assumptions of normality (Shapiro-Wilk, $p > .05$), homoscedasticity (Breusch-Pagan, $p > .05$), and multicollinearity (all VIF values < 2.0) were verified and found to be satisfied. Table 5 presents the regression coefficients.

Table 5

Multiple Regression Analysis: Predictors of Mathematics Achievement

Predictor	B	SE B	β	t	p	VIF
Constant	14.23	2.81	—	5.06	.000	—
App Usefulness	6.41	0.88	.312	7.28	.000	1.42
Frequency of Use	5.87	0.91	.274	6.45	.000	1.38
Ease of Navigation	4.12	0.85	.201	4.85	.000	1.31
App Interactivity	3.74	0.79	.189	4.73	.001	1.27
$R^2 = .612$ | Adjusted $R^2 = .609$ | $F(4, 495) = 195.43$, $p < .001$						

The overall regression model was statistically significant, $F(4, 495) = 195.43$, $p < .001$, $R^2 = .612$, indicating that the four predictors jointly accounted for 61.2% of the variance in mathematics achievement. Perceived app usefulness was the strongest predictor ($\beta = .312$, $p < .001$), followed by frequency of use ($\beta = .274$, $p < .001$), ease of navigation ($\beta = .201$, $p < .001$), and interactivity ($\beta = .189$, $p = .001$). All predictors made unique and statistically significant contributions to the model.

Research Question 4 & 5: ANOVA on Retention by App-Usage Level and Gender

A two-way ANOVA was conducted to examine the main and interaction effects of app-usage level (high, moderate, and low) and gender (male vs. female) on mathematics retention scores. The analysis revealed a statistically significant main effect of app-usage level on retention, $F(2, 494) = 87.42$, $p < .001$, $\eta^2 = .26$, indicating a large effect. The main effect of gender was also significant, $F(1, 494) = 11.43$, $p = .001$, $\eta^2 = .02$, suggesting that male students (M =

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

56.84) had marginally higher retention scores than female students (M = 52.79). Importantly, the interaction effect of app-usage level × gender on retention was significant, $F(2, 494) = 4.14$, $p = .016$, $\eta^2 = .01$, suggesting that the advantage of high app usage on retention differed slightly by gender, with female high-frequency users closing the gender gap considerably compared to low-frequency female users.

Table 6

Two-Way ANOVA: Effects of App-Usage Level and Gender on Mathematics Retention

Source	SS	df	MS	F	p	η^2
App Usage Level	18432.7	2	9216.35	87.42	.000	.26
Gender	1204.3	1	1204.30	11.43	.001	.02
Interaction	872.4	2	436.20	4.14	.016	.01
Error	51872.6	494	105.00			
Total	**72381.9**	**499**				

Discussion

Online Mathematics App Perceptions and Achievement

The finding that students' perceived usefulness of online mathematics apps correlates significantly with their mathematics achievement ($r = .612$, $p < .001$) is consistent with the theoretical predictions of the Technology Acceptance Model (Davis, 1989; Venkatesh & Bala, 2008). Students who perceive an app as instrumentally valuable — that is, as genuinely helping them understand mathematical concepts and improve their performance — are more likely to engage with it purposefully and persistently, thereby accumulating more mathematical practice and exposure than peers who regard the apps as peripheral or irrelevant. This finding aligns with the empirical evidence reported by Adeleke and Hassan (2023) in Lagos State, Eze and Obiora (2022) in Anambra State, and the broader international literature reviewed by Bhagat and Chang (2020).

The regression analysis further illuminates the relative importance of specific app attributes in predicting achievement. Perceived usefulness emerged as the strongest predictor ($\beta = .312$), underscoring that students' belief in the educational value of a tool matters more than any single design feature in determining outcomes. This has important implications for app developers and educators: apps that clearly communicate their learning objectives, demonstrate measurable performance improvements to users, and align their content with the national curriculum are likely to generate stronger outcomes than aesthetically sophisticated platforms that lack pedagogical coherence. Frequency of use ranked second in predictive strength ($\beta = .274$), reinforcing the widely established principle that practice volume is a key mediator of mathematics achievement.

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

App Usage and Mathematics Retention

The finding of a significant positive correlation between app-use frequency and mathematics retention ($r = .574$, $p < .001$), and the substantial gap in retention scores between high-frequency ($M = 61.23$) and low-frequency users ($M = 47.61$) across a four-week interval, supports the constructivist view that active, repeated engagement with mathematical content promotes deeper encoding in long-term memory (Vygotsky, 1978). This is consistent with the findings of Obi et al. (2024) on gamified apps and those of Okeke and Eze (2021) on e-learning platforms in Enugu State.

The mechanism through which apps appear to support retention is likely multifaceted: immediate corrective feedback prevents the consolidation of misconceptions; spaced practice algorithms embedded in some platforms (such as the Leitner system used in certain flashcard apps) align with well-established principles of memory reconsolidation; and the visual and interactive representation of abstract concepts reduces cognitive load, making information more accessible to retrieval at a later point (Hwang & Chen, 2022). These mechanisms collectively suggest that the benefits of app use for mathematics learning extend beyond short-term performance gains to produce more durable knowledge structures.

Gender, App Usage, and Retention

The statistically significant interaction effect of app-usage level and gender on retention ($F(2, 494) = 4.14$, $p = .016$) merits careful interpretation. The main effect of gender revealed a modest but significant advantage for male students in overall retention scores, which may reflect broader sociocultural patterns of technology access and use in Nigerian society (Agbo & Usman, 2022). However, the interaction effect suggests that this gender gap was substantially attenuated among high-frequency app users: female students who used mathematics apps frequently approached the retention scores of their male counterparts, whereas among low-frequency users, the male advantage was more pronounced.

This finding carries important equity implications. It suggests that access to and sustained use of mathematics apps may function as an equalising mechanism that narrows — though does not entirely eliminate — gender-based disparities in mathematics retention. Educational policymakers and school administrators in Enugu State should therefore attend not only to providing access to mathematics apps but also to actively encouraging and supporting female students' engagement with these tools. Targeted initiatives — such as girls-only digital skills workshops, mentorship programmes, and app-mediated after-school mathematics clubs — could help consolidate this equalising effect.

Conclusion

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

This study has provided empirical evidence that online mathematics teaching apps have a significant positive perceived effect on students' achievement and retention in mathematics among secondary school students in Enugu State, Nigeria. The magnitude of these effects — captured in correlations ranging from .574 to .689 and a regression model explaining over 61% of the variance in achievement — suggests that app-based mathematics learning is not a marginal supplement but a substantive contributor to learning outcomes when used consistently and intentionally. The Technology Acceptance Model proved a useful theoretical lens: students' perceptions of app usefulness and ease of use are pivotal in determining whether the potential benefits of these tools are realized. Gender was found to moderate the relationship between app usage and retention, with sustained app engagement showing a promising equalizing effect on female students' mathematics retention.

The findings have broader implications for mathematics education in Nigeria at a time of significant curriculum reform and growing emphasis on EdTech integration. As the federal government and state ministries of education scale up digital learning infrastructure, the evidence from this study argues for policies that go beyond mere provision of devices and internet access to address the quality of educational apps, the alignment of app content with the national curriculum, teacher training in app-guided pedagogy, and deliberate equity strategies for female learners.

Recommendations

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

1. The Enugu State Ministry of Education should develop a curated list of approved, curriculum-aligned mathematics apps and formally integrate these into the secondary school mathematics curriculum as supplementary instructional resources.
2. Mathematics teachers in secondary schools should receive professional development training on how to select, recommend, and blend mathematics apps with conventional classroom instruction to maximise student engagement and achievement.
3. School administrators and government agencies should institute targeted programmes to enhance female students' access to and confident use of digital mathematics tools, recognising the equalising potential of sustained app engagement for girls' mathematics retention.
4. App developers and educational technologists should prioritise the design of high-quality, locally contextualised mathematics apps that align with WAEC/NECO curriculum standards, incorporate spaced repetition and immediate feedback mechanisms, and are optimised for low-bandwidth environments characteristic of many schools in Enugu State.
5. Future research should employ experimental or quasi-experimental designs to establish causal relationships between specific mathematics app features and learning

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.

outcomes, and should examine the longitudinal effects of app use on retention beyond the four-week interval used in this study.

Limitations of the Study

This study is not without limitations. First, the use of a descriptive survey design limits the ability to draw causal conclusions about the effect of online mathematics apps on student outcomes; the significant relationships reported should be interpreted as associational rather than causal. Second, the self-report nature of the OMAPS means that students' perceptions may not perfectly reflect their actual app-use behaviour, introducing potential common-method bias. Third, the sample was restricted to five LGAs in Enugu State, which limits the generalisability of findings to other states in Nigeria, particularly those with different levels of digital infrastructure or cultural attitudes toward technology. Fourth, the study did not control for prior mathematics ability, socioeconomic status, or the specific apps used by individual students, all of which are potentially important confounding variables.

References

Adeleke, J. A., & Hassan, M. O. (2023). Mobile mathematics applications and senior secondary school students' performance in algebra in Lagos State, Nigeria. Journal of Mathematics and Science Teaching, 43(1), 112–129. https://doi.org/10.51891/jmst.v43i1.4782

Agbo, F. J., & Usman, S. S. (2022). Technology integration in mathematics education: Perceptions of secondary school teachers and students in north-central Nigeria. African Journal of Educational Research and Development, 15(2), 88–105.

Bhagat, K. K., & Chang, C. Y. (2020). Incorporating GeoGebra into secondary mathematics instruction: A meta-analysis. Journal of Educational Technology & Society, 23(3), 14–26.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319–340. https://doi.org/10.2307/249008

Eze, C. U., & Obiora, C. K. (2022). Effect of mathematics application software on the academic achievement of senior secondary school students in Anambra State, Nigeria. Nigerian Journal of Educational Technology, 9(1), 44–61.

Federal Republic of Nigeria. (2023). National policy on education (7th ed.). Nigerian Educational Research and Development Council (NERDC).

Hwang, G. J., & Chen, P. Y. (2022). Improving students' learning achievements and mathematics problem-solving skills using an inquiry-based mobile learning approach. Computers & Education, 181, 104451. https://doi.org/10.1016/j.compedu.2022.104451

Ibrahim, A. T., & Abdullahi, M. U. (2022). Gender difference in students' achievement in mathematics through ICT-aided instruction in public senior secondary schools in Kano State. Abacus: Journal of Mathematical Association of Nigeria, 47(1), 210–224.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30(3), 607–610.

Nunnally, J. C., & Bernstein, I. H. (1994). Psychometric theory (3rd ed.). McGraw-Hill. Obi, I. E., Chukwuemeka, E. J., & Onah, T. A. (2024). Gamification of mathematics instruction and students' academic retention in secondary schools in Enugu State. Journal of Educational Innovations and Technology, 6(1), 73–91.

Okeke, N. S., & Eze, M. C. (2021). E-learning platforms and students' retention of algebraic concepts in secondary schools in Nsukka Local Government Area, Enugu State. Journal of Education and Practice, 12(28), 56–67.

Ugwuanyi, C. S., & Okeke, C. I. O. (2021). Effect of technology-based instruction on students' achievement in mathematics in Enugu State: A quasi-experimental study. Mathematics Education Research Journal, 33(2), 391–411. https://doi.org/10.1007/s13394-020-00341-8

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. Decision Sciences, 39(2), 273–315. https://doi.org/10.1111/j.1540-5915.2008.00192.x

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

West African Examinations Council. (2023). Chief examiner's report: Mathematics (Objective and Essay), May/June WASSCE 2023. WAEC.

Cite this article as:
Uguru, N.O. et. al. (2026). Perceived Effect of Online Mathematics Teaching Apps on Students' Achievement and Retention in Mathematics Among Secondary School Students in Enugu State, Nigeria. *International Journal of Advances in Science, Vocational & Technical Education (IJASVOTE), 3(2)* 148-162.