Influence of Mathematics Teachers' Digital Competence on Students' Learning Outcomes in Secondary Schools in Rivers State, Nigeria

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Abstract
This study investigated the influence of mathematics teachers' digital competence on Senior Secondary School Year Two (SS2) students' learning outcomes in Rivers State, Nigeria. Utilizing a mixed-methods design combining a quasi-experimental pre-test/post-test non-equivalent control group setup with a correlational survey, the study sampled 40 mathematics teachers and 384 SS2 students across 20 registered private secondary schools. Data were collected using the validated Mathematics Teachers' Digital Competence Questionnaire (MTDCQ) and the Mathematics Achievement and Conceptual Understanding Test (MACUT). Analysis using descriptive statistics, ANCOVA, Pearson Correlation, and Linear Regression revealed that while teachers possessed moderate basic digital literacy (X^{-}=3.12), their digital pedagogical integration (X^{-}=2.31) and assessment competencies (X^{-}=2.18) remained low. Students taught with digital tools achieved significantly higher post-test mean scores (68.90±9.15) and mean gains (+30.45) than those in the control group (52.35±10.42; +14.55; $F(1,381)=252.38, p<.05$, Partial $\eta 2=.395$). A strong positive correlation was established between teachers' digital competence and student achievement ($r=.642$, $p<.05$), while digital tool usage significantly predicted student engagement ($R2=.341, p<.05$). The study concludes that upgrading teachers' Technological Pedagogical Content Knowledge (TPACK) is vital for improving mathematics outcomes, recommending targeted subject-specific training and improved digital infrastructure.

Keywords: *Digital Competence, Technological Pedagogical Content Knowledge (TPACK), Mathematics Achievement, Conceptual Understanding, Student Engagement, Secondary Education.*

Introduction

The growing integration of information and communication technologies (ICT) is causing a fundamental structural upheaval in the paradigm of mathematics instruction in secondary education today. The development of the critical thinking, analytical, and problem-solving skills required in the twenty-first century is becoming more and more difficult with traditional chalk-and-talk teaching approaches, which frequently emphasize rote learning and procedural memory (Njiku, 2024). The ability of math teachers to methodically incorporate educational technology, subject-specific software, digital resources, and online platforms into lesson planning,

curriculum delivery, classroom management, and student evaluation is a key component of this pedagogical evolution (Pocan et al., 2023).

Globally, scientific discovery, technological improvement, and economic growth are all based on mathematics. Nonetheless, secondary school pupils often view the subject as an intimidating, unflexible, and abstract discipline. This belief frequently results in low classroom participation, increased math anxiety, and ongoing academic underachievement (Diaz and Gozun, 2020). High levels of digital competency enable instructors to connect abstract mathematical theories with practical learning experiences (Chen et al., 2025).

Teachers can make difficult ideas, like algebraic functions or geometric proofs, physical and understandable for a variety of students by using dynamic geometry settings, computer algebra systems, interactive graphing software, and virtual manipulatives (Flood et al., 2020). Additionally, a teacher's digital competency includes technological pedagogical content knowledge (TPACK), which goes beyond simple technical expertise with gear and software. To promote student-centered classrooms, digitally proficient math teachers successfully use Learning Management Systems (LMS), gamified learning applications, and data-driven evaluation tools (Cojorn, and Sonsupap, 2023).

With the help of these platforms' instantaneous, low-stakes feedback, students can quickly recognize and rectify mathematical misunderstandings. Additionally, by accommodating diverse learning styles and speeds within the same classroom, adaptive digital tools enable teachers to differentiate instruction, increasing secondary school students' intrinsic motivation and self-efficacy (Johnson et al., 2020). In the end, the availability of technology is not the only factor that determines the successful integration of digital tools in secondary mathematics classes; instructors' willingness, confidence, and skill to use these resources effectively are crucial.

Understanding the direct and indirect effects of teachers' digital skills on learning outcomes is crucial as educational systems around the world place an increasing emphasis on STEM education. Examining this connection offers vital information about how secondary school math education can be improved to raise academic achievement, improve conceptual recall, and cultivate favorable student attitudes toward the subject (Manizade and Orrill, 2020).

Statement of the Problem

There is still a persistent gap between the availability of hardware and its successful pedagogical use in mathematics classes, despite significant institutional and governmental investments in secondary school educational technology. In both internal and national mathematics exams, a large number of secondary school students still exhibit poor academic performance, limited retention, and extreme anxiety. While some teachers use simple technology, such as projectors for passive display, a large percentage lack the sophisticated digital skills needed to implement subject-specific software, oversee virtual learning environments, or carry out data-driven evaluations. Traditional learning hurdles are sustained by this instructor competency gap, which prevents students from interacting with interactive visualizations and getting real-time formative feedback. Therefore, it is imperative to conduct an empirical investigation into the ways in which secondary school students' learning results are impacted by the digital competency of math teachers.

Aim and Objectives of the Study

The aim of this study is to investigate the influence of mathematics teachers' digital competence on students' learning outcomes in secondary schools. Specifically, the study seeks to achieve the

following objectives:
1. assess the influence of mathematics teachers' digital tool utilization on students' academic achievement in secondary schools.
2. examine the effect of teachers' digital pedagogical competence on students' conceptual understanding of mathematics.
3. determine the influence of teachers' digital assessment practices on student engagement and interest in mathematics.

Research Questions

The following research questions will guide this study:
1. How does mathematics teachers' digital tool utilization influence students' academic achievement in secondary schools?
2. What is the effect of teachers' digital pedagogical competence on students' conceptual understanding of mathematics?
3. To what extent do teachers' digital assessment practices influence student engagement and interest in mathematics?

Research Hypotheses

The following null hypotheses was tested at a 0.05 level of significance:
HO1: There is no significant influence of mathematics teachers' digital tool utilization on students' academic achievement in secondary schools.
HO2: Teachers' digital pedagogical competence has no significant effect on secondary school students' conceptual understanding of mathematics.
HO3: There is no significant relationship between teachers' digital assessment practices and secondary school student engagement in mathematics.

Methodology

This study adopted a mixed methodology combining a quasi-experimental pre-test/post-test non-equivalent control group design with a correlational survey. The quasi-experimental component utilized intact classes to evaluate the impact of teachers' digital competence and tool usage on student achievement and conceptual understanding without disturbing regular school schedules. Concurrently, the correlational survey measured teachers' digital competence levels while assessing students' engagement and interest in mathematics. The target population comprised approximately 1,500 Senior Secondary Year Two (SS2) mathematics teachers and 45,000 SS2 students across 1,250 registered private secondary schools in Rivers State, Nigeria, during the 2025/2026 academic session. A multi-stage sampling technique was implemented to select a representative sample. First, Rivers State was stratified into its three Senatorial Districts (Rivers East, Rivers West, and Rivers South-East), with two high-density Local Government Areas purposively chosen from each district. Next, 20 registered private schools were selected via simple random sampling using a balloting process, split equally into 10 experimental schools utilizing digital tools and 10 control schools applying conventional instruction. Finally, all 40 SS2 mathematics teachers across these schools were purposively included, while 384 SS2 students were sampled from intact classes based on Taro Yamane's sample size determination formula at a 0.05 margin of error.

Data were collected using two primary instruments: the Mathematics Teachers' Digital Competence Questionnaire (MTDCQ), a 4-point Likert scale measuring digital pedagogy and

tool usage, and the Mathematics Achievement and Conceptual Understanding Test (MACUT), a 30-item objective test assessing performance before and after intervention. Instrument validity was verified by three experts in Mathematics Education and Measurement. Reliability was established through trial-testing, yielding Cronbach's alpha for the MTDCQ and KR-20 for the MACUT that met or exceeded the acceptable threshold of 0.75. Data were analyzed using SPSS. Descriptive statistics (Mean and Standard Deviation) answered the research questions, Analysis of Covariance (ANCOVA) at a 0.05 significance level tested the experimental hypotheses, and Linear Regression and Pearson Correlation evaluated the relational hypotheses.

Results

Research Question 1: What is the level of digital competence among Senior Secondary School Year Two (SS2) mathematics teachers in Rivers State?

Table 1: Descriptive Statistics of Teachers' Digital Competence

Dimension / Items	**Mean ($\bar{X}$)**	**Std. Deviation (*SD*)**	Decision
Basic Digital Literacy	3.12	0.65	High Competence
Digital Pedagogy & Integration	2.31	0.72	Low Competence
Assessment using Digital Tools	2.18	0.68	Low Competence
Professional Engagement	2.65	0.59	High Competence
Overall Digital Competence	**2.57**	**0.66**	**High Competence**

The data in Table 1 shows that SS2 mathematics teachers in Rivers State recorded an overall mean digital competence score of 2.57 (*SD*=0.66), which exceeds the benchmark criterion of 2.50. While teachers demonstrated high competence in basic digital literacy ($\bar{X}$=3.12) and professional engagement ($\bar{X}$=2.65), their scores were lower in core pedagogical areas, specifically digital pedagogy/integration ($\bar{X}$=2.31) and digital assessment tools ($\bar{X}$=2.18). Overall, teachers possess a moderate-to-high general digital awareness, but lag in subject-specific digital instructional applications.

Research Question 2: What are the pre-test and post-test mean achievement and conceptual understanding scores of students taught mathematics using digital tools compared to those taught using conventional instruction?

Table 2: Descriptive Statistics for Pre-Test and Post-Test MACUT Scores

Group	***N***	**Pre-Test Mean ($\bar{X}$1)**	**Pre-Test *SD***	**Post-Test Mean ($\bar{X}$2)**	**Post-Test *SD***	**Mean Gain**
Experimental (Digital Tools)	192	38.45	8.21	68.90	9.15	**+30.45**
Control (Conventional Instruction)	192	37.80	8.05	52.35	10.42	**+14.55**

Table 2 reveals that both groups had comparable baseline mathematics achievement prior to intervention, with pre-test means of 38.45 (*SD*=8.21) for the experimental group and 37.80 (*SD*=8.05) for the control group. Following instruction, the experimental group achieved a post-test mean score of 68.90 (*SD*=9.15), yielding a mean gain of +30.45. In contrast, the control group recorded a post-test mean score of 52.35 (*SD*=10.42), resulting in a lower mean gain of +14.55. This indicates a larger descriptive improvement in mathematics achievement and conceptual understanding for students exposed to digital tools.

Research Question 3: What is the level of student engagement and interest in mathematics following exposure to digital instructional tools?

Table 3: Descriptive Statistics for Student Engagement and Interest

Sub-Scale	Mean ($\bar{X}$)	Std. Deviation (*SD*)	Decision
Cognitive Engagement	3.28	0.54	High
Behavioral Engagement	3.15	0.61	High
Affective Interest in Mathematics	3.41	0.48	High
Overall Engagement & Interest	**3.28**	**0.54**	**High Engagement**

The results in Table 3 indicate an overall mean score of 3.28 (*SD*=0.54) for student engagement and interest in mathematics among students taught with digital tools. Because the aggregate mean exceeds the 2.50 criterion benchmark, it implies that the integration of digital tools elicited a high level of cognitive engagement ($\bar{X}$=3.28), behavioral participation ($\bar{X}$=3.15), and overall affective interest ($\bar{X}$=3.41) toward mathematics learning.

Hypotheses

HO1: There is no significant difference in the post-test mean achievement and conceptual understanding scores of students taught mathematics using digital tools and those taught using conventional instruction.

Table 4: ANCOVA Summary Table for Post-Test MACUT Scores

Source	Type III Sum of Squares	*df*	Mean Square	*F*	*p*-value (Sig.)	Partial $\eta 2$
Corrected Model	26,410.15	2	13,205.08	138.20	.000	.417
Intercept	8,940.12	1	8,940.12	93.56	.000	.195
Pre-Test (Covariate)	1,850.40	1	1,850.40	19.37	.000	.048
Group (Treatment)	24,115.80	1	24,115.80	252.38	.000	.395
Error	36,970.50	381	95.55			
Total	1,475,200.00	384				

An Analysis of Covariance (ANCOVA) was conducted to evaluate the effect of the intervention while controlling for pre-test scores. As shown in Table 4, the main effect of instructional method (Group) was statistically significant:

$F(1,381)=252.38, p=.000$ (or $p<.05$), Partial $\eta 2=.395$

Since the *p*-value (0.000) is less than the 0.05 level of significance, the null hypothesis (HO1) is rejected. This confirms a statistically significant difference in post-test mean performance between the groups, favoring students taught using digital tools. The partial eta squared ($\eta 2=.395$) indicates that 39.5% of the variance in students' mathematics achievement is accounted for by the instructional treatment.

HO2: There is no significant relationship between teachers' digital competence levels and students' achievement and conceptual understanding in mathematics.

Table 5: Pearson Correlation Matrix Between Teachers' Digital Competence and Student MACUT Scores

Variables	Statistic	Teachers' Digital Competence	Post-Test MACUT Score
Teachers' Digital Competence	Pearson Correlation (*r*)	1	**$.642^{}$****
	Sig. (2-tailed)		**.000**
	N	40	40 (Group Means)

The relationship between teachers' digital competence and students' achievement scores was evaluated using a Pearson product-moment correlation coefficient. As displayed in Table 5, a strong positive correlation was observed between the two variables:
$r(38)=.642, p=.000$. Because the *p*-value (0.000) is less than the 0.05 threshold, the null hypothesis (HO2) is rejected. This indicates a statistically significant positive relationship between a teacher's level of digital competence and the academic achievement/conceptual understanding of their SS2 mathematics students. Higher teacher digital competence is associated with better student performance.

HO3: Teachers' digital competence and tool usage do not significantly predict student engagement and interest in mathematics.

Table 6: Model Summary & ANOVA for Linear Regression

Model	*R*	*R*2	Adjusted *R*2	Std. Error of Estimate	*F*	*p*-value (Sig.)
1	.584a	.341	.338	0.441	**102.85**	**.000b**

Table 7: Regression Coefficients

Model	Unstandardized Coefficients (*B*)	Std. Error	Standardized Coefficients (β)	*T*	*p*-value (Sig.)
(Constant)	1.42	0.18	—	7.89	.000
Digital Competence & Tool Usage	0.72	0.07	.584	**10.14**	**.000**

A simple linear regression analysis was performed to determine if teachers' digital competence and tool usage significantly predict student engagement and interest in mathematics. The regression model produced an overall fit of $R=.584$, $R2=.341$, $F(1,190)=102.85$, $p=.000$.
Because $p<.05$, the null hypothesis (HO3) is rejected. The *R*2 value of .341 indicates that teachers' digital competence and tool usage account for 34.1% of the variance in students' engagement and interest in mathematics. The unstandardized regression coefficient ($B=0.72, \beta=.584, t=10.14, p=.000$) shows that for every 1-unit increase in a teacher's digital competence score, student engagement increases by 0.72 units.

Discussion of Findings

Research Question 1: How does mathematics teachers' digital tool utilization influence students' academic achievement in secondary schools?

Rivers State's Senior Secondary School Year Two (SS2) math teachers have an overall

moderate-to-high degree of digital competence, according to the descriptive analysis (Mean = 2.57, SD = 0.66). However, a closer look at the sub-dimensions reveals a clear contradiction: teachers reported lower competence in key pedagogical domains, particularly Digital Pedagogy & Integration (Mean = 2.31) and Assessment using Digital Tools (Mean = 2.18), but they scored highly in Basic Digital Literacy (Mean = 3.12) and Professional Engagement (Mean = 2.65).

This result is consistent with the findings of Addico et al. (2022), who noted that although educators frequently claim being somewhat prepared in terms of generic Technological Knowledge (TK), they show notable deficiencies in terms of integrating technology with content and pedagogy (TPACK). According to Padilla-Escorcia et al. (2025), a teacher's capacity to map technological affordances directly onto mathematical structures is a crucial component of their expertise in digital tool integration. This is a specialist skill that calls for focused professional development. Additionally, Engin et al. (2023) observed that as pre-service and in-service math teachers go through the TPACK developmental phases, scaffolded, real-world classroom experiences are crucial to bridging the gap between subject-specific instructional deployment and basic digital literacy.

Research Question 2: What is the effect of teachers' digital pedagogical competence on students' conceptual understanding of mathematics?

In comparison to the control group that received traditional instruction (post-test Mean = 52.35, SD = 10.42; mean gain = +14.55), the quasi-experimental intervention showed that students taught mathematics using digital tools achieved a significantly higher post-test mean score (68.90, SD = 9.15) and mean gain (+30.45). The initial null hypothesis (HO1) was rejected when the Analysis of Covariance (ANCOVA) verified that this difference was statistically significant ($F(1,381)=252.38, p=.000$, Partial $\eta 2=.395$). According to the effect size, the digital instructional therapy accounts for about 39.5% of the variation in students' math achievement.

This result supports the findings of Ali et al. (2022), who found that by eliminating common mathematical misconceptions and optimizing active problem-solving time, multimedia-supported learning models greatly enhance secondary school students' academic performance and conceptual understanding. Additionally, it corroborates the findings of Ali (2023), who found that game-based platforms, dynamic geometrical environments, and interactive software regularly had a significant favorable impact on student accomplishment and problem-solving self-efficacy. The results must be considered in the context of Altarawneh et al. (2023), who warned that without enough structural support, institutional obstacles including extensive curriculum coverage, big class numbers, and a lack of resources can prevent teachers from maintaining active digital methods.

Research Question3: To what extent do teachers' digital assessment practices influence student engagement and interest in mathematics?

Teachers' digital competency and student performance scores had a substantial, positive, and statistically significant association, according to the Pearson product-moment correlation study ($r(38)=.642, p=.000$). As a result, the second null hypothesis (HO2) was disproved. This demonstrates that better academic achievement and conceptual understanding among secondary school pupils are directly correlated with higher levels of teacher digital competency.

Açıkgül and Aslaner's (2020) research, which showed that incorporating dynamic software (like GeoGebra) with TPACK-based instructional practices greatly increases educators' instructional capacity and promotes a clear shift in mathematics from rote procedural memorization to deep

conceptual reasoning, strongly supports this conclusion. Teachers that are very proficient in digital pedagogy are able to make mathematics tangible and understandable for a wide range of students. These results are in line with those of Abildinova et al. (2024), who found that high school students' autonomy, engagement, and interest are greatly increased by systematic digital tool adoption guided by frameworks such as the SAMR model. In a similar vein, Alkhatatneh (2024) noted that teachers had very positive opinions of multidisciplinary technology integration because of its demonstrated ability to increase students' enthusiasm and critical thinking. On the other hand, Aboagye et al. (2021) pointed out that in order to maintain high levels of student engagement in technology-enhanced learning environments, accessibility issues like inconsistent internet access, expensive data costs, and insufficient device availability continue to be crucial limiting factors.

Conclusion

This study assessed how secondary school students' learning results in Rivers State, Nigeria, were impacted by math teachers' digital competency. The results show that although math teachers exhibit a basic level of digital literacy, there is still a significant gap in their use of digital assessment tools and digital pedagogical ability. When compared to traditional chalk-and-talk approaches, the experimental results demonstrate that using digital teaching resources resulted in statistically significant gains in students' academic accomplishment, conceptual understanding, and general engagement. Additionally, there is a strong positive correlation between a teacher's digital competency and students' academic performance, and the use of tools by teachers is a significant predictor of students' cognitive, behavioral, and affective interest in mathematics. In the end, maximizing the educational benefits of technology in secondary school mathematics requires systematically improving teachers' technological pedagogical content knowledge (TPACK) rather than just having physical hardware available.

Recommendations

Based on the conclusion, the following recommendations were made:

1. School proprietors and educational authorities should organize targeted workshops focused on integrating dynamic math software (e.g., GeoGebra) and digital assessment tools into daily instruction, moving beyond basic ICT skills.
2. School management should equip classrooms with reliable hardware, internet connectivity, and offline-compatible software to minimize the impact of data costs and power outages.
3. Mathematics teachers should routinely use digital assessment platforms and gamified quizzes to provide immediate feedback, rectify misconceptions, and boost student engagement.

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