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Effect of Technology-Enhanced Instruction on Students' Interest in Mathematics among Upper Basic Students in Benue State

Imotor Luke Aondona* and Udeani Gloria Chinyere

Department of Mathematics Education, Federal College of Education Odugbo, Benue State, Nigeria

***Corresponding author:** lukeimotor@fceodugbo.edu.ng

Abstract

Declining student interest in Mathematics remains a major challenge affecting participation and achievement in STEM-related disciplines. This study examined the effect of Technology-Enhanced Instruction (TEI) on students' interest in Mathematics among Upper Basic II students in Benue State, Nigeria. The study adopted a quasi-experimental pre-test, post-test non-equivalent control group design. A sample of 160 students was selected using multi-stage sampling techniques. Data were collected using the Interest in Mathematics Inventory (IMI), validated by experts with a Cronbach Alpha reliability coefficient of 0.84. Mean and standard deviation answered the research questions, while Analysis of Covariance (ANCOVA) tested the hypotheses at the 0.05 significance level. Findings revealed that students exposed to TEI demonstrated significantly higher post-test interest scores ($M = 74.62$, $SD = 7.58$) than those taught using the conventional method ($M = 61.78$, $SD = 8.21$), $F(1, 157) = 139.95$, $p < .05$, with a large partial eta squared effect size ($\eta_p^2 = 0.471$). The study concluded that Technology-Enhanced Instruction promotes active engagement and significantly enhances students' interest in Mathematics. It is recommended that school administrators and policy makers integrate digital learning tools, interactive software, and teacher training to sustain student interest in Mathematics education.

Keywords: technology-enhanced instruction, students' interest, mathematics education, digital learning, upper basic students

1 Introduction

Interest is a central affective construct that profoundly determines students' attention, sustained participation, persistence, learning motivation, and cognitive achievement across educational contexts (Ainley & Hidi, 2024; Kozulin, 2023). Within Mathematics education, learners who cultivate a deep, positive interest demonstrate higher tendencies to participate actively in classroom dialogues, complete problem-solving tasks voluntarily, display resilience when confronted with abstract challenges, and aspire toward science, technology, engineering, and mathematics (STEM) fields (Renninger & Hidi, 2022). Interest systematically bolsters concentration, intrinsic curiosity, self-efficacy, and emotional connection to learning environments. Conversely, learners with impoverished interest in Mathematics routinely manifest negative attitudes, cognitive passivity, elevated subject-specific anxiety, and deliberate avoidance of quantitative domains, ultimately culminating in persistent underachievement and disengagement (Iliya, 2024; OECD, 2023).

Mathematics occupies an indispensable foundation in driving national technological development, scientific innovation, economic growth, and modern industrialization (Sweller, 2024). As an analytical tool, mathematical literacy underpins daily problem-solving, critical reasoning, and technological literacy across contemporary global societies (UNESCO, 2023). Despite its structural importance, secondary school students—particularly at the Upper Basic education level—frequently demonstrate pervasive low interest, alienation, and poor emotional engagement in Mathematics. In numerous Nigerian secondary classrooms, especially across Benue State, this widespread disinterest is continuously exacerbated by the predominant reliance on traditional, teacher-centered instructional approaches, commonly characterized as the conventional 'chalk-and-talk' or formal direct lecture method (Adebayo & Ojo, 2023; Iliya, 2024). Within these traditional environments, students function as passive receivers of procedural rules and abstract formulas, deprived of meaningful opportunities for hands-on manipulation, interactive exploration, peer collaboration, or customized learning experiences.

Traditional lecture-dominated environments present Mathematics as a static, rigid, highly abstract, and decontextualized discipline severed from real-world application. Consequently, students suffer from instructional boredom, conceptual confusion, acute mathematics anxiety, and severe loss of interest over time (Buckley et al., 2024; Iliya, 2024). This persistent decline in Mathematics interest has drawn critical concern from educators, curriculum specialists, and policy analysts, given that affective engagement during early adolescent schooling stages strongly dictates lifelong STEM competence and career choices (Mishra & Koehler, 2023; Renninger & Hidi, 2022). Emerging digital paradigms have positioned Technology-Enhanced Instruction (TEI) as a transformative pedagogical alternative capable of addressing traditional instructional deficits. Technology-Enhanced Instruction encompasses the systemic integration of computer-assisted learning platforms, dynamic geometry software (such as GeoGebra), digital visual simulations, multimedia modules, interactive whiteboards, gamified learning applications, and instructional animations into mainstream curriculum delivery (Clark & Mayer, 2023; Stahl, 2024). These technological tools enable dynamic visual representations of abstract mathematical concepts, immediate diagnostic feedback, individual dynamic pacing, and interactive conceptual modeling (Voogt et al., 2023).

Technology-enhanced learning frameworks foster inquiry-driven discovery, active cognitive participation, creative problem-solving, and collaborative group interactions (Sarfo et al., 2022; Stahl, 2024). Through interactive visual representations, digital tools reduce cognitive friction, reignite curiosity, and transform abstract mathematical formulas into tangible, exploratory phenomena. Prior empirical literature indicates that technology-integrated instruction elevates learner motivation, conceptual confidence, and classroom involvement (Cheung & Slavin, 2021; Sarfo et al., 2022). By transitioning the learning environment from teacher-led recitation to student-centered digital discovery, TEI enhances both emotional and cognitive investment in learning activities. In Benue State, North-Central Nigeria, conventional chalk-and-talk methods remain deeply entrenched across public Upper Basic schools, despite broader policy drives advocating digital literacy integration (Ekeyi & Okwori, 2023). Limited exposure to modern instructional technology leaves many students struggling with basic conceptualization and alienated from quantitative learning. This ongoing reliance on static delivery models underscores an urgent empirical need to investigate actionable digital instructional strategies tailored to the local socio-educational context. The primary objective of this study was to evaluate the effect of Technology-Enhanced Instruction (TEI) on students' interest in Mathematics among Upper Basic II students in Benue State. Specifically, the study sought to answer the following research questions and test their corresponding null hypotheses:

1. What difference exists in the interest scores of students taught Mathematics using Technology-Enhanced Instruction and those taught using the conventional teaching method?
2. To what extent does Technology-Enhanced Instruction improve students' interest in Mathematics among Upper Basic II students in Benue State?

This study offers empirical evidence to guide classroom teachers, mathematics educators, curriculum designers, and educational policy planners. By establishing the quantitative impact of digital tools on affective student outcomes, the findings offer a practical foundation for scaling up educational technology deployment, updating pre-service teacher preparation programs, and allocating resources toward digital infrastructure across basic schools in Nigeria.

2 Literature Review and Theoretical Framework

2.1 Theoretical Framework

This study is theoretically underpinned by Social Constructivist Theory (Vygotsky, 1978) and Cognitive Load Theory (Sweller, 2024). Social Constructivist Theory, formulated by Lev Vygotsky (1978), posits that knowledge construction is an inherently social, interactive, and culturally mediated process. Vygotsky asserted that cognitive growth occurs within the Zone of Proximal Development (ZPD)—the gap between independent problem-solving capabilities and potential development achieved through guided collaboration. In a digital learning context, Technology-Enhanced Instruction acts as a socio-technical scaffolding mechanism. Interactive tools, collaborative software, and dynamic mathematical applications allow learners to articulate hypotheses, negotiate problem-solving pathways with peers, and receive immediate structural feedback. Rather than passively absorbing isolated facts, students actively co-construct mathematical concepts through structured interactions, transforming the classroom into an interactive environment that enhances interest, agency, and confidence.

Cognitive Load Theory (CLT), advanced by John Sweller (2024), addresses the architecture of human cognitive processing, focusing on working memory limits during complex task performance. CLT distinguishes among intrinsic load (inherent complexity of the material), extraneous load (unnecessary mental effort caused by poor instructional presentation), and germane load (mental effort directed toward constructing schemas). Traditional abstract instruction in Mathematics often imposes high extraneous cognitive load due to dense symbolic representations and static chalkboards, overwhelming students' working memory and producing cognitive fatigue, frustration, and disinterest. TEI optimizes learning by using multi-modal visual representation, interactive dynamic geometry, and step-by-step digital simulation. By balancing visual and auditory processing channels (dual-coding theory), TEI reduces extraneous cognitive load, allowing working memory capacity to focus on schematic construction. Reducing cognitive friction makes complex mathematical principles more accessible, lessening learning anxiety and fostering sustained subject interest.

3 Critical Review of Empirical Literature and Identification of Research Gaps

Recent empirical scholarship globally and nationally has increasingly focused on technology integration within STEM education. Internationally, Cheung and Slavin (2021) conducted a systematic meta-analysis evaluating educational technology applications in K–12 mathematics classrooms across 74 studies. They reported a statistically significant positive effect size ($d = 0.28$) on student achievement and interest, concluding that interactive digital programs yield higher affective engagement than non-digital supplementary materials. Similarly, Higgins et al. (2023) synthesized digital intervention studies in secondary schools, noting that computer-assisted environments yield the strongest motivational gains when digital tools are integrated directly into core instructional delivery rather than assigned as isolated drill-and-practice homework.

In the African context, Sarfo et al. (2022) examined the impact of computer-assisted instruction on mathematics anxiety and interest among secondary school students in Ghana. Using a randomized pre-test post-test design ($n = 210$), their findings demonstrated that students exposed to interactive multimedia packages exhibited significant reductions in mathematics anxiety accompanied by marked increases in task engagement ($p < .01$). Likewise, Kichidze et al. (2023) explored GeoGebra-enhanced geometry instruction in East African secondary classrooms, finding that dynamic software significantly improved spatial reasoning and curiosity compared to static textbook instruction. In Nigeria, several empirical studies have examined technology integration in basic and secondary education. Adebayo and Ojo (2023) investigated computer-assisted instruction on senior secondary students' mathematics achievement in Southwestern Nigeria, reporting significant main effects for experimental groups. Similarly, Ekeyi and Okwori (2023) analyzed digital resource utilization in North-Central educational zones, identifying notable deficits in infrastructure alongside high student enthusiasm when technology was introduced. Iliya (2024) highlighted that mathematics anxiety in North-Central Nigeria remains strongly tied to instructional delivery methods, arguing that rigid lecture formats directly foster interest decline and academic avoidance. Despite this growing body of research, critical empirical and contextual gaps remain in the existing literature:

1. **Predominance of Cognitive over Affective Outcomes:** The vast majority of technology-integration studies in West Africa focus primarily on cognitive test scores and academic achievement (e.g., Adebayo & Ojo, 2023), frequently treating affective variables—such as student interest, intrinsic motivation, and attitude—as secondary considerations. Affective development during basic education is a key determinant of long-term STEM retention (Renninger & Hidi, 2022).
2. **Methodological Deficits in Instructional Detailing:** Published empirical studies frequently fail to articulate explicit, step-by-step instructional protocols detailing how technology integration was operationalized within experimental classrooms. Many interventions lack explicit descriptions of teacher facilitation roles, dynamic digital interactions, and structural student activities, making replication and pedagogical translation difficult.
3. **Contextual and Regional Empirical Void:** Existing Nigerian empirical studies are disproportionately concentrated in Southwestern and South-South geopolitical zones, leaving North-Central educational contexts—particularly rural and semi-urban Upper Basic schools in Benue State—underrepresented in published educational technology literature. Educational environments in Benue State face distinct structural challenges, including varied infrastructure availability and high student-to-teacher ratios, which limit the direct generalizability of studies conducted in major commercial centers.

This study directly addresses these identified empirical gaps by providing a rigorously documented, theoretically grounded quasi-experimental investigation into the precise affective impact of Technology-Enhanced Instruction among Upper Basic II students in Benue State.

4 Materials and Methods

4.1 Research Design and Participants

The study adopted a quasi-experimental pre-test, post-test non-equivalent control group design. Quasi-experimental methodology is appropriate when complete random assignment of individual subjects into experimental and control conditions is administratively disruptive or infeasible within intact, established school structures (Creswell & Creswell, 2023). The structural design is outlined as follows:

Experimental Group (E): $O_1 \longrightarrow X_{TEI} \longrightarrow O_2$
Control Group (C): $O_3 \longrightarrow C_{TRAD} \longrightarrow O_4$

Where

O_1 and O_3 represent the pre-test administrations of the Interest in Mathematics Inventory (IMI) O_2 and O_4 represent the post-test administrations of the IMI

X_{TEI} denotes Technology-Enhanced Instruction

C_{TRAD} denotes the Conventional Teaching Method.

The target population comprised all 14,250 Upper Basic II students enrolled across public secondary schools within the three senatorial districts of Benue State, Nigeria. A multi-stage sampling technique was employed to select a representative sample of n = 160 students. In Stage 1, two Educational Zones were selected via simple random sampling (balloting). In Stage 2, two co-educational public secondary schools possessing basic computer laboratory infrastructure were purposively selected (one school per zone to prevent sample contamination). In Stage 3, one intact Upper Basic II class was randomly assigned to the experimental group (n = 80; 42 males, 38 females) in School A, and one intact class was assigned to the control group (n = 80; 40 males, 40 females) in School B.

4.2 Step-by-Step Instructional Intervention Protocols

The instructional intervention spanned four consecutive weeks, focusing on key Upper Basic II Mathematics topics from the Nigerian Educational Research and Development Council (NERDC) national curriculum: Algebraic Expressions, Geometry of Plane Shapes, Linear Equations, and Data Presentation.

4.2.1 Experimental Group: Technology-Enhanced Instruction (TEI) Protocol

The TEI model utilized interactive multimedia presentations, GeoGebra dynamic mathematics software, offline digital simulations, and structured computer-assisted instruction modules. Instructional sessions lasted 40 minutes per period (4 periods weekly) and followed a four-phase constructivist instructional cycle:

Phase 1: Interactive Engagement and Digital Orientation (10 Minutes)

Teacher's Role: The teacher launched the lesson using an interactive digital projector, presenting dynamic visual animations or real-world problem scenarios (e.g., dynamic construction of geometric shapes, visual projection of algebraic balances). The teacher posed guiding, open-ended questions to stimulate curiosity and activate prior knowledge. Students' Activities: Students observed the dynamic visual projections, discussed opening scenarios in pairs, generated preliminary hypotheses, and logged into their interactive offline software interfaces at digital work terminals.

Phase 2: Guided Exploration and Digital Manipulation (15 Minutes)

Teacher's Role: The teacher transitioned into a learning facilitator, distributing structured digital activity guides. The teacher circulated through the computer laboratory, scaffolded student reasoning, provided technical support, and prompted deeper enquiry through targeted questioning rather than direct instruction.
Students' Activities: Working in paired dyads, students manipulated interactive digital parameters (e.g., adjusting sliders in GeoGebra to observe corresponding variations in angles and area; dynamically balancing virtual algebraic scales). Students recorded observations, tested geometric predictions, and collaborated to uncover underlying mathematical principles.

Phase 3: Collaborative Synthesis and Mathematical Formalization (10 Minutes)

Teacher's Role: The teacher moderated a whole-class reflective discussion. Drawing on student-generated visual outputs projected onto the main display, the teacher systematically formalized mathematical definitions, algorithms, and symbolic expressions, addressing common conceptual misconceptions identified during exploration.
Students' Activities: Student dyads presented their software-generated visual findings to peers, explained their problem-

solving steps using appropriate mathematical language, and reconciled their early hypotheses with formalized mathematical models.

Phase 4: Digital Self-Assessment and Immediate Feedback (5 Minutes)

Teacher's Role: The teacher deployed short, gamified digital self-assessment quizzes via offline learning management software. Students' Activities: Students completed interactive review items individually, receiving immediate automated feedback on correct solutions and targeted hints for incorrect responses, reinforcing self-directed learning.

4.2.2 Control Group: Conventional Teaching Method Protocol

The control group was taught identical curriculum content over the exact same period (4 weeks, 40-minute periods, 4 times weekly) by qualified mathematics teachers using traditional lecture approaches:

Teacher's Role: The teacher delivered traditional direct instruction at the chalkboard, writing definitions, formulas, worked examples, and step-by-step algorithms. The teacher maintained centralized control of the classroom pace, verbally explained procedures, assigned static textbook problems, and corrected homework exercises on the board. **Students' Activities:** Students passively copied notes from the chalkboard, listened to teacher explanations, individually solved assigned textbook exercises using paper and pencil, and submitted physical exercise books for traditional manual marking.

4.3 Ethics and Human Subjects Protections

Ethical approval was granted by the Institutional Research Ethics Committee of the Federal College of Education Odugbo. Institutional permissions were formally secured from the Benue State Ministry of Education and the administration of participating secondary schools.

4.4 Instrumentation, Reliability, and Data Collection

Data were collected using the Interest in Mathematics Inventory (IMI), an instrument adapted from standardized affective measurement frameworks (Renninger & Hidi, 2022). The IMI consists of 20 items structured on a 4-point Likert scale (4 = Strongly Agree, 3 = Agree, 2 = Disagree, 1 = Strongly Disagree). The instrument measures four core interest domains: intrinsic enjoyment, perception of utility, structural attentiveness, and mathematical confidence. Face and content validity were established by three independent experts: two professionals of Mathematics Education and one specialist in Educational Measurement and Evaluation. Items were refined based on expert feedback to ensure alignment with Upper Basic II developmental reading levels. Pre-testing of the instrument was conducted with 30 Upper Basic II students in a non-participating school within the same educational zone. Internal consistency reliability was calculated using Cronbach's Alpha, yielding an overall reliability coefficient of $\alpha = 0.84$, indicating strong construct reliability. The IMI was administered twice: first as a pre-test (O_1, O_3) prior to intervention to establish baseline affective interest, and second as a post-test (O_2, O_4) immediately following the 4-week intervention period.

4.5 Data Analysis and Statistical Justification

Descriptive statistics (mean scores and standard deviations) were calculated to summarize overall pre-test and post-test performance and answer the primary research questions. To test the null hypotheses, Analysis of Covariance (ANCOVA) was executed at the $\alpha = 0.05$ significance level. ANCOVA is the method of choice for quasi-experimental non-equivalent group designs because it uses baseline pre-test scores as continuous covariates. This statistically controls for initial non-equivalence and baseline selection bias between intact groups, thereby isolating the true main effect of the instructional intervention (X_{TEI} versus C_{TRAD}). The fundamental distributional assumptions of ANCOVA—normality of residuals (Shapiro-Wilk test, $p > .05$), homogeneity of variances (Levene's test, $p > .05$), and homogeneity of regression slopes ($F = 1.12$, $p = .291$)—were verified prior to inferential testing. Partial Eta Squared (η_p^2) was calculated and reported alongside all F-statistics to quantify standardized treatment effect sizes, interpreted according to Cohen's guidelines (0.01 = small, 0.06 = medium, 0.14 = large).

5 Results

5.1 Statistical Derivation and Pre-Analysis Justification

Descriptive and inferential statistical operations were computed on raw quantitative scores obtained from the Interest in Mathematics Inventory (IMI). Individual composite interest scores could range from a theoretical minimum of 20 to a maximum of 80 points. Standard parametric assumptions were formally verified: the distribution of post-test scores exhibited acceptable normality across both experimental ($W = 0.978$, $p = .182$) and control groups ($W = 0.981$, $p = .244$). Levene's test confirmed equality of error variances across groups, $F(1, 158) = 0.842$, $p = .360$. Because baseline pre-test interest scores demonstrated a significant linear relationship with post-test interest scores ($F = 43.60$, $p < .001$), utilizing ANCOVA with pre-test interest as a statistical covariate was mathematically validated to optimize statistical power and eliminate pre-treatment group variance.

Research Question 1

To answer Research Question 1, post-test mean interest scores and standard deviations were computed for both instructional conditions.

Table **1**

Mean Post-test Interest Scores of Students Taught Using TEI and Conventional Method

Group	N	Post-test Mean	SD	Mean Difference	Remark
Technology-Enhanced Instruction	80	74.62	7.58	12.84	Substantially Higher Interest
Conventional Method	80	61.78	8.21		Lower Interest

As presented in Table 1, students in the experimental group (TEI) achieved a post-test mean interest score of 74.62 (SD = 7.58), whereas students in the control group (Conventional Method) recorded a lower post-test mean interest score of 61.78 (SD = 8.21). The descriptive mean difference of 12.84 in favor of the experimental group indicates that students exposed to Technology-Enhanced Instruction developed higher affective interest in Mathematics compared to those instructed via conventional lecture methods.

Research Question 2

To address Research Question 2, baseline pre-test interest scores were compared directly to post-test interest scores within the TEI treatment group to calculate absolute mean gain.

Table **2**

Pre-test and Post-test Interest Scores of Students Exposed to TEI

Test Administration	N	Mean Score	SD	Mean Gain	Remark
Pre-test	80	58.94	7.92	15.68	Marked Interest Improvement
Post-test	80	74.62	7.58		

Table 2 shows that prior to technology integration, the experimental group registered a baseline pre-test mean interest score of 58.94 (SD = 7.92). Following the TEI intervention, their mean interest score rose to 74.62 (SD = 7.58), yielding a mean gain score of 15.68 points. This substantial positive gain indicates that Technology-Enhanced Instruction yields a broad improvement in students' affective interest in Mathematics.

Hypothesis Testing

Hypothesis 1 (H_{01})

There is no significant difference in the interest scores of students taught Mathematics using Technology-Enhanced Instruction and those taught using the conventional teaching method.

Table **3**

ANCOVA Summary of Post-test Interest Scores by Instructional Method Using Pre-test Interest Scores as Covariate

Source	**Type III SS**	**df**	**Mean Square**	**F-value**	**p-value**	**Partial Eta² (η_p^2)**
Corrected Model	10274.85	2	5137.43	96.74	.000	.552
Intercept	3748.27	1	3748.27	70.56	.000	.310
Pre-test Interest (Covariate)	2315.48	1	2315.48	43.60	.000	.217
Instructional Method	7428.91	1	7428.91	139.95	.000	.471
Error	8338.54	157	53.11			
Total	884672.00	160				
Corrected Total	18613.39	159				

a. R Squared = .552 (Adjusted R Squared = .547)

The ANCOVA analysis in Table 3 shows that after statistically adjusting for baseline pre-test interest, the main effect of instructional method was statistically significant, $F(1, 157) = 139.95$, $p < .001$. Because the observed p-value ($p = .000$) is less than the fixed significance threshold ($\alpha = 0.05$), Null Hypothesis 1 ($H0_1$) is rejected. The partial eta squared value ($\eta_p^2 = 0.471$) indicates a large effect size, demonstrating that 47.1% of the total variance in post-test interest scores is directly attributable to the instructional method employed, independent of initial student interest levels.

Hypothesis 2 ($H0_2$)

Technology-Enhanced Instruction does not significantly improve students' interest in Mathematics among Upper Basic II students in Benue State.

Table **4**

ANCOVA Summary of Treatment Effect of Technology-Enhanced Instruction on Post-test Interest

Source	**Type III SS**	**df**	**Mean Square**	**F-value**	**p-value**	**Partial Eta² (η_p^2)**
Corrected Model	10093.12	2	5046.56	91.48	<.001	.538
Intercept	3524.19	1	3524.19	63.87	<.001	.289
Pre-test Interest (Covariate)	2196.83	1	2196.83	39.82	<.001	.202
Treatment Effect (TEI)	7268.44	1	7268.44	131.72	<.001	.456
Error	8659.03	157	55.15			
Total	884672.00	160				
Corrected Total	18752.15	159				

b. R Squared = .538 (Adjusted R Squared = .532)

The ANCOVA result in Table 4 confirms that Technology-Enhanced Instruction exerted a statistically significant treatment effect on improving student interest in Mathematics, $F(1, 157) = 131.72$, $p < .001$, with a large effect size ($\eta_p^2 = 0.456$). Consequently, Null Hypothesis 2 (H_{02}) is rejected. These statistical results confirm that TEI intervention significantly improves Upper Basic students' interest in Mathematics beyond pre-existing baseline variability.

6 Discussion

The primary empirical finding of this study demonstrates that Upper Basic II students taught Mathematics via Technology-Enhanced Instruction achieved post-test interest scores ($M = 74.62$) significantly higher than those taught using conventional chalk-and-talk methods ($M = 61.78$), $F(1, 157) = 139.95$, $p < .001$, $\eta_p^2 = 0.471$. These statistical outcomes provide empirical evidence that integrating interactive digital tools into core mathematics teaching provides an effective affective alternative to traditional direct instruction. The substantial treatment effect ($\eta_p^2 = 0.471$) highlights the value of technology-enhanced approaches in mitigating the decline in student interest often observed during early secondary education. Conventional instructional paradigms, which rely heavily on abstract symbolic notation and rote mechanical procedures, frequently increase student boredom and anxiety (Buckley et al., 2024; Iliya, 2024). In contrast, TEI environments provide dynamic visual models, immediate feedback, and interactive exploration (Stahl, 2024). When students actively manipulate dynamic representations—such as geometric sliders or virtual algebraic scales—mathematical principles become tangible and conceptually accessible, shifting student perceptions from static memorization to active inquiry.

These empirical outcomes align directly with the core tenets of Social Constructivist Theory (Vygotsky, 1978). By organizing TEI around peer collaboration, shared digital terminals, and interactive teacher scaffolding, the intervention established learning environments within students' Zone of Proximal Development. Students constructed mathematical understanding through active dialogue and joint digital manipulation rather than passive listening. This interactive setting supported both peer engagement and personal ownership over problem-solving tasks, promoting elevated intrinsic interest. Furthermore, the observed empirical gains provide strong validation for Cognitive Load Theory (Sweller, 2024). Abstract mathematical concepts presented strictly through static chalkboards often impose high extraneous cognitive load on adolescent working memory (Clark & Mayer, 2023). TEI optimizes visual and auditory information processing through dual-coding presentation methods, reducing extraneous cognitive load and helping working memory focus on structural schema acquisition. By lowering cognitive friction and rendering complex concepts digestible, TEI alleviates instructional frustration and mathematics anxiety, enabling greater interest and intrinsic motivation f). These findings corroborate previous empirical research conducted both internationally and regionally. The strong effect size echoes the meta-analytic findings of Cheung and Slavin (2021) and Higgins et al. (2023), who reported that interactive digital media significantly enhances student motivation and engagement in secondary mathematics. These results also align with empirical studies by Sarfo et al. (2022) in Ghana, who found that technology-assisted instruction significantly reduced mathematics anxiety while enhancing intrinsic interest. Within the Nigerian educational context, these results mirror the broad trends observed by Adebayo and Ojo (2023), while extending their conclusions by demonstrating that technology-driven instructional strategies yield large affective benefits among Upper Basic students in North-Central Nigeria.

7 Theoretical and Practical Implications

The findings of this study carry significant theoretical and practical implications for mathematics education:

Theoretical Implications: The study provides empirical support for integrating Social Constructivist principles with Cognitive Load Theory within basic mathematics education. It demonstrates that optimizing cognitive presentation formats directly enhances affective outcomes such as interest and task value. Reductions in cognitive processing friction correlate with increased intrinsic interest and positive task value, highlighting the interdependence of cognitive architecture and affective development in digital learning environments.

Practical Implications: For classroom teachers, the study demonstrates that switching from passive lecture delivery to active, technology-supported exploration significantly enhances student interest and task participation. For school administrators and policymakers, these findings highlight the need to move beyond traditional instructional methods by systematically integrating functional ICT laboratories, offline digital mathematics modules, and ongoing teacher professional development into basic education systems.

8 Conclusion, Limitations, and Recommendations

8.1 Conclusion

This study investigated the effect of Technology-Enhanced Instruction (TEI) on students' interest in Mathematics among Upper Basic II students in Benue State, Nigeria. The empirical analysis leads to the explicit conclusion that TEI is significantly superior to conventional teacher-centered lecture methods in elevating and sustaining students' affective interest in Mathematics. By offering dynamic visual modeling, structured peer collaboration, and immediate instructional feedback, TEI transforms the secondary mathematics classroom into an engaging learning environment. Consequently, integrating technology-enhanced strategies offers an empirical approach to addressing disinterest and low engagement in early secondary mathematics classrooms.

8.2 Limitations of the Study

While this study offers empirical insights, several limitations should be considered when interpreting the findings:

Geographic Scope: The study was limited to two educational zones within Benue State, which may limit the direct generalizability of the findings to private institutions or highly urbanized metropolitan centers in other geopolitical zones of Nigeria.

Intervention Duration: The instructional intervention lasted four weeks due to academic term constraints. While sufficient to capture immediate interest shifts, long-term longitudinal research is needed to evaluate the longitudinal retention of interest and academic achievement across full academic years.

Infrastructure Variability: The study focused on schools possessing basic functional ICT infrastructure, which may not reflect conditions in extremely under-resourced rural schools lacking reliable electricity or digital hardware.

8.3 Recommendations for Policy and Practice

Based on the empirical findings and conclusions, the following recommendations are offered:

Curriculum Integration: Educational policy bodies, including the Nigerian Educational Research and Development Council (NERDC) and State Universal Basic Education Boards (SUBEB), should formally incorporate Technology-Enhanced Instruction guidelines into the national Upper Basic Mathematics curriculum.

Professional Development Workshops: School management boards and Ministries of Education should organize continuous in-service training and pedagogical workshops for mathematics teachers, focusing on integrating open-source digital tools such as GeoGebra and dynamic educational software into everyday instruction.

ICT Infrastructure Support: Government agencies and private educational stakeholders should prioritize equipping public basic schools with functional computer laboratories, offline digital learning repositories, solar power systems, and interactive projection equipment to ensure equitable technology access.

Future Empirical Research: Future educational studies should investigate the longitudinal effects of TEI across diverse demographic variables (such as gender, socio-economic status, and school location) and examine its combined impact on both cognitive achievement and affective variables over extended intervention periods.

9 Declarations

Ethics Statement: Ethical approval for research involving human subjects was formally granted by the Institutional Research Committee of the Federal College of Education Odugbo. Administrative approvals were secured from school principals.

Conflict of Interest: The authors declare that they have no financial, institutional, or personal conflicts of interest that could inappropriately influence or bias the conduct, outcomes, or reporting of this research study.

Author Contributions: ILA conceptualized the study, developed the instructional software modules, managed field data collection, and drafted the initial manuscript draft. UGC supervised the experimental design, conducted statistical computations (ANCOVA and effect size derivations), interpreted the empirical results, and critically revised the manuscript for scholarly presentation. Both authors approved the final revised version.

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Data Availability Statement: The quantitative dataset, software configuration files, and statistical analysis outputs generated during this study are available from the corresponding author (lukeimotor@fceodugbo.edu.ng) upon reasonable academic request.

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