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Nigerian Teachers' Knowledge and Use of ICT in Secondary Mathematics Teaching

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ABSTRACT

Like many other nations, Nigeria believes that information and communication technology (ICT) has the potential to improve educational standards. Research on the subject of ICT integration expertise among secondary mathematics instructors in Nigeria is, however, lacking. Our goal in doing this study was to find out how much information secondary math instructors in Nigeria knew about using ICT in the classroom. The study used a cross-sectional survey strategy in conjunction with a quantitative method. It was carried out in a province of Nigeria, and 200 secondary mathematics teachers provided information for the questionnaire survey. The results indicate that secondary math instructors in Nigeria are generally lacking in their understanding of ICT and how to use it in the classroom. It was contended that, in light of the results, it is imperative to raise the level of both the teachers' and students' understanding of these areas in Nigeria, and that additional teacher training programs are required.

Keywords: ICT, Nigerian mathematics education, teacher education, teacher knowledge

1.0 Introduction

Nigeria's secondary mathematics curriculum currently emphasizes the use of ICT in teaching and learning, much like many other countries across the world do. The secondary school mathematics curriculum document makes this very clear when it states that "schools should promote the use of information and communication technology, such as computers, concrete material, and other media to improve the effectiveness of teaching and learning" (Evermeld and Andala, 2023).

The first attempt at a policy direction to incorporate contemporary technologies into mathematics classes was made when the Nigerian government redesigned the curriculum (Abid *et al*., 2022). It served as an illustration of the government's initiatives to improve the nation's mathematics education system (Chand *et al*., 2021).

This suggests that the country's mathematics curriculum has long included the incorporation of contemporary technology into instruction. This also helps to explain why the Nigerian mathematics curriculum has long included the incorporation of contemporary technology into instruction. It is often accepted that educators have a big say in how ICT is integrated into the classroom. Therefore, more recent studies have shifted focus to teachers' development of their knowledge (Atteh, Boadi and Amoah, 2023), whereas earlier research on the integration of ICT has mostly focused on the students' outcome (Simões, Oliveira and Nunes, 2022).

Many studies have been done on the use of ICT in the classroom and teachers' knowledge of it. Researchers in mathematics education have to still look into the ICT integration and knowledge of mathematics teachers. According to Dele-Ajayi, Fasae, and Okoli (2021) mathematics teachers lacked adequate ICT understanding and did not know how to use it in the classroom. There are still a few gaps in the prior research, though. First off, the majority of research on teachers' understanding of ICT use in the classroom and their knowledge of mathematics has been done in industrialized nations. On the other hand, it seems that there have not been many publications on this topic for developing nations like Nigeria.

Second, the purpose and the extent of most previous studies' disclosure of Nigerian secondary mathematics teachers' ICT integration expertise were not achieved. Thus, the purpose of this study is to ascertain how well-versed in ICT secondary mathematics instructors in Nigeria are, as well as how they employ it in their instruction. Therefore, this study set out to find out how much information and how Nigerian secondary mathematics instructors used ICT. The study specifically aims to respond to the following research questions: How much do secondary mathematics instructors in Nigeria know about ICT and how it may be used in the classroom? The two domains of teacher knowledge that were the focus of this study were ICT knowledge and ICT use in the classroom.

2.0 Research Methodology

2.1 Research Design

The study used a quantitative technique since it is thought to give the results greater validity, reliability, objectivity, and generalizability. More specifically, a large number of participants can be given a questionnaire.

2.2 Population of the Study

Nigeria is a vast country, to gather data across the entire nation for practical reasons was not found easy. In a strict sense, every senior secondary mathematics teacher in one of Niger State was the study's population.

Table 1: Construct of knowledge of ICT and knowledge of ICT use in teaching

Construct of Knowledge	**Description**
Knowledge of ICT	Being able to utilize software, technology, and the internet without taking into account any mathematical concepts or instructional strategies
Knowledge of ICT use in teaching	Description
ICT-Content Knowledge	Being able to express, discuss, address, and examine mathematical concepts, ideas, or issues using ICT without taking teaching strategies into account.
ICT-Pedagogical Knowledge	Having the ability to use ICT to improve particular facets of teaching strategies without having to think about a particular subject
ICT-Pedagogical Content Knowledge	Understanding how to use ICT to improve teaching and learning by representing, teaching, and enabling the acquisition of certain mathematical knowledge using particular teaching methodologies

The table created by Barlett, Kotrlik, and Higgins (2001) was used to establish the minimal returning sample size of 200. Table 1 displays the demographic backgrounds of the participants.

2.3 Research Instrument

TPCK-M questionnaire, which is composed of three constructs: technical pedagogical content knowledge (TPK), technological content knowledge (TCK), and technological pedagogical knowledge (TPCK) was employed in this study. In addition, every response about the knowledge of teachers was rated on a 5-point scale, with 1 denoting strongly disagree and 5 denoting strongly agree.

The reliability of the instrument was assessed using internal consistency reliability. A Cronbach's coefficient alpha of greater than 0.7 was used to evaluate the inter-item correlation. The outcome demonstrated that, with an alpha coefficient of 0.952, the instrument's data has a respectably high level of reliability.

The questionnaire's validity was assessed using both construct and content validity. The questionnaire's construction was grounded in the conceptual framework, literature study, and existing instruments about content validity. In addition, the instrument underwent multiple stages of development at which time specialists reviewed it with the goal of improving its content validity.

2.4 Data Analysis Procedure

Every response regarding the knowledge of teachers was rated on a 5-point scale. To address the research topics, statistical analysis, both descriptive and inferential, was used. In relation to the descriptive analysis, a frequency distribution of the answers on each of the teachers' knowledge questions was computed and shown in tabular form. Additionally, the Handal *et al.* (2013) questionnaire score range was used to explain the means of all the items (Table 2). To investigate significant variations in teachers' knowledge across survey items, a repeated measure ANOVA and paired-t test were used for inferential statistical analysis.

Table 2: Participants Demographic Background

Demographic Background	**Frequency**	**Percentage**
Gender		
Male	120	60

Female	80	40
Age		
30 Years or Less	10	5
31-35 Years	32	16
36-45 Years	50	25
46-55 Years	90	45
Over 55 Years	18	9
Teaching Experience		
Over 30 years	20	10
21-30 Years	63	31.5
11-20 Years	44	22
6-10 Years	52	26
1-5 Years	21	10.5
Highest Level of Education		
Post Graduate Degree	31	15.5
Undergraduate Degree	165	82.5
Post-Secondary Degree	4	2

Table 3: Questionnaire score range

Score Range	Score Range
$1.0 \leq x < 1.5$	Very low
$1.5 \leq x < 2.0$	Low
$2.0 \leq x < 2.5$	Moderately low
$2.5 \leq x < 3.0$	Slightly below average
3.0	Average
$3.0 < x \leq 3.5$	Slightly above average
$3.5 < x \leq 4.0$	Moderately high
$4.0 < x \leq 4.5$	High
$4.5 < x \leq 5.0$	Very high

3.0 Results and Discussion

3.1 Results

The study examined secondary mathematics teachers' understanding of ICT and their use of it in the classroom, as was previously mentioned. The survey's results for both categories of knowledge were offered. The results of a repeated measure ANOVA and a paired-t test are presented after the mean scores and standard deviations for each item.

3.1.1 Teachers' Knowledge of ICT

Table 4 displays the results of the teachers' ICT knowledge, including their familiarity with hardware, general software, mathematical software, and online resources. The average hardware knowledge score was 3.11, which is marginally above normal. They knew more about computers and laptops than they did about calculators and tablets and mobile devices. Additionally, the participants' understanding of general software was found to be slightly below average, as indicated by the mean score of 2.63 for teachers' knowledge of this subject. Additionally, it demonstrated that the participants knew more about word processing software than they did about other types of general software. The findings showed that teachers had a moderately poor level of software knowledge for mathematics (Mean = 2.10).

Table 4: Mean scores of participants' responses to items of ICT knowledge

Teachers' Knowledge of ICT	**Mean**	**Standard Deviation**
Knowledge of hardware		
a. Graphing Calculator	2.57	1.22
b. Tablet/Mobile Device	3.18	1.04
c. Computer/Laptop	3.66	0.88
Mean	3.11	
Knowledge of general software		
a. Word processor software(e.g., Ms Word)	3.85	0.90
b. Presentation software (e.g., Ms PowerPoint)	3.54	0.98
c. Online presentation software (e.g., Prezi)	1.99	0.94
d. Spreadsheet software (e.g., Ms Excel)	3.48	1.01
e. Mind mapping software (e.g., Inspiration)	2.04	0.99
f. Animation software (e.g., Macromedia Flash)	2.17	1.00
g. Three dimensional visualisation software (e.g., Sketch Up)	1.91	0.92
Mean	2.63	
Knowledge of Mathematical software		
a. Computer Algebra System (e.g., Maple and Maxima)	2.09	1.10
b. Dynamic Geometric Software (e.g., Geometer's Sketchpad and Cabri Geometry)	2.04	1.01
c. Dynamic Mathematics Software (e.g., Geogebra and Autograph)	2.32	1.06
d. Statistical Software (e.g., Tinkerplots and Fathom)	1.87	0.92
Mean	2.10	
Knowledge of online tools		
a. Online Learning Resources (e.g., Khan Academy)	2.23	1.20
b. Learning Management System (e.g., Moodle)	2.05	1.10
Mean	2.14	

According to the findings, participants knew more about dynamic geometry and dynamic mathematics software for this type of software than they did about computer algebra systems and statistical software. Additionally, the findings showed that participants' awareness of online resources was only fairly high (Mean = 2.14), with their familiarity with learning management system software being lower than that of online teaching and learning resources. Given that the majority of mean scores are poor, it can be said that instructors' ICT understanding was lacking. A series of actions An ANOVA test was conducted to ascertain whether there existed a statistically significant variation in the instructors' understanding of hardware, general software, and teachers' knowledge of mathematical software across the items.

The degree of freedom was corrected using the Huynh-Feldt estimate of sphericity (ε =.92) after Mauchly's test revealed that the assumption of sphericity had been broken in terms of teachers' hardware knowledge ($x_2(2) = 28.07$, p = 0.00). The findings demonstrate a substantial variation in the degree of hardware knowledge among teachers for computers/laptops, tablets/mobile devices, and graphing calculators (F (1.84, 540.01) = 163.21, p = 0.00).

When it came to the instructors' familiarity with generic software, Mauchly's test revealed that the sphericity assumption had been broken (x_2 (20) = 516.59, p = 0.00). As a result, the degree of freedom was adjusted using the sphericity estimate from Greenhouse-Geisser (ε =.48). The findings indicate that teachers' levels of familiarity with general software varied significantly across the items, with the highest levels of familiarity with word processors, presentations, spreadsheet programs, and mind mapping. The lowest levels of familiarity with three-dimensional visualization programs, online presentations, and mind mapping program (F(2.86, 686.55) = 461.36, p =.00). Estimate of Greenhouse-Geisser (44) = 615.47, = 0.00 Mauchly's test revealed that there had been a violation of the sphericity assumption in terms of the teachers' understanding of mathematical software, therefore the degree of freedom was adjusted using the sphericity assumption (~). Dynamic Geometric Software, about Computer Algebra System, about Dynamic Mathematics Software ((F (6.38, 16) = 35.48, p = 0.00).

Additionally, a paired t-test was used to see whether instructors' knowledge of internet resources varied statistically significantly between the two items. According to the responses, teachers' knowledge of online learning resources is significantly better than their knowledge of learning management systems. The results indicated a significant difference in the scores for teachers' knowledge of online learning resources (M = 2.23, SD = 1.20) and learning management systems (M 2.05, SD = 1.10); t (287) = 4.15, p =.000).

3.1.2 Teachers' Knowledge of ICT Use in Teaching

As previously indicated, there were three components to teachers' understanding of using ICT in the classroom in this study: ICT-content knowledge, ICT-pedagogical knowledge, and ICT-pedagogical content knowledge. The mean ratings for all the related survey questionnaire items provided by the participating instructors are displayed in Table 3. According to the findings, instructors' understanding of ICT (mean = 2.96), ICT pedagogy (mean = 2.97), and ICT pedagogical content (mean = 2.87) was marginally below average. The findings imply that instructors' understanding of ICT use in the classroom was lacking.

A repeated measures ANOVA were performed to see if there was a statistically significant difference in the instructors' knowledge across the sphericity ((2) = 97.98, = 0.00) categories. Following Mauchly's test, which showed that the sphericity assumption had been used in =.80~, the degree of freedom was adjusted using the Huynh-Feldt estimate of violated, 2. The findings demonstrated that there were notable variations in the degree of ICT teaching expertise among teachers concerning the three components, namely, ICT pedagogical knowledge, ICT content knowledge, and ICT pedagogical content knowledge (F (1.59, 513.85) = 48.9, p =.013). According to the findings, among all the categories of teachers' knowledge about using ICT in the classroom, teachers' ICT-pedagogical content knowledge was the least.

Table 4: Mean scores of participants' responses to items of ICT-content knowledge

Teacher Knowledge of ICT Use in Teaching		**Mean**	**Std. Deviation**
ICT-Content Knowledge			
a.	Use ICT to represent mathematical ideas	3.10	1.03
b.	Use ICT to communicate mathematical processes	3.02	1.08
c.	Use ICT to solve mathematical problems	2.90	1.10
d.	Use ICT to explore mathematical ideas	2.84	1.08
Mean		2.96	
ICT-Pedagogical Knowledge			
a.	Use ICT for direct instruction	3.33	0.93
b.	Use ICT for inquiry-based teaching and learning	3.14	0.94
c.	Use ICT for project-based teaching and learning	2.85	0.95
d.	Use ICT for discovery-based teaching and learning	2.81	0.91
e.	Use ICT for collaborative-based teaching and learning	2.72	0.97
Mean		2.97	
ICT-Pedagogical Content Knowledge			
a.	Use ICT to teach topics of mathematics that are better learned when employing specific teaching	3.20	0.90

	approaches		
b.	Use strategies that combine mathematical content, ICT and teaching approaches to support students' understandings as they are learning mathematics	3.10	0.93
c.	Use ICT in teaching that enhances mathematical content and how it taught	3.06	0.97
d.	Use ICT to incorporate authentic tasks in teaching mathematics through project-based learning	2.88	1.08
e.	Use ICT to teach students to develop their mathematics problem solving through inquiry-based learning	2.07	1.06
Mean		2.87	

3.2 Discussion

This decade has seen an increase in interest in the study of teachers' ICT-related knowledge. Research of this kind is still important for comprehending and enhancing the use of digital technology in the classroom. The findings to the literature about both forms of knowledge was examined and compared because the focus of this study was on teachers' knowledge of ICT and their understanding of using it into the classroom.

The results mostly showed that secondary math teachers in Nigeria were not well-versed in ICT and how to use it in the classroom. In terms of hardware knowledge, the results showed that participants knew more about computers and laptops than they did about tablets and other mobile devices, which in turn knew more about graphing calculators.

Given that teachers must utilize computers on a regular basis, it is not unexpected that they felt they had a high level of computer knowledge. It was found interesting, nonetheless, that the graphing calculator category had the lowest amount of instructor understanding. It has been sought, according to the literature (Salani, 2013), to integrate calculators into secondary mathematics classrooms in Nigeria. Teachers' familiarity with this digital instrument appears to be unaffected by a lengthy history of its usage in policy directives. Moreover, just few mathematics teachers reported knowing how to use a graphic calculator, according to Ruthven (1996), teachers' knowledge of mathematical software and general hardware was examined in addition to their ability to operate hardware. The findings demonstrated that the participants knew more about general software than they did about mathematical software. This result corroborates the findings of Clark-Wilson, Robutti and Thomas (2020) study, which showed that although teachers lacked knowledge of specialized mathematical software like dynamic geometry software, they did possess a basic understanding of software for general use like word processing and spreadsheets. This research suggests that, given the accessibility of specialized software for mathematical instruction, Nigerian secondary math teachers should broaden their understanding of mathematical software. It is generally accepted that this knowledge is important for developing and executing ICT-based mathematics curricula in the classroom.

According to the majority of participants, their greatest software knowledge was for word processors (like Microsoft Word), followed by presentation software (like Microsoft PowerPoint). The results are not shocking because this kind of software is publicly accessible and often utilized. It is consistent with a study conducted in Tanzania by Kazoka and William (2016), which found that 50% of secondary school teachers could use Microsoft PowerPoint and the majority (75%) could use Microsoft Word.

This result corroborates Timothy, Mariam and Afeez (2022) study, which found that few of science and math teachers in Nigeria are proficient in utilizing specialized software like SPSS, yet over most of teachers are familiar with using Microsoft Word, PowerPoint, and the Internet. However, as common software lacks characteristics that help pupils build their mathematical knowledge; teachers' familiarity with it may not have a substantial impact on the integration of ICT in mathematics classrooms. The results showed that instructors' understanding of mathematical software was less than their understanding of general software in this area.

As previously indicated, the goal of this study was to determine how well teachers understood the various categories of mathematical software, including Computer Algebra System (CAS), Statistical Software, Dynamic Geometry Software (DGS), and Dynamic Mathematics Software (DMS). The findings showed that teachers knew more about DMS and DGS than they did about Statistical Software and CAS. Since DGS is now the most extensively used software in schools worldwide, Iglesias-Pradas *et al* (2021) discovered a similar result and proposed that it is appropriate for instructors to rate their knowledge of DGS higher than their knowledge of other software kinds. We looked at specific software to have a better grasp of instructors' knowledge of DMS and DGS, and we discovered that teachers' knowledge of GeoGebra was the highest among all.

GoeGebra is widely available and simple to use for both teachers and students because it is open-source software. Teachers' familiarity with this software may have been impacted by this circumstance. Given that it has spread among a limited number of teachers, we think it has the potential to enhance the mathematical software expertise of Nigerian math teachers.

The final facet of educators' ICT proficiency is their familiarity with internet resources. The findings demonstrate that instructors' familiarity with these resources was limited, with their understanding of learning management systems (LMS) being less than that of online learning materials. Since learning management systems (LMS) were initially implemented in higher education, Timotheou *et al* (2023) claim that LMS is a relatively recent technology in secondary education.

As previously said, the second area of teachers' knowledge that this survey looked into was their familiarity with using ICT in the classroom. The results showed that instructors' understanding of using ICT in the classroom is lacking. This study modified the TPACK framework to examine this knowledge, as was covered in the conceptual framework. Thus, the framework is used to discuss the results and tie them to earlier research. The results are in line with earlier research that examined teachers' knowledge in various nations using the TPACK framework. This suggests that the issue of mathematics instructors' ignorance regarding the integration of ICT has been present in both industrialized and developing nations, including Australia and Ghana. As a result, raising teachers' awareness of this issue makes it harder for education investors in Nigeria and other nations to support the integration of technology in the classroom. Three components make up teachers' ICT proficiency: ICT-Pedagogical Content Knowledge, ICT-Content Knowledge, and ICT-Pedagogical Knowledge.

In accordance with Huq Shamim, Jeng and Raihan (2024) study, the results showed that teachers' ICT-Content Knowledge and ICT-Pedagogical Knowledge were greater than teachers' ICT-Pedagogical Content Knowledge. Compared to ICT-Pedagogical Knowledge and ICT-Content Knowledge, this suggests that ICT-Pedagogical Content Knowledge is more advanced and complex. As a result, teachers have a significantly harder time learning this information. This study suggests that there may be a connection between the lack of training programs and the ignorance of ICT among Nigerian secondary mathematics teachers. Hatos, Cosma and Clipa (2022) found that few Nigerian secondary mathematics teachers had never taken an ICT-related training course.

Moreover, Fahm *et al* (2022) characterize Nigerian secondary mathematics teachers as digital migrants since a significant portion of them are older. It is commonly held that digital migrants require more professional development and training regarding ICT and its usage in the classroom than digital natives do. They are also seen to be slower to accept new technologies. Lastly, this study indicates that, rather than focusing only on technical training for the use of ICT resources, it is imperative to provide Nigerian secondary mathematics teachers with training courses emphasizing the connection between pedagogical and mathematical content of ICT integration.

Research findings in the literature have firmly supported this. For instance, Vandeyar and Adegoke (2024) contend that it is critical to teach ICT in contexts that illustrate the relationship between pedagogy, subject, and technology when preparing instructors to incorporate it into their instruction.

4.0 Conclusion

The purpose of this study was to examine the ICT usage and understanding of secondary mathematics instructors in Nigeria. The study's findings showed that secondary math teachers in Nigeria lacked appropriate understanding of ICT and how to use it in the classroom. It was discovered that teachers knew more about computers than they did about mobile devices and graphing calculators. Additionally, the results indicated that teachers' familiarity with general software was greater than that with mathematical software. This study showed that teachers' ICT-Pedagogical Content Knowledge was lower than their ICT-Pedagogical Knowledge and ICT-Content Knowledge when it came to their knowledge of using ICT in the classroom.

Drawing from the results, we propose a number of critical considerations. Future research is required to investigate how Nigerian secondary school math teachers are developing their ICT skills in order to teach particular mathematical subjects like geometry and algebra. Regarding the study's practical implications, it is recommended that Nigerian education stakeholders assist secondary mathematics instructors in enhancing their ICT skills and understanding of how to apply it in the classroom. In particular, the Nigerian government must offer ICT training programs to enhance teachers' pedagogical and mathematical content knowledge of ICT integration, in addition to their technical proficiency with the technology.

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