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Influence of Mathematics Teachers' Technology Use on Secondary Students' Motivation, Attitude, and Achievement in Nigeria

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Walden University
2020

Abstract

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by

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MSc, Greenwich University, 2012

MSc Southbank University, 1995

BSc, University of Sokoto, 1987

Dissertation Submitted in Partial Fulfilment

of the Requirements for the Degree of

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Abstract

Students in Nigeria are not finishing school with the math skills needed for gainful employment and economic self-reliance, possibly due to a lack of technology use in math classes. Specifically, the influence of technology use in math classrooms on students' motivation, attitude, and math achievement in Nigeria was not well understood. Guided by the technological, pedagogical, and content knowledge (TPACK) theoretical framework, the purpose of this ex post facto, causal-comparative study was to compare the differences in student motivation, attitude, and achievement scores between students in math classrooms with low technology use and students in classrooms with high technology use in 3 private secondary schools in Nigeria. All secondary level math students ($N = 398$) completed the Motivational Strategies for Learning Questionnaire and Attitude Towards Mathematics Inventory. Of those, the 72 graduating students who completed the West African Secondary School Certificate of Examination served as the sample for math achievement. Mann-Whitney *U* tests showed motivation, attitude, and math achievement scores were all significantly higher ($p = .00$) for students taught in high technology use classrooms than in low technology use classrooms, indicating technology integration had a positive influence. Findings suggest that with heightened technology integration in math classes, positive social change can occur as students may be more likely to gain the math skills necessary for enhancing their future employment opportunities and economic self-reliance. With these superior outcomes, positive economic growth and development in Nigeria may be enhanced over time.

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Dedication

This research is dedicated to the Almighty God for His loving kindness and my mother, Late Margaret Ann Ejoh, who encouraged me and showed me how determination gets you a long way. Although you did not see this day, Mum, you will always be in my life. Also, Late Lucky Babatunde Omoluwa—my friend indeed, and I miss the times we shared RIP. Mum and Lucky, rest in peace. Also, to my wonderful daughters Nicole and Francine, you are the best, and my son Jnr.

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It is with gratitude of heart to the Almighty God that I celebrate the achievement of this milestone against high odds. He that lives in me is greater than he that lives in the world, and for that reason, I can do all things through Christ who strengthens me. Wow, Jesus is Lord. I think about my mother and realize that with her strength of character, I developed an understanding that she still lives in me through my accomplishments. Thanks, mum, for just being you. I miss you greatly and wish you could have been here, but it was not to be. I made it, and I know you would have been proud of me.

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Chapter 1: Introduction to the Study

In modern and industrialized societies, school systems are experiencing progress in international academic achievement. International academic success is measured when countries are ranked based on their competitive advantage in science, mathematics, and reading. However, Nigeria and other African countries still need to make progress to compete with developed countries. Depending on the study and methodology used, Nigeria has been ranked anywhere between 210th–250th in the world (DeSilver, 2017). Further, Algeria is the only African country ranked in the Program for International Student Assessment, a study of how well students perform in mathematics, science, and reading (DeSilver, 2017; Fouché & Chubb, 2017). Industrialized countries that do not meet global academic milestones are at a socioeconomic disadvantage to make the necessary enhancements to their educational systems to create competitive viability. However, it is not always feasible to focus on attaining international achievement levels without funding and valuable resources.

African nations need to make significant academic progress to compete on a global level. Since declaring its independence from the United Kingdom in 1960, Nigeria has struggled to create an academically sound education system (Adedokun, 2016; Oduwole, 2015). Nigeria must improve student learning to impact social change positively (Aja, 2020). Focusing on positive social change in the education sector in Nigeria is justified because of the need to address poverty, wide gaps in the socioeconomic status, out-of-school children, population increase, and social cohesion (Aja, 2020; Chudgar, Kim, Morley, & Sakamoto, 2019; Ejike & Oke, 2018). However, the lack of technology has continued to stifle academic achievement. Recognizing the impact technology has had in the 21st century, this study focused on an aspect of technology integration that can positively influence social change.

Too many students in developing countries lack the motivation to learn when faced with outdated technology, lack of resources, and non-motivated teachers. Teachers need to ensure that they contribute to social change by embracing new initiatives across Nigeria to integrate technology (Koehler, 2012; Kola & Sunday, 2015). Further, mathematics specialists tend not to recognize how technology integration impacts student motivation, attitudes, and achievement in mathematics (Johnston-Wilder et al., 2016; Larkin & Jorgensen, 2016). Because technology can be a tool to enhance children's learning experience in mathematics, focusing on the influence of student motivation, attitudes, and achievement in mathematics was central to this study. The focus on mathematics was particularly important because it is considered a gateway to engineering, medicine, and architecture careers, which developing countries need.

Chapter 1 provides an overview of educational systems in developing countries. Additionally, it provides an overview of the study, which explored the extent of the difference of students taught by teachers with low technology use compared with students taught by teachers with high technology use on attitudes, motivation, and mathematics achievement in Nigeria. Teachers can improve children's opportunities for socioeconomic well-being when the skills required to succeed are embedded in the mathematics classroom (Aja, 2020). A brief outline of the background, problem statement, and purpose as it influences its comparative extent on mathematics students' motivation, attitudes, and achievement is included in this chapter. The chapter also outlines the research questions and hypothesis, theoretical framework, nature of the study, and definitions. With a detailed alignment of the various aspects, the assumptions, scope, delimitations, limitations, significance, and a summary enhance a clear understanding of the literature review that follows in Chapter 2.

Background

Skill development for students requires teaching and learning initiatives to be evaluated to identify a model that will be the best fit for schools in developing countries such as Nigeria. For instance, technology integration in education may be one way to address the lack of motivation in mathematic lessons, which can enhance students' skills required to succeed after leaving school (Adedokun, 2016; Olagunju, Adenegan, & Lawal, 2015; Riswanto & Aryani, 2017; Sohngen, 2017; Tella, 2017). Technology integration includes educational software, computers, simulation, and other resources that enhance learning. However, the inadequate resourcing of technology and instructional materials to engage learners is a concern in Nigeria (Suleiman et al., 2019; Zakariya, 2017). The education system faces challenges, including limited available funding to meet the changing technology demands in sub-Saharan Africa and Nigeria (Abdulrasheed & Bello, 2015; Awofala & Lawani, 2020; Solomon & Fidelis, 2018). With the United Nations Educational, Scientific, and Cultural Organization recommending a 26% budgetary allocation and Nigeria allocating less than 10% on education, funding challenges need to be highlighted (Ukaigwe & Nwosu, 2019).

Additionally, Nigeria's national and international education policies highlight technology integration's significance in reducing stakeholders' challenges in improving student motivation, attitudes, and achievement in the mathematics classroom. The challenges faced in schools include lack of supervision, socioeconomic status, school climate, and parental involvement to drive positive attitude and engagement (Alordiah, Akpadaka, & Oviogbodu, 2015; Kafyulilo, Fisser, Pieters, & Voogt, 2015). These challenges have impacted the learning experiences and achievement of children across the country. The National Teacher Education Policy (2014) enforced the need for quality teachers and instruction with its objective "to produce highly knowledgeable, skilled, and creative teachers who are capable of producing students who can compete globally" (p. 12).

Furthermore, in 2009, Nigeria introduced the NV20:2020, a vision intended to put the country on the path of economic growth and success (Olusola, 2020; Sanubi & Akpotu, 2015). It is essential for public and private schools to implement instructional changes and integrate technology to achieve its progressive goal. The need for Nigeria to meet its economic vision for 2030 is dependent on skills development, which is one of the central goals of the education sector (Nwosu et al., 2017; Olusola, 2020; Sanubi & Akpotu, 2015).

These policies' impact on engaging learners is necessary to enhance teaching and learning (Bishop et al., 2017; Larkin & Jorgensen, 2016). However, for success, Nigeria needs to invest in an education system that places technology at the forefront of educational change. Because mathematics is crucial in international and national rankings, Nigerian schools may consider adapting the technological, pedagogical, and content knowledge (TPACK) framework to produce students who can compete globally (Higgins, Huscroft-D'Angelo, & Crawford, 2019; Junaid & Maka, 2015). In the current study, the TPACK framework provided constructs for measuring student motivation, attitudes, and achievement from a teacher's perspective: technological content knowledge (TCK), technological pedagogical knowledge (TPK), pedagogical content knowledge (PCK), technological knowledge (TK), content knowledge (CK), and pedagogical knowledge (PK).

This study addressed how the integration of technology by secondary school teachers in Nigeria affected mathematics students' attitudes, motivation, and achievement. This study focused on the extent of the difference between low and high technology use teachers' impact on students' motivation, attitude, and achievement in mathematics in Nigeria. Having relevant, useful data to plan for educational development in Nigeria may promote data-driven initiatives over a long-term period. Learners need to have the basic skills necessary to inspire their career choice to improve their socioeconomic status because education is fundamental to economic independence. The current gap in learner skills highlights the need to emphasize that young adults do not have the required mathematics skills for gainful employment. Therefore, understanding the influence of motivation, attitude, and achievement toward mathematics was necessary to this study (Alordiah et al., 2015; Mussa & Saxena, 2018; Riswanto & Aryani, 2017).

Problem Statement

The problem addressed in this study was the unknown influence technology in teaching mathematics classes has on student motivation, attitude, and achievement in Nigeria. Due to the lack of technology use in teaching mathematics classes, students in Nigeria are not leaving with the skills they need for employment and therefore are not as economically self-reliant as adults (BBC, 2017; Etuk & Bello, 2016; Ugwumba & Amara, 2015). Despite the skills, experience, and capability Nigerian mathematics teachers bring to their classrooms, achievement has remained below 50% overall in Nigerian schools (BBC, 2017; Olanrewaju & Alabi, 2018; Oyedeji, 2017; Sohngen, 2017).

Research over the last 5 years on students' motivation, attitudes, and achievement supported the need for this study. Educators of mathematics in Nigeria have continued to raise concerns about the impact teaching strategies and a lack of technology has had on students' attitudes. This was the fundamental overarching gap in the literature (Perry et al., 2016; Zakariya, 2017). Several studies recognized that various factors influence student attitudes about mathematics, including societal norms and the diversity of heritage, hence the need to consider its impact on achievement (Oyedeji, 2017; Perry et al., 2016; Zakariya, 2017). Attitude toward mathematics in Nigeria tends to decrease as children in Nigerian schools age, which links to a lack of motivation (Oyedeji, 2017; Sanubi & Akpotu, 2015).

The West African Examination Council (WAEC) regulated the WASSCE, and all graduating students in Nigeria, Ghana, Sierra Leone, The Gambia, and Liberia complete the assessment annually. Based on scores of the WASSCE, table 1 presents evidence that there was a decline from 1997 to 2015 in the national examinations scores (BBC, 2107; Eno-Abasi, 2015; Olanrewaju & Alabi, 2018). Student attitudes and motivation toward learning mathematics were low, influencing their achievement, which could also be influenced by their socioeconomic status (Henry & Olukemi 2015; Kola & Sunday, 2015).

Table 1

Summary of National Test and West African Senior Secondary Certificate Examination Results

Year	% Pass Rate	Candidates Passed	Total Number of Candidates
2016	38.00%	621,554	1,605,248
2015	38.68%	616,370	1,593,442
2014	31.28%	529,425	1,552,758
2013	38.81%	639,769	1,034,263
2012	36.57%	355,266	1,102,608

Note. Source *Daily Post* (2016)

Despite an earlier decreasing trend in mathematics achievement, globally, technology integration has improved student motivation, attitudes, and achievement in mathematics (Ameen, Adeniji, & Abdullahi, 2019; Howard, Chan & Caputi, 2015). Evidence also supports technology integration as a motivator to improve Nigerian students (Awofala, 2017; Fayomi et al., 2015). Many educators in Nigeria believe that technology integration in the mathematics classroom is one answer to the challenge of low achievement among learners (Badmus et al., 2018; Dele-Ajayi et al., 2019). Thus, the focus needs to be on the effective use of instructional facilities that enhance student achievement through improved attitude and motivation (Kalagbor, 2016; Msila, 2015), such as integrating technology into the mathematics curriculum (Brown, 2017; Kaleli-Yilmaz, 2015; Ríordáin, Johnston, & Walshe, 2016). In the past 10 years, there have been technological innovations in a mathematics curriculum that have benefitted students (Bicer & Capraro, 2017; Kaleli-Yilmaz, 2015; Shittu, Gambari, Gimba, & Ahmed, 2018). However, qualified teachers must teach and engage students with these tools (Ríordáin et al., 2016). Placing computers and other technological devices in the classroom has little influence unless teachers embrace technology and use it effectively (Bicer & Capraro, 2017; Dele-Ajayi et al., 2019).

Purpose

The purpose of this ex post facto, causal-comparative study was to compare the extent of the difference in student motivation, attitude, and achievement scores in mathematics classrooms taught by teachers with a low level of technology use compared to a student taught by teachers with high technology use. A quantitative study was conducted using a comparative approach to achieve this purpose. Based on teacher responses to the Technology Knowledge Base (TKB) Questionnaire, they were grouped into low technology use and high technology use group (independent variable). The students taught by the two groups of teachers had their motivation, attitude, and achievement scores (dependent variables) compared to provide answers to the research questions.

Research Questions and Hypotheses

1. What is the extent of the difference in student motivation scores as measured by the Motivational Strategies for Learning Questionnaire (MSLQ) for students taught by

teachers with low technology use compared to students taught by teachers with high technology use in mathematics classrooms?

$H_0$1: There is no significant difference in student motivation as measured by MSLQ for students taught by teachers with low technology use compared to students taught by teachers with high technology use in mathematics classrooms.

H_a1: There is a significant difference in student motivation as measured by MSLQ for students taught by teachers with low technology use compared to students being teachers with high technology use in mathematics classrooms.

2. What is the extent of the difference in student attitude scores as measured by the Attitude Towards Mathematics Inventory (ATMI) for students taught by teachers with low technology use compared to students taught by teachers with high technology use in mathematics classrooms?

$H_0$2: There is no significant difference in student attitude towards mathematics as measured by ATMI for students taught by teachers with low technology use compared to students taught by teachers with high technology use in mathematics classrooms.

H_a2: There is a significant difference in student attitude towards mathematics as measured by ATMI for students taught by teachers with low technology use compared to students taught by teachers with high technology use in mathematics classrooms.

3. What is the extent of the difference in student achievement scores in mathematics as measured by the West African Secondary School Certificate of Examination (WASSCE)

for students taught by teachers with low technology use compared to students taught by teachers with high technology use in mathematics classrooms?

$H_0$3: There is no significant difference in student mathematics achievement in mathematics as measured by WASSCE between teachers with low technology use compared to teachers with high technology use.

H_a3: There is a significant difference in student achievement in mathematics as measured by WASSCE between teachers with low technology use compared to teachers with high technology use.

Theoretical Framework

The theoretical approach to understanding teachers' capabilities related to technology integration was the TPACK framework (Koehler & Mishra, 2008). It is a framework developed to explain a variety of knowledge bases required by teachers to effectively teach students the course content using technology (Blau, Peled, & Nusan, 2016; Koehler, 2012). The use of technological, pedagogical, and content knowledge (TPACK) was a practical framework to examine how teachers were integrating technology in the classroom (Koehler & Mishra, 2008). The TPACK framework highlights the various constructs that influence teaching and learning to understand its influence on students' mathematics achievement (Koehler & Mishra, 2008; Kola & Sunday, 2015). Teachers' effective use of technology can be divided into three primary domains using the TPACK framework: CK, PK, and TK. These domains' combinations are broken down further into four additional knowledge bases—PCK, TCK, TPK—and the aggregate of all three, TPACK.

Technology integration and TPACK may partially explain mathematics performance variability in private schools in Nigeria (Awofala, 2017; Fayomi et al., 2015). There is a conceptual relationship between TPACK, student motivation, attitudes, and achievement. Figure 1 provides a conceptual map outlining the variables and survey instruments used for this study.

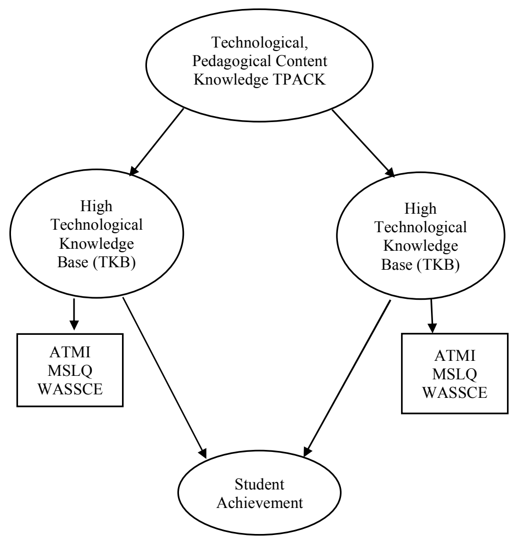

Figure 1. Conceptual map of the relationship between TPACK, student attitudes, and motivation, and student achievement.

Figure 1 explains the relationships between low technology use scores of teachers' use of technology compared with high technology use scores of teachers' use of technology in the mathematics classroom, measured by the TKB. The independent variable influences the dependent variables of student motivation (MSLQ), attitude (ATMI), and mathematics achievement (WASSCE) results, respectively. The conceptual map shows how the study approach supported the framework in ensuring the research questions explored the extent of the difference. The archival data used for this study were TKB questionnaire responses reporting on teachers' self-reported technology integration. The data created low technology use and high technology use groups for teachers. Chapter 2 provides a further discussion of TPACK, MSLQ, ATMI.

Nature of the Study

This study used archival data collected between 2018-2019 to compare scores on the MSLQ, ATMI, and WASSCE on motivation, attitude, and achievement of mathematics students taught by teachers with either low technology or high technology use. The study used archival data from three private schools in two states with different school sizes but similar student household incomes and state populations. All the schools had similar limitations in using technology. This study's independent variable was the level of technology use by teachers grouped into subgroups of low technology use teachers and high technology use. The TKB questionnaire scores of teachers' technology use in the classroom were used to group the teachers. The dependent variables were motivation, attitudes, and achievement, as measured by MSLQ, ATMI, and WASSCE.

As the researcher in this study, I collected the archival data with all the necessary approvals and interpreted the data retrieved from the school representatives. During the archival data collection process, the school leaders signed off on the data use agreement, confirming that they were willing to provide access to the questionnaires and mathematics WASSCE results of students in 2018 and 2019 without any identifiers. Participating schools could request a generic statistical report of the findings; however, the report was not tailored to a named school but rather to the group. The teacher's questionnaire (TKB) results provided the data points to divide them into two groups based on low technology use against high technology use in the participating schools based on the lower 25th and upper 25th percentiles. Finally, SPSS statistical software generated statistical outcomes from the data analyzed. As the researcher, I selected the strategies and opportunities to enhance the collection, analysis, and interpretation of the participants' data without collecting any information on their identities (Creswell, 2009; Ersoy & Oksuz, 2015).

The MSLQ and ATMI questionnaires are in the public domain. All students who participated in this study completed the MSLQ and the ATMI. All students completed identical questionnaires. The TKB questionnaire, an edited version of the original TPACK questionnaire, is also available in the public domain. The TKB questionnaire contains a selection of questions relating to mathematics from the original survey instrument. All teachers who participated in this study completed the TKB. All teachers who participated in this study received the same version of the TKB.

Definitions

Achievement: Measures learners' academic progress in specific instructional standards within a learning period—in this case, the WASSCE (Bello, 2014; Tapia & Marsh, 2004).

Attitude: Focuses on how students' positive and negative feelings influence their achievement in mathematics, emphasizing relevance, value self-confidence, challenges, and general ability to overcome (Tapia & Marsh, 2000a).

Continuous professional development: The training and personal development initiatives given to teachers to enhance their skills and ensure they are equipped to teach children using various instructional materials and technology.

Graduating students: For the purposes of this study, the term *graduating students* refers to the group of students who took the WASSCE achievement assessment irrespective of grades attained and graduation status.

Motivation: A student's aspiration to engage and excel in a classroom's learning experience (Keller, 1983; Skaalvik, Federici, & Klassen, 2015).

Private schools: Learning environments owned by individuals or groups where parents pay fees to fund the children's education (Awofala, 2017).

Technology: The compilation of systems, skills, approaches, and procedures used to create goods and services that a teacher uses for educational instructional change (Collins & Halverson, 2018). Technology referenced in this study includes laptops, calculators, computers, printers, scanners, interactive whiteboards, projectors, handheld devices (phones, tablets, or pads), software, and learning applications.

Technology integration: The range of technology used in the classroom to enhance students' learning experiences in mathematics (Sung, Chang, & Liu, 2016). Technology used in this study's classrooms includes computers, internet, laptops, digital cameras, overhead projectors, e-books, personal handheld devices, and external devices ranging from DVDs, CDs, and USBs.

Assumptions

There were a few assumptions that influenced this study. The first assumption was that teachers were honest and forthcoming about their technology use as a teaching and learning tool to raise achievement. This assumption was important because if the teachers were not forthcoming on the answers to TKB survey questions, then the technology-use groupings' criteria would not be an accurate representation. A similar assumption was that the learners responded to the motivation and attitude questionnaires honestly during the school audit. Similarly, if the learners were not forthcoming regarding their motivation and attitudes, the results would not be accurate.

It was also assumed that the schools in this study represented the greater population of private school students within the identified states in Nigeria. The assumption that the assessments selected would accurately measure the constructs was also considered. The questionnaires focused on the motivation, attitudes, and achievement of students. The research supporting this study demonstrated a strong content validity of the instruments (Ker, 2016; Tapia & Marsh, 2004; Voogt & McKenney, 2017).

Finally, the assumption that technology use will enhance the learning experience is pivotal to this study. With a focus on using the TKB questionnaire to gain knowledge of the teacher's perceptions of using technology in the classroom, it was assumed that technology use would enhance learning and impact student motivation, attitude, and achievement in mathematics classrooms.

Scope and Delimitations

The study was conducted with data from three private secondary schools in Nigeria that offer WASSCE, a secondary school learning assessment. The focus was on student motivation, attitude, and achievement measured against teachers' technology use levels from two groups. Teachers completed the TKB questionnaires, and students completed the MSLQ and ATMI questionnaires and WASSCE achievement exam.

The study compared students' archival data from between 2018–2019 in mathematics against teachers' use of technology in the low technology and high technology groups. The aim was to explore the extent of technology integration on motivation, attitudes, and achievement in Nigerian secondary schools as research and data analysis is limited. The states chosen for retrieving archival data were Niger state and Ogun state, where the population of children between the ages of 1-19 is 2,248,790 and 1,792,277, respectively. The city of Minna in Nigeria has a population of 345,000, while the city Ijebu Ode in Ogun has a population of 154,161 (McKenna, 2018a; McKenna, 2018b).

The primary strategy to identify the population was to approach schools registered with the Association of International School Educators of Nigeria and the Association of Private Educators of Nigeria to canvas volunteer participation. All data retrieved from the schools were from teachers who teach mathematics and information and communication technology (ICT) at both the junior secondary and senior secondary school levels. The archival data were collected from schools where the owners or principals were willing to provide the data. When generalizing teaching skills in mathematics classrooms, there must be clarity on how TPACK is embedded in the curriculum. The schools in the sample were limited because all had to meet the criteria of WASSCE and completion of the questionnaires. Both the questionnaires were tailored to mathematics/ICT and administered to the mathematics/ICT teachers. With the varied sizes of each school population, the impact on the findings of the study may determine the statistical model to be used for the analysis.

Limitations

The use of archival data was a limitation of this study as it only provided a snapshot within an identified interval of 1 year. The data collected by the three private schools during this timeframe may not capture all participants' experiences in the target population. An unbalanced number of participants across the regions was another limitation. The data was not generalizable to all Nigerian learners because the study was based in only two states of the 36 states in Nigeria. Generalizing from these results requires caution when comparing different types of schools, locations of schools, and sizes of schools across the country. The imbalance was due to the variance in the enrolment of the schools that agreed to provide the data for this study.

This study also measured motivation, attitudes, and achievement using archival data within a specific timeframe. Retrieval of archival data was limited as the schools had only recently started collecting the specific data required, which aligned with the TKB, MSLQ, and ATMI questionnaires and WASSCE. A final possible limitation to the study is that a lack of technology skills, CK, or mathematical pedagogy might bias the teacher's responses. This limitation could have an impact on the findings, which could potentially influence the recommendations. The potential bias in the teachers' responses may not be detectable because archival data were used.

Significance of the Study

Mathematics is a compulsory subject in Nigeria and a pre-requisite for admission into higher education. Therefore, learners need progression in mathematics grades if they will further their education. (Bakare, 2015; Kalagbor, 2016; Oyedeji, 2017). Student achievement in mathematics has a positive impact on economic growth and self-development. An educated population influences job opportunities, financial productivity, and positive social change in communities (Chudgar et al., 2019).

This study will contribute to the existing research in the education sector in Nigeria and elsewhere by focusing on the differences in student motivation, attitudes, and achievement in mathematics when taught by teachers with either a low or high technology use. The comparison is essential when making connections between motivation, attitudes, and achievement to learning mathematics and teachers' impact on the learners' experiences. According to WASSCE scores, approximately 50% of Nigerian children are failing mathematics. Therefore, this study aimed to understand the effects of technology use by mathematics teachers on students' motivation, attitude, and achievement.

With mathematics having a high failure rate nationally, understanding the impact teachers have on motivation, attitude, and achievement is central to planning for teacher-centered initiatives that will influence research beneficial to Nigeria's education plans for the future. This study's rationale was to contribute to the research on how teachers influence student motivation, attitudes, and achievement when using technology in the mathematics classroom. The study can inform decision-makers when developing policies that impact student achievement.

Summary

Education is at the heart of nation-building, yet education in Nigeria faces challenges that impact student motivation, attitude, and achievement. Mathematics education and achievement are especially important, as mathematics is linked to higher education access, future success, and by extension, positive social change. The effects of technology integration and teacher engagement, particularly in mathematics, are a concern across Nigeria. Understanding how teachers' level of technology use influence student motivation, attitudes, and achievement was central to this study. The research questions and hypotheses were aligned with the purpose and problem statement to impact positive social change in Nigeria.

The next chapter provides insight into the literature review on TPACK, TKB, MSLQ, and ATMI, and a theoretical discussion of this quantitative research design. A review and summary of the roles of TPACK and the effect of technology integration on learning from a global, continental, and national perspective is included to ensure the identification of the differences and common challenges. This chapter also supports the importance of TPACK from the global, African, and Nigerian perspectives with an understanding of the difference its impact may have on motivation, attitudes, and achievement of students, thereby promoting positive social change.

Chapter 2: Literature Review

This study addressed the effect that technology use in mathematics classes has on student motivation, attitude, and achievement in Nigeria by comparing student motivation, attitude, and achievement scores in mathematics classrooms in Nigeria. Many studies have examined the relationship between the TPACK elements and student variables such as motivation, student attitudes, achievements, ethnicity, gender, literacy, and numeracy skills (Batiibwe & Bakkabulindi, 2016; Fisser Voogt, Van Braak, Tondeur, & Spector, 2015; Igbokwe, 2015). However, there have been limited studies in Africa, specifically in Nigeria (Hamid & Singram, 2016; Kafyulilo et al., 2015; Malubay & Daguplo, 2018). This study focused on the effect of technology use by mathematics teachers on student motivation, attitudes, and achievement in Nigeria (Oyedeji, 2017; Skaalvik et al., 2015).

The review of research in this chapter explores the problem and purpose of the study. This chapter provides an understanding of the TPACK theoretical framework. It also develops an understanding of the MSLQ, ATMI, and WASSCE instruments used to measure motivation, attitude, and achievement. The existing research provides insight into information on technology integration in Nigeria, Africa, and globally while summarizing the impact of TPACK on student motivation, attitude, and achievement.

Literature Search Strategy

I used several databases to find relevant research aligned with this study: SAGE, ERIC, ProQuest, Google Scholar, and Dissertations and Theses from the Walden University Library. The scope of this literature review was predominantly between 1987 to 2020, emphasizing studies within the last 5 years. Peer-reviewed articles and various targeted scholarly papers were from 2015 to 2020, although some essential articles reviewed were published before 2015. Eighty-six percent of the articles referenced dated 2015-2020, and 91% were peer-reviewed within the same period. This study's search strategy included reviewing the relevant literature on technology integration and TPACK in Africa and globally.

The search terms and keywords used were *TPACK*, *technology integration*, *student motivation*, *attitude*, *and achievement*, *raising achievement in mathematics*, *mathematics WASSCE in Nigeria*, *teacher efficacy in mathematics as measured by WASSCE*, *student motivation and attitudes in mathematics and ICT for senior school (WASSCE*), *technology in sub-Saharan Africa*, *the impact of technology on achievement in Nigeria*, *TPACK in Nigeria*, *technology innovation in Nigeria*, *student achievement in mathematics*, *attitudes to learning mathematics*, *technology integration in Africa and Nigeria*, *benefits and limitations of technology integration in the classroom*, *pedagogical knowledge*, *content knowledge*, *technological knowledge*, and *motivational strategies in the 21st century*. The keywords and ATMI and MSLQ research articles from different perspectives focusing on Nigeria, Africa, and global trends were central to ensure an exhaustive search.

The literature review for this study was focused on a synopsis of TPACK and technology integration as it influences learning globally in Africa and specifically in Nigeria. Additionally, with a limited amount of research on the impact of technology and TPACK in Nigeria, this literature review also forms the basis for understanding the contextual framework. The review of the literature identified the benefits and challenges for technology integration. Finally, a summary is provided on raising motivation, attitudes, and achievement using TPACK as the central framework for mathematics teachers.

Theoretical Foundation

The theory used for this comparative quantitative study was TPACK. The TPACK framework focuses on the relationship between teachers' technology, content, pedagogy, and knowledge in promoting a motivating learning environment (Shulman, 1987). TPACK is a framework to understand the knowledge bases teachers need to promote technology integration in learning environments (Koehler, 2012; Malubay & Daguplo, 2018; Rangel, 2019). TPACK is a framework implemented to enhance teachers' skills and recognizes the need to offer appropriate teaching and learning experiences (Batiibwe & Bakkabulindi, 2016; Koehler, 2012). The rationale for selecting the TPACK model was that it is most appropriate when divided into constructs that show the effects of teachers' use of technology. The TPACK framework also aligns with the MSLQ, ATMI, and WASSCE instruments used to measure student motivation, attitudes, and achievement. The TKB questionnaire used for this study also supports the TPACK framework.

Overview of TPACK

Extending from Shulman's idea of PCK, technology became an integral part of TPACK over the past two decades. The TPACK framework has had a significant impact on motivating learners (Getenet, 2017; Koehler, 2012). Therefore, a combination of CK, teacher knowledge, pedagogy, and technology make the learning process engaging, exciting, and enriching (Koehler, 2012; Rosenberg & Koehler, 2015).

TPACK has 21 assessment instruments divided into subsections that measure different competencies. The 4Cs of communication, creativity, collaboration, and critical thinking are central to TPACK. Other sections include life and career skills, information technology skills, and 21st-century themes. The 21st-century themes are assessments and standards, curriculum and instruction, professional development, and learning environments, measuring student achievement. Teachers are expected to ensure that their pedagogical skills and CK support the students' development and lifelong learning experiences (Voogt, & McKenney, 2017). Students’ motivation and attitude are dependent on the teachers’ skills. However, even within the 21st century, many teachers are still not familiar with using technology devices to develop and drive effective and efficient learning strategies (Kafyulilo et al., 2015; Koh et al., 2017; Rangel, 2019).

The impact of TPACK on teaching practice highlights teachers’ expectations when considering the influence of technology and how it is used in a classroom. With various educational variables, teachers must measure technology’s impact on motivating and engaging learners to succeed in the classroom with an improved attitude (Ergen et al., 2019; Malubay & Daguplo, 2018; Oyedeji, 2016). Simply using technology to promote teaching and learning is generally insufficient for measuring progress, achievement, and success. The variety of technology tools and instructional materials available to support learning with instant feedback that measures progress influences students’ learning experiences through improved motivation, attitude, and achievement. (Koh & Chai, 2016; Voogt & McKenney, 2017).

Further lesson plans need to include multiple teaching and technology pedagogies while ensuring the course's learning objectives are met (Koehler, 2012; Rosenberg & Koehler, 2015; Koh, Chai, & Lim, 2017; Sung et al., 2016). Effective lesson planning for technology integration includes tools to enable relevant, real-life learning experiences through authentic examples. Technology can motivate and engage learners while making learning exciting (Voogt & McKenney, 2017). It can also improve students' attitudes toward learning (Perry, Catapano, & Ramon, 2016). Teachers who integrate technology into the classroom use resources and tools to make learning authentic (Getenet, 2017; Herring, Koehler, & Mishra, 2016; Sari & Bostancioglu, 2018).

Three knowledge bases form the TPACK framework: CK, PK, and TK. However, these knowledge bases' intersections are necessary to understand the TPACK framework: TCK, TPK, PCK. The cumulative variable of all six is the complete framework of the TPACK framework. In Figure 2, the components of TPACK are illustrated based on their contexts. Knowledge of both the content and the relationship between the seven components of TPACK is important for teachers (Koehler & Mishra, 2009). Pedagogy and CK were the original descriptors of Shulman's framework (Koehler & Mishra, 2009). However, Koehler and Mishra later added technology as part of the framework's description because technology became a vital part of instruction. Identifying the type of knowledge base required to integrate technology was critical when contemplating the complexities and complications crucial to teacher knowledge (Koehler 2012; Willermark, 2017).

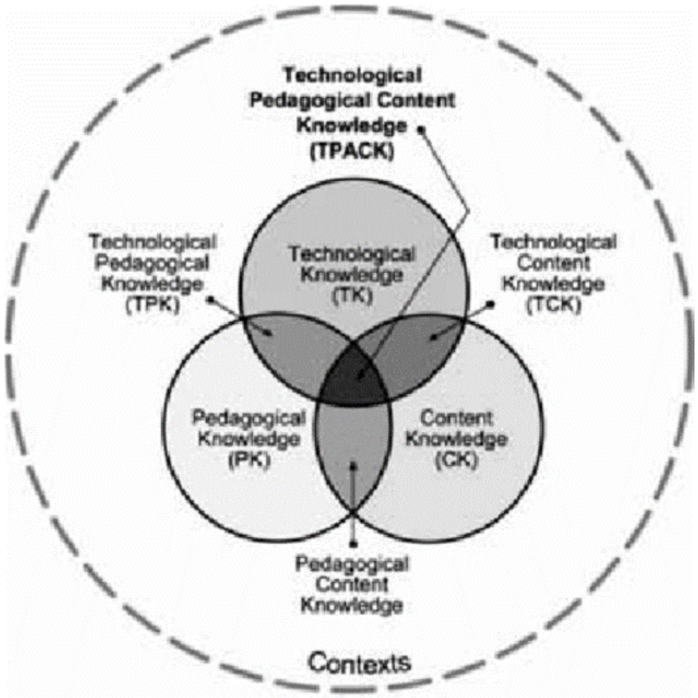

Figure 2. TPACK model. Reproduced by permission of the publisher, 2012 by tpack.org. (Koehler, 2012).

Content Knowledge

The organization of knowledge in engaging teachers' communication process is known as or referred to as CK. CK is significant when reflecting on a teacher's ability to disseminate course contents. It reveals the teacher's knowledge about the course content taught or learned by students (Koh et al., 2017; Sari & Bostancioglu, 2018). It is essential for mathematics teachers to develop the skills required to teach with fluency in the subject/CK (Sari & Bostancioglu, 2018; Stoilescu, 2015; Shulman, 1987; Willermark, 2017). PCK depicts the fact that knowledge and context are determined by having a clear understanding of the course content and the most effective and efficient strategies to present the knowledge to students (Shulman, 1987).

CK forms part of a whole when examining the various components and how it influences students' learning experiences. Philosophies, values, perceptions, organizational contexts, and resilient practices provide teachers with an understanding of the importance of CK (Malubay & Daguplo, 2018; Rosenberg & Koehler, 2015; Shulman, 1987). Teachers need to ensure the course's primary contents are taught effectively and that they engage the learners to empower them to achieve. Learning is then realized through improved motivation, attitude, and achievement, mainly because the mathematics curriculum continues to be an area of challenge to learners (Larkin & Jorgensen, 2016; Riswanto, & Aryani, 2017; Shulman, 1986). The impact of CK is imperative if teachers are to make a difference in motivating students in mathematics. The content of a course empowers learners to succeed when given the tools to develop the necessary skills.

Pedagogical Knowledge

The teachers' experiences and confidence in delivering course content also require an understanding of PK's influence on the learning experiences of learners. PK implies that teachers effectively use a range of teaching strategies to engage learners and improve their attitude and motivation while teaching course content (Koh et al., 2017; Stoilescu, 2015). PK can be demonstrated when teachers develop learning plans to include prior knowledge and incorporate various strategies addressing the targeted groups' different learning styles (Shulman, 1986; Voogt & McKenney, 2017). The learning process differences tend to occur when considering the various learning styles teachers use to plan their lessons. Appreciating how the content is shared or presented to learners based on clearly defined learning objectives highlights the complexities related to teachers' technological ability (Koh, 2017; Stoilescu, 2015).

The ability of a teacher determines the transformation of learning by interpreting the course content through multiple strategies. These strategies transform the subject and content through exciting and engaging instructional materials. Prior knowledge is needed to inform the planning process and incorporate the reporting process to measure learning. Transforming student learning experiences highlights teachers' need to demonstrate the impact PK has on engaging learners to achieve their full potential. Finally, identifying and teaching misconceptions is essential. It requires exploring content, sharing ideas, challenging the connections within different contexts, allowing flexible learning opportunities, promoting learner inquiry, and engaging through various technology tools (Batiibwe & Bakkabulindi, 2016; Voogt & McKenney, 2017).

Further, PK recognizes that technology is pivotal to academic achievement. Knowing how to use specialized tools becomes fundamental. Although challenging to many learners, mathematics has a range of exciting and enriching learning tools to motivate learners, especially when linked to real-life and relevant needs for future development. There is a need to provide evidence in a mathematics class that the knowledge bases impact learning through engagement and motivation to make a difference when reviewing PK.

Technological Knowledge

Technology's relevance to promoting an engaging, flexible, and exciting learning environment is fundamental when considering TK's impact on student achievement. TK focuses on how teachers use their skills and various technologies to engage learners through the Internet and digital resources (Bingimlas, 2018; Deng Chai, So, Qian, & Chen, 2017). The strategies used to teach with technology highlights the need to identify pedagogical links between learning experiences and their impact on student achievement. Confident teachers who use technology tend to have a wider variety of strategies and instructional materials to stimulate the learners (Deng et al., 2017; Ergen et al., 2019).

Technology supports learning through the effective use of acquired skills embedded in various opportunities and tasks. Teachers acquire and use their skills to develop effective lesson plans that impact learning. Technology tools provide learners with opportunities to explore tasks through developmental stages and open-ended questions linked to real-life scenarios and relevance (Herring et al., 2016; Voogt & McKenney, 2017). TK does not suggest an end, but rather it participates in open-ended integration that generates and evolves over a lifetime. Nevertheless, technology has its challenges; therefore, teachers should recognize the need to develop their skills and confidence before engaging them. Digital technology, including computers, mobile devices, and applications, are usable as an instructional tool in several ways (Ergen et al., 2019; Getenet, 2015). Teachers need to accept the changing learning environment and understand that the ultimate goal is for success in student achievement.

Global Implementation of TPACK

This section reviews how the TPACK framework uses instructional materials to improve motivation, attitudes, and achievement. The overview summarizes the framework globally by identifying the role of technology integration and its influence on student learning through consistent implementation. The literature supports how teachers' knowledge of students' motivation, attitudes, and achievement impacts the challenges in different contexts and learning areas.

The influence teachers have on encouraging students to think outside the box motivates them and promotes the need to challenge their learning experiences and opportunities. These elements are fundamental in TPACK. Teachers develop their knowledge of the subject and disseminate it to the students through positive and engaging use of technological devices and instructional materials (Herring et al., Koh et al., 2017; Voogt & McKenney, 2017). Additionally, with technology use, students' confidence and engagement will increase, improving student attitude and motivation using technology as an instructional tool in mathematics. Technology use has an important role in engaging teachers and students in a mathematics lesson (Koh et al., 2015; Musti-Rao, Lynch, & Plati, 2015). The experiences of learners in developing an understanding of their subject matter can be complicated. However, with technology integration, there is a relationship between CK, PK, and TK that supports enjoyment and motivation in the mathematics classroom (Voogt & McKenney, 2017; Willermark, 2017).

The challenges faced by using technology vary depending on its accessibility and each teacher's ability to use the learning environment resources. Technology accessibility can be deemed a challenge across developing countries, and teachers' inability to use it confidently hinders its potential benefits as a learning tool (Kola & Sunday, 2015; Tella, 2017; Willermark, 2017). However, if teachers accept and utilize technology to engage learners promotes a positive learning experience, they improve learners' motivation and attitudes (Ortega, Martinez, Cuberos, & Jiménez, 2019; Riswanto & Aryani, 2017). TPACK encourages technology as an effective alternative to textbooks because students find it more motivating (Voogt & McKenney, 2017).

TPACK Research in Africa

The impact of TPACK across Africa highlights the variance in understanding the benefits of technology in schools. In Nigeria, ICT has been incorporated into the curriculum and forms part of the National Policy on integrating technology. It was expected to impact students' learning (Batiibwe & Bakkabulindi, 2016; Stoilescu, 2015). In sub-Saharan Africa, the curriculum's implementation faced challenges, even though governments-built computer laboratories and procured various technology tools necessary to impact learners (Ali & Faaz, 2017; Batiibwe & Bakkabulindi, 2016).

TPACK in Africa continues to be an area for research development, as it supports an understanding of the impact on student achievement irrespective of national challenges in developing countries. Professional development is central to the successful implementation of TPACK. With knowledgeable teachers, student achievement in mathematics can improve irrespective of their country or community of origin (Kafyulilo et al., 2015). With adequate and appropriate professional development for mathematics teachers, TPACK has the prospect of enhancing technology use in classrooms (Ameen et al., 2019; Batiibwe & Bakkabulindi, 2016; Herring et al., 2016; Msila, 2015). Even with the necessary infrastructure and professional development for teachers, measuring student achievement will have its challenges. However, TPACK provides the avenue to positively impact students' motivation, attitudes, and achievement.

TPACK Research in Nigeria

Technological tools are essential and crucial when reviewing student achievement in mathematics in Nigeria. Because students find mathematics mundane, challenging, and too theoretical, technology has been identified as a useful instructional resource (Safo, Ezenwa, & Wushishi, 2013). Research suggests that students find mathematics challenging because of their low ability to recall learned skills and applications (Ameen, Abdullahi, & Jibril, 2018; Awofala, 2017; Safo et al., 2013). However, there is evidence that students make better progress where technology is coupled with effective teaching strategies (Ameen et al., 2018; Safo et al., 2013).

TPACK in Nigeria provides an insight into teacher self-efficacy with PCK as a significant component to the contextual framework. Teachers' self-efficacy depends on disseminating knowledge and competencies to learners (Kafyulilo, 2015; Kola & Sunday, 2015). This has a negative impact on achievement due to teachers' inability to convey knowledge effectively and efficiently to students. Therefore, in this example, the learning experience is theoretical because learning is in a lecture form. The importance of teachers having technology skills is apparent when incorporating CK, technology tools, and smaller class sizes expected to encourage learners' attitudes and motivate students (Kola & Sunday, 2015; Olagunju et al., 2015).

PCK focuses on the course content and the strategies used to teach students, aimed at achieving success. PCK ensures the teacher delivers the content using various tools in complex and diverse contexts, making it relevant and engaging to the learner (Kola & Sunday, 2015). These skills and competencies are developed with experience. Teachers with limited subject knowledge may find content delivery challenging. This may hinder students' opportunity to participate in a varied, engaging, and interesting lesson. Because recognizing, accepting, adapting, exploring, and progression are central principles of TPACK, teachers need to be versatile in content knowledge. Hence, they can fully engage in guided learning while using appropriate and relevant technologies. Results from this strategy impact achievement through improved motivation and attitudes (Perry, Catapano, & Ramon, 2016; Kafyulilo, 2015).

Benefits of TPACK in Raising Achievement in Mathematics

Technology must be integrated into the equation when evaluating the importance of attitude, motivation, and achievement. Technology hardware includes desktops, laptops, scanners, printers, and telephones. Other technologies used in a mathematics classroom could include game-enhancing tools, digital audio, media resources, and instructional materials. These are essential in developing problem-solving and word problems, subject-specialized instructional software, and Microsoft Office. Software often acts as a tool for enforcing and reinforcing knowledge. Teachers require technological tools to contribute to the pedagogical strategies that foster mathematical skills development (Rosenberg & Koehler, 2015; Sari & Bostancioglu, 2018).

The impact of game-enhancing tools used to engage learners to develop their skills and attitudes is increasingly evident in the mathematics classroom. The introduction of games has shown student productivity through increased motivation and enhanced attitudes (Koh et al., 2015; Koh et al., 2017; Sari & Bostancioglu, 2018). Digital teaching tools, including gaming, supports students internalizing mathematical concepts by promoting independent learning (Koh et al., 2017; Ortega et al., 2019; Ríordáin et al., 2016). This has revolutionized the learning environment by providing technology fundamental in improving students' motivation and attitude.

Digital technology can be used to manipulate data and create opportunities that access fieldwork through mobile devices. The growing range of technology devices and resources enhances opportunities that influence the pedagogy and strategies that motivate teachers and students (Howard et al., 2015; Sung et al., 2016). Further, digital technology improves access to instructional resources for effective communication. These resources are available on student devices, and they stimulate independent learning within and outside the classroom (Blau et al., 2016; Ríordáin et al., 2016). Access to instructional resources has been recognized as particularly important when considering children's Nomadic lifestyle in northern Nigeria and the terrorist insurgencies that challenge education (Sanubi & Akpotu, 2015).

Problem-solving and word problems are central to making real-life connections in mathematics content. The assessment criteria for national standardized tests encompass word problems that encourage effective and efficient problem-solving skills. Teachers need to ensure students acquire transferable skills required to solve word problems using various tools (Blau et al., 2016; Howard et al., 2015). Technology use also improves student motivation, attitude, and achievement by enhancing teachers' ability to share information in creative and enriching ways. Current practice indicates teachers' low self-efficacy limits learners' opportunities to explore learning through a range of instructional materials (Kola & Sunday, 2015; Tella, 2017).

Finally, using videos, games, and music to teach rhymes and concepts has been identified as useful for improving attitudes and motivating learners. The experiences vary with the pedagogy and assessment procedures (Collins & Halverson, 2018; Kafyulilo et al., 2015). With digital tools, teachers can efficiently plan flexible and creative lessons and deliver an exciting experience for learners (Henrie, Halverson, & Graham, 2015; Lau & Lee, 2015). Overall, the use of TPACK as a framework can be beneficial for mathematics teachers, even with its complexities. As mathematics is a subject that students generally have a negative attitude, teachers' use of technology should engage learners.

TPACK Influence on Motivation

In conjunction with TPACK, the MSLQ (Koehler & Mishra, 2008) supports this study's theoretical framework. Technology frameworks, such as TPACK, could be used to address the difficult challenge of motivating students to learn. Furthermore, the interaction of technology, pedagogy, content knowledge is essential to a teacher's understanding of what motivates students.

TPACK Influence on Attitudes

With educational researchers' challenging the definition of students' attitudes towards mathematics, several studies developed various models to clarify this in mathematics classrooms (Banks, 2015). Attitude is the action taken to achieve specific objectives by self-motivation (Albarracin & Shavitt, 2018). Using the TPACK framework to evaluate students' attitudes, ATMI provides an instrument to measure and compare information on students. Nevertheless, with the TPACK framework, teachers can positively shift students' attitudes in mathematics classrooms.

TPACK Influence on Achievement

Learners' experiences are pivotal when promoting achievement, regardless of ability. The promotion of student achievement highlights the need for varying instructional resources and technology. TPACK provides teachers with the technological tools required to engage learners. It encourages understanding the relevance of content, pedagogy, and technology in mathematics classrooms. Research has shown that mathematics teachers need to be skilled in utilizing a variety of technological resources and tools. Globally, evidence shows that learners make progress when the content is stimulating, and the delivery is engaging, thereby enhancing achievement in mathematics (Ersoy & Oksuz, 2015; Wang et al., 2015).

The teacher's ability to disseminate the content effectively influences learners' motivation and attitude (McLaughlin & Whatman, 2015; Ortega et al., 2019; Skaalvik et al., 2015). The impact of TPACK on students' achievement also highlights the importance of motivation and attitudes by incorporating exciting and enriching learning experiences. Learners' attitudes are influenced by the confidence, approach, knowledge, relationship, and teacher's control within the classroom. Furthermore, teachers who participate in curriculum design enhance the development of skills. These promote reflection, and there is an expectation that PK should improve student attitudes (McLaughlin & Whatman, 2015). When teachers share content knowledge that is creative and stimulating, learners are more likely to have a positive attitude when presented with difficult subjects like mathematics.

The Intersection of TPACK, Motivation, Attitude, and Achievement

The benefits of students' positive attitudes and motivation influence the role of TPACK, providing some clarity that raises achievement in mathematics from a global perspective. With the conversations of global mathematic councils to create and adapt interactive, creative, and active learning environments, technology could be a strategy to make a difference (Association of Mathematics Teachers, 2002; Commission of the European Community, 2007; National Council of Teachers of Mathematics, 2000). Technological devices have provided opportunities to influence student motivation and attitudes by using games, problem-solving, evaluation, graphical presentation, mathematical software, and media.

The influence teachers have on their students' motivation, attitudes, and achievement is evident in the CK, PK, and effective and efficient use of technology in the classroom. Therefore, teachers can improve the attitude of learners if they are confident in delivering the content. With a range of tools, resources, and effective strategies, technology stimulates the learners. Teachers must possess the mental capacity to understand the world and its relevance within the curriculum they teach students. Further, teachers cultivate a learning environment where students are interested and engaged in the learning process (Skaalvik et al., 2015).

The outcomes of teacher and student motivation, attitude, and achievement are pivotal in developing strategies that stimulate and enrich learning. When reflecting on the challenges learners face in the mathematics classroom, students' anxiety also affects their motivation and leads to limited progress (Wang et al., 2015). Even with some anxiety levels in a mathematics classroom, students appear to be motivated intrinsically (Dowker, Sarkar & Looi, 2016; García-Santillán et al., 2016). The learning should encourage positive behavior in an exciting environment because students are motivated even when there is some anxiety (McLaughlin & Whatman, 2015; Skaalvik et al., 2015; Wang et al., 2015).

Summary of Theoretical Framework

This knowledge bases of CK, PK, and TK are meaningful in engaging learners when improving motivation, attitudes, and achievement irrespective of ability and confidence. These knowledge bases are imperative and should include ICT tools to engage the learners and promote independent learning that stimulates exploration. The links between CK and TK have been fundamental in developing the TPACK framework. Understanding how students learn is the foundation for disseminating PK. TK, PK, and CK continue to be vital when analyzing and evaluating TPACK benefits (Voogt & McKenney, 2017; Koh et al., 2017). By recognizing the influence technology has on engaging teachers, TPACK helps support and promote learners' opportunities. TPACK, as a framework, has also enabled teachers to review their practices. It incorporates all the knowledge bases into teachers' lesson planning process to influence student achievement. PK integrates classroom management, curriculum and assessment methodology, learners' needs and expectations, and evaluating students' understanding (Batiibwe & Bakkabulindi, 2016; Voogt & McKenney, 2017).

Technology Integration

Research suggests that technology integration in mathematics education has a positive impact, specifically concerning student achievement (Howard et al., 2015). The next section will provide an overview of how technology integration has influenced learning globally, particularly in Africa and Nigeria. This section aims to provide an understanding of the limitations, benefits, and implementation strategies used globally, which gives context to the subsequent discussion on literature related to key variables.

Technology Integration Globally

The integration of necessary technology hardware, such as laptops, interactive whiteboards, overhead projectors, and tailor-made software, provides some understanding of the type of technology relevant in different countries and why it is appropriate. Kerrey & Iskason (2000) stated, "If this era of globalization has proven anything, it is that a growing world economy can create strong and lasting demand for technologically skilled workers and a technologically savvy workforce" (p.6). The impact of technology integration on different continents highlights the pace of change in varying environments.

The use of instructional technology for mathematics education is instrumental in developing learners' ability to understand concepts, application, logical reasoning, and problem-solving skills relevant to real-life expectations (Koehler & Mishra, 2008; Leendertz et al., 2013). Multiple studies show that technology integration in the mathematics classroom positively impacts student achievement through improved attitudes and motivation (Davies & West, 2014; Howard et al., 2015; Liu, 2013).

Furthermore, the curriculum's relevance and accessibility are fundamental when measuring students' achievement via technology integration. It is important to review the impact of technology integration within the changing 21st-century educational landscape (Eyyam & Yaratan, 2014; Kamau, 2014; Msila, 2015; Perrotta, 2017). The influence technology and media have had on engaging students in mathematics correlates with attitudes and motivation (Henrie et al., 2015). Improved attitude and motivation have a positive effect on student achievement. Technology also broadens the experiences, examples, and materials available in the mathematics classroom. These enhanced instructional tools and students' improved attitude and motivation in the classroom impact academic achievement outcomes (Kamau, 2014; Lui, 2013; Msila, 2015).

All strands of the mathematics curriculum have not been measured against technology integration to ascertain if there are any areas that the tools may have a negligible impact (Lui, 2013; Musti-Rao et al., 2015). The strands of mathematics are algebra, numbers, shapes, space, measurement, and data handling. This observation highlights the effect of technology integration in the classroom. With a positive approach to technology, learners and teachers are motivated to be experimental, and it is expected to make a difference (Costley, 2014; Gilbert et al., 2014).). Studies show that embedding various technology tools in students' learning experiences becomes pivotal, leading to academic success (Costley, 2014; Hunter, 2015; Nwangwo et al., 2014).

Technology Integration in Africa

Measuring student achievement when using technology tools and instructional resources emphasizes the need to address students' engagement through motivation, attitude, and mathematics achievement. Technology integration in schools across Africa has challenges in the implementation process because of infrastructural and teacher limitations in using the resources as instructional tools to promote teaching and learning (Msila, 2015; Mereku & Mereku, 2015). Teachers in Africa often lack training and skills development opportunities due to the lack of technology resources, including hardware and software. The National Curriculum, which is prescriptive and limits creativity, is viewed as the main hindrance in the classroom (Koh & Chai, 2016; Mereku et al., 2015; Msila, 2015). Evidence from three different countries in Africa, namely, South Africa, Kenya, and Nigeria, suggests that there are common challenges when integrating technology in schools. These challenges include inadequate educational funding, poor infrastructure, limited technology integration, and the socioeconomic impact on children (Abdulrasheed & Bello, 2015; Koh & Chai, 2016; Mereku et al., 2015; Msila, 2015). The resulting benefits based on technology integration, including student engagement, creativity, motivation, and achievement, outweigh the challenges (Msila, 2015; Perrotta, 2017).

Student achievement improves with teachers' confidence in using technology; however, it is not sufficient to assume these findings are equal across African classrooms (Howard et al., 2015; Mereku et al., 2015). The availability of technology tools in the classroom enables children to develop the skills necessary for future demands independently (Dele-Ajayi et al., 2019; Msila, 2015). The research suggests that infusing technology in students' learning experiences is pivotal to enhanced student achievement. (Mereku et al., 2015; Msila, 2015). Technology use encourages student engagement, motivation, attitudes, high-level thinking, and logical problem-solving opportunities. Evidence indicates that there is added interest and engagement through motivation, attitude, and willingness to gain knowledge due to technology use, which leads to improved student achievement on standardized tests (Howard et al., 2015). While research indicates the need for technology integration in the classroom, the technological challenges facing Africa impact technology availability for students.

Technology Integration in Nigeria

Technology integration in Nigeria is limited due to infrastructural challenges and lack of funding (Ali & Faaz, 2017; Olasehinde & Olatoye, 2014). Because of the fundamental infrastructural challenges, including lack of power, water, security, teacher perceptions, and teachers' limitations to using technology, the influence technology can have on student achievement in mathematics is limited (Dele-Ajayi et al., 2019; Suleiman et al., 2019). Evidence from the limited studies in Nigeria suggested private schools obtained success in student achievement, while public schools struggled to reach a level of educational scholarship needed for students to progress (Akinloye, Adu, & Adu, 2015;

Badau, 2015; Oyedeji, 2016). This difference is due to private schools' better facilities and teacher knowledge of engaging students in mathematics (Mussa & Saxena, 2018; Oyedeji, 2016; Oduwole, 2015). Nigerian public-school teachers' inability to use technology needs to be evaluated to understand how to progress academically to improve attitudes and motivation in the mathematics classroom while helping learners achieve their full potential.

The implications of technology as an intervention tool are relevant when evaluating its implementation. Mathematics is considered challenging, and its national achievement rate is below 50% at the national standardized tests, highlighting the need for significant intervention (Ariyo & Adeleke, 2018; Ajumobi, 2015). Without adequate PCK, teachers will have low self-efficacy, which can negatively impact their students. A teacher with sound CK will motivate learners and ensure the curriculum is engaging, thus improving learners' attitudes (Kola & Sunday, 2015). The combination of the limited infrastructure, teachers' limited self-efficacy, and outdated technology have negatively affected Nigeria's mathematics education (Obijekwu & Muomah, 2018; Oyedeji, 2016).

Benefits and Limitations of Technology Integration

This section reviews the benefits and limitations that justify technology integration and its influences on student motivation, attitude, and achievement. Because technology integration has raised student achievement debates over the last two decades, some relevant knowledge would benefit Nigeria and developing countries in justifying its implementation (Larkin & Jorgensen, 2016; Oyedeji, 2016; Suleiman et al., 2019). With poor results in mathematics, an analysis of its benefits and limitations need to be undertaken to understand its implications for Nigeria. Consequently, understanding the challenges and benefits technology integration can have on student achievement has a critical role in Nigeria and, subsequently, other developing countries.

Benefits of Technology Integration

The benefits of technology integration in the classroom include having a positive impact on student attitude and motivation. The research implies that technology empowers teachers with relevant skills to promote an enriching learning environment (Carver, 2016). Integration of technology in the classroom provides an opportunity for independent and personalized learning. Technology use also promotes collaboration, group discussions, and professional development for teachers, including how to better motivate and engage learners (Carver, 2016; Perrotta, 2017). Technology use allows learning to occur beyond the classroom and brings the world into the learning space. Better technology use in the classroom also creates opportunities for assessing and measuring progress through varied assessments (Chen, 2015; Sung et al., 2016).

The advent of technology integration promoted the need to design the ICT curriculum to equip children with the skills to use technology as a learning resource. This system's use improves students' 21st-century skills and supports the enhancement of knowledge (Ameen et al., 2019; Sung et al., 2016). ICT influences student motivation, attitudes, and achievement in the classroom, supporting the benefits of promoting an engaging and creative learning environment. The impact of technology integration on student achievement in mathematics is pivotal. The need to engage learners and develop the skills for life-long learning becomes embedded in their educational experiences. With the use of technology, mathematics becomes easier and more accessible. Technology integration can promote active learning in the mathematics classroom and enhance creativity and equality in learning opportunities. Research also shows teachers who effectively use technology in the mathematics classroom provide timely formative feedback (Awofala, 2017; Bicer & Capraro, 2017; Kaleli-Yilmaz, 2015). Therefore, if schools aspire to promote an in-depth learning experience for learners, the leaders and administrators need to support and promote a positive learning environment that integrates technology (Amanchukwu, Stanley, & Ololube, 2015; Bingimlas, 2018).

When looking at technology integration in Nigeria, there is some evidence of a positive impact on mathematics (Ajao & Awogbemi, 2015; Bicer & Capraro, 2017; Etuk & Bello, 2016). The employment of capable and skilled teachers allows students to use a range of interesting and engaging instructional resources in the classroom to raise achievement (Ajao & Awogbemi, 2015; Suleiman et al., 2019). With technology integration as a tool to raise achievement, researchers hope that some knowledge of relevant implementation processes would benefit children in Nigeria. The ultimate belief is that it will improve student attitudes and motivation in mathematics (Brown, 2017; DeSilver, 2017; Ríordáin et al., 2016).

Limitations of Technology Integration

It is essential to evaluate teachers' challenges using technology to focus on the implementation, accessibility, and PK. Teachers support the notion that technology integration increases achievement because of engagement, interest, and motivation. However, it does not develop the Bloom's Taxonomy higher-order skills necessary for lifelong learning (Carver, 2016). Teachers' use of technology and comfort with technology is vital if its integration into schools is expected to improve student participation (Fayomi, Ayo, Ajayi, & Okorie, 2015; Henrie et al., 2015; Voogt & McKenney, 2017). Therefore, managing technological challenges requires that school leaders understand the benefits of technology in the classroom. Technology must be fully integrated into teacher training programs to fully capitalize on the positive impact on student achievement (Carver, 2016; Junaid & Maka, 2015).

In Nigeria, technology has been deployed to higher institutions of learning across the country; however, there are limited studies that focus on its impact on student achievement and teaching and learning in secondary schools (Etuk & Bello, 2016; Kalagbor, 2016). The justification for the limited studies is that technology integration is still at the preliminary stages of implementation. There are still theoretical and organizational challenges faced by the implementation and rationale for technology integration in Nigerian schools, particularly as a tool for measuring and evaluating motivation, attitudes, and achievement (Mereku & Mereku, 2015). Infrastructural challenges such as lack of electricity and basic amenities, including water, roads, educational funding, teacher empowerment, and other resources, are recognized as areas that impact technology integration in Kenya, Nigeria, and South Africa (Howard et al., 2015; Mereku & Mereku, 2015; Msila, 2015). With these contextual challenges, there is evidence that technology integration will become an area for further research when measuring student motivation, attitudes, and achievement in Nigeria.

Considering both the limitations and challenges, technology tools are deemed essential when reviewing the impact of student achievement in mathematics in Nigeria. Because students find mathematics mundane, challenging, and too theoretical, research indicates that technology is a useful instructional resource (Badmus, 2018). Frequently, through a lack of motivation and concerns with teacher CK and TK, mathematics is poorly taught across the country. This is reflected in learners' low achievement on national standardized testing levels (Blau et al., 2016; Kola & Sunday, 2015). However, there is evidence that students make better progress when technology is integrated into learning (Ameen et al., 2019; Awofala, 2017).

Benefits and Limitations of Technology Integration in Nigeria

The use of instructional technology has been limited in public secondary schools across Nigeria. The students have not benefitted from the use of technology integration in developing their skills. Although mathematics is a core subject and influences science and technology, public secondary schools have shown little progress. Research suggests that there has been significant improvement in student achievement by using technology tools in Niger State versus lecture-type lessons due to improved attitude and motivation (Etuk & Bello, 2016). This observation raises how technology may affect learners' positive learning attitudes in mathematics (DeSilver, 2017; Suleiman et al., 2019). The use of technological tools promotes an engaging learning environment. Furthermore, the success of technology on achievement across Nigeria is determined by several issues that impact the implementation by teachers for teachers and students. These include CK, PK, and TK resources and instructional materials; leadership and willingness to drive change;

time management; teacher engagement in training to use technology as a learning tool; commitment to engage in the change process, and motivation (Adedokun, 2016; Perry et al., 2016).

Promoting interesting, exciting, and engaging mathematics lessons is essential when developing strategies to improve achievement at the standardized national test levels (Skaalvik et al., 2015). There is a need for schools to ensure teachers have the tools required to enhance instructional experiences through media, digital technology, pedagogical knowledge, teaching strategies, and methodology. The use of investigation, teamwork, independent learning, and fun activities or games is essential when teachers aim to ensure engaging and impacting students' attitudes (Tella, 2017). The knowledge teachers determine the learning experiences and differences in classroom expectations have in delivering the course content with positive and exciting dissemination of content.

The challenges faced in developing countries across Africa are similar to those in Nigeria. There are no exceptions, and the complexities encountered when developing educational reforms are comparable. Mathematics research that focuses on the effects of technology indicated it positively affects motivation, improves students' attitudes, and raises achievement (Adedokun, 2016; Fayomi et al., 2015). With the introduction of the National Economic Empowerment and Development Strategy initiated in 2003 to reduce poverty in Nigeria, the need to transform education and ensure sustainability required developing skills inclusive of technology that should empower the nation (Ajai & Imoko, 2015; Igbokwe, 2015). The inadequacies of primary education and the impact on economic growth in Nigeria become critical due to its technological limitations in the 21st century (Ajai & Imoko, 2015).

Teachers’ ability to use technology as a teaching and learning tool is one of the main limitations in education across Nigeria. The inability to effectively use technology to enhance instructional materials aligned to the learning objectives is a challenge when teachers cannot use computers, visual aids, electronic boards, and mobile devices as learning aids (Amanchukwu et al., 2015; Perrotta, 2017). The necessary technology and continuous professional development form part of the government’s and school owner’s responsibility. It is expected to promote engagement and improve student attitude to motivate learners to achieve their full potential (Ker, 2016; Kola & Sunday, 2015). Nigerian private schools provide better training and equipment to align with TK, CK, and PK in the classroom. Teachers and students enjoy learning and are motivated to succeed in mathematics when they have a range of teaching resources. Therefore, using technology effectively is determined by the teachers’ attitudes, principles, and views towards technology’s benefits (Awofala, 2017; Kola & Sunday, 2015). The students also view technology as a tool with perks, availability, justifiable options, and PK impact on engaging the learners (Kola & Sunday, 2015; Mussa & Saxena, 2018).

The financial implications of technology infrastructure, training, and planning have had limitations across schools in Nigeria (Amanchukwu et al., 2015; Msila, 2015). Financial constraints have a significant impact on the acceptance of technology in educational environments. The need to ensure technology can be powered during the school day is a financial challenge, even though the technology has been proven to motivate learners. The need for accessibility of the technology and the opportunity to use it as required is an area that needs planning aligned with its financial implications over a long-term period. Additionally, planning for technology implementation in schools across the country requires ensuring the curriculum, equipment, and teachers can effectively teach using a range of instructional materials aligned with the national curriculum. These resources need funding, which is not readily available for many schools in Nigeria.

Literature Review Related to Key Variables

Various tools measure the motivation, attitude, and achievement of teachers and learners in the mathematics classroom. This section reviews three tools used to measure motivation, attitude, and TPACK. The relationship between attitude and motivation is expected to impact student achievement (Banerjee, 2016; Tella, 2017). The advantage of having carefully planned strategies, pedagogy, technology, and content is stimulating an engaging and inspiring learning experience crucial to student achievement.

Technology Knowledge Base Questionnaire

Teachers provide learners with the skills relevant to the 21st century through multiple pedagogical approaches. The TKB questionnaire allows for flexibility when all variables are considered. Pedagogy, psychometric qualities, and TKB are essential when developing the instrument of a questionnaire for teachers. The PK considers the assessment criteria and the strategies teachers use to organize learning with effective classroom management, promoting self-assessment and reflection. CK measures the teachers’ ability to ensure all learners can access the curriculum content, and TK reviews the use of a range of technology and activities (Herring et al., 2016; Rosenberg & Koehler, 2015).

Teachers are expected to ensure their skills and CK safeguard the interest of developing lifelong learning (Voogt & McKenney, 2017; Rosenberg & Koehler, 2015). Motivation, attitudes, and achievement are dependent on the skills teachers have that should enhance mutual respect and confidence in the classroom.

Attitudes Toward Mathematics Inventory

The role and impact of technology have become fundamental to improving learners' attitudes in the information age. Society has become dependent on technology, reflected in learners' preparation for the future, societal development, and economic growth (Tapia & Marsh, 2000a; Tapia & Marsh, 2000b). There is a variance in student attitude to mathematics, which is crucial when using ATMI to measure progress. It has been recognized that a positive attitude influences student performance. Students are more likely to achieve good results and take mathematics-related courses when motivated (Tapia & Marsh, 2004). Some learners have anxiety when learning mathematics; therefore, aligning the impact teachers' use of technology has on motivation, attitude, and achievement is exciting.

Case study research has examined the effects of students' attitudes regarding mathematics over the last decade (Banks, 2015). There is a recognition that mathematics may negatively impact learners, except for those who have confidence in the subject and find it interesting and engaging (Federici, Skaalvik, & Tangen, 2015; Muis, Psaradellis, Lajoie, Di Leo, & Chevrier 2015). Anxiety and lack of confidence cause students to avoid mathematics classes and be unwilling to participate in the learning, irrespective of the technology available (Banks, 2015; Tapia & Marsh, 2000a). Additionally, parents' and peers' influence in promoting a positive attitude toward mathematics has also been found to be important in ensuring students achieve realistic and motivating targets (Banks, 2015; Wang & Degol, 2017).

ATMI provides an understanding of how and what motivates learners to improve their mathematics attitudes when using technology as a tool to enhance their learning experiences was central to this study (Albarracin & Shavitt, 2018; Awofala, 2017). Students' poor performance and relaxed attitudes towards mathematics can be measured with exact controlled parameters. These measures may provide some knowledge on how to improve student attitude with technology as its baseline. With the challenges faced in Nigeria in improving mathematics achievement, ATMI aims to provide some knowledge of strategies that align with the TPACK framework.

Motivational Strategies for Learning Questionnaires

Motivation is crucial in the classroom as it impacts students' attitudes; therefore, using various digital tools to engage the learners' motivation becomes essential in achieving the desired outcomes (Tapia & Marsh, 2000a). The MSLQ is a widely used self-reporting instrument, focusing on measuring student motivation within sample schools. Therefore, using MSLQ for this study has highlighted the fact that poor learning strategies may be a factor that influences the failure rate across Nigeria, especially in mathematics (Hamid & Singram, 2016; Obiero, 2018). With an understanding of students' views of their beliefs and managing their learning strategies, MSLQ allows for flexibility in understanding students' motivational strategies and coping mechanisms in a mathematics classroom.

Implications of TPACK on Schools and Teachers on Motivation and Attitude

When examining the implications of TPACK on motivation and attitude, we must acknowledge the tools that promote higher-order thinking skills and learning (Banks, 2015; Henrie et al., 2015). The group and class sizes, PCK and TCK, curriculum content, teacher and learners' experiences and opportunities, instructional and learning resources, and ICT also impact achievement (Baş & Beyhab, 2017; Howard et al., 2015). Three components are essential when considering the implications for schools and learners: insufficient TK learner's knowledge, skills, and continuous professional development (Collins & Halverson 2018; Howard et al., 2015).

The changing curriculum and the wide range of different learners in a classroom influence student motivation and is essential when considering how students engage in their learning. The increased focus on problem-solving, logic and reasoning, and conceptual understanding, affects how teaching occurs and motivates the learners to engage (Baş & Beyhab, 2017; Novak, Johnson, Tenenbaum, & Shute, 2016; Obiero, 2018). Therefore, learners are less driven to engage in the learning environment, and their attitudes towards learning become a concern. Defining teachers' expectations on their relationship with the learners supports the teachers in setting clear, high, and consistent targets while engaging in quality PK (Albarracin & Shavitt, 2018; Rosenberg & Koehler, 2015).

Insufficient knowledge of technology can have an impact on students' motivation. The ability to manipulate learning, develop team and group work, promote discussions and questioning, engage thinking and reasoning, reflecting, and problem-solving can be more engaging with technology. Technology can also support teachers in assessing the instructional experience (Albarracin & Shavitt, 2018; Hunter, 2015).

Learners' knowledge and skills are paramount when reflecting on the impact of TPACK on motivating teachers and students. Positive behavior and attitudes influence persistent effort to achieve and focus, thereby producing enthusiastic students (Hunter, 2015). Tasks are not goals, but stepping stones to achieving learning objectives, and teachers need to provide independent learning opportunities, including the use of technology (Novak et al., 2016). Group work promotes discussion and interactions that stimulate learning.

Teachers' knowledge is determined by their CK, an all-encompassing outset of knowledge on using technology. Professional development has a positive impact on how teachers improve attitude and motivation through engagement. PK strategies and CK motivate learners, influencing student motivation, attitudes, and achievement (Novak et al., 2016; Sung et al., 2016). Teachers need to be confident in using technology as the primary teaching tool to provide engaging resources that focus on the subject matter and align with the instructional materials.

Understanding the benefits and limitations of TPACK and technology integration provides information on the literature available and its impact on student motivation, attitude, and mathematics achievement. The instruments (TKB, MSLQ, and ATMI) were used to impact this study's methodology.

Summary

Achieving success using the TPACK model as a measuring tool highlights the need for schools to provide adequate professional development that engages the teachers in developing skills that impact student motivation, attitude, and achievement. With effective and efficient use of technology as a teaching tool, it is anticipated that social skills promote student participation, improved attendance, and increased confidence in mathematics lessons by both teacher and learners (Novak et al., 2016; Howard et al., 2015). The pathway used to integrate technology while aligning content and pedagogy is beneficial to students in ensuring they are motivated and engaged in their learning attitude. It is expected that the findings will contribute to understanding how teachers' use of technology would impact raising student achievement because of interest, creativity, flexibility, and independent learning. Because mathematics is a universal language of accuracy, it is meticulous. The central focus of PK and CK is creativity, problem-solving, precision, thinking, and logic to influence motivation, attitudes, and achievement (Awofala, 2017; Musti-Rao et al., 2015).

The next chapter develops an understanding of the methodology by clearly elaborating on the strategy used to carry out this comparative study. A brief recap of the literature review, detailed research design, and rationale is explained and justified. The methodology includes the population, sampling and sampling procedures, recruitment procedures, participation, data collection, details for using archival data, and details on the instrumentation and operationalization of constructs. Additionally, this clarifies the data collection process and the nature of the data sample that indicated any threats to validity and ethical procedures by providing precision on human subjects' protection.

Chapter 3: Research Method

The purpose of this ex post facto, causal-comparative study was to compare the difference in student motivation, attitude, and achievement scores in classrooms taught by teachers with a low level of technology use compared to classrooms taught by teachers with high technology use. Common features influencing students' mathematics achievement include student self-confidence and teacher self-confidence in the mathematics classroom (Ker, 2016). Multiple strategies were used to collect and evaluate the archival data. The questionnaires initially used to collect the data were TKB completed by teachers; MSLQ and ATMI, completed by all students; and the WASSCE results of the final year students in three private schools in Nigeria. These measurement instruments focused on the critical variables of motivation, attitude, and achievement.

This chapter provides a description of the research design and rationale for using the identified instruments. The Methodology section includes accessing archival data, the method, description of the population, sampling procedures, and the questionnaires' details. The chapter also contains a brief overview of the data collection and analysis necessary to complete the study and make recommendations from the conclusion. It also provides a brief outline of the statistical measures, procedures, participation, data analysis strategy, knowledge of the threat of validity, ethical procedures, and a summary

Research Design and Rationale

The design choice of comparative quantitative aligned with the research questions and supported the understanding of how technology in mathematics classrooms across Nigeria can enhance students' learning through improving motivation, attitudes, and achievement. The comparative design was the most appropriate design choice, as the study was dependent on archival data from the 2018-2019 school year. Using a comparative design allowed an examination of the differences between motivation, attitudes, and achievement from two groups of students. The students' motivation, attitudes, and achievement (dependent variables) were compared between two groups of teachers, ones with low technology use and the other with high technology use. Student groupings were identified by the independent variable of teacher technology use groups (low and high) determined by the TKB. The analysis compared the extent of the differences between the independent variable groupings (teachers' technology use) and each dependent variable (scores from the MSLQ and ATMI surveys and the WASSCE achievement scores). Motivation and attitude data addressed the first and second research questions. Achievement data were based on a smaller subgroup of seniors who completed the WASSCE, which addressed the third research question. The comparative design was the most appropriate design choice as the study was dependent on archival data from the 2018-2019 school year. The rationale was to compare the student differences on the dependent variables-based groupings based on their teacher's low-level or high-level technology use.

Methodology

With the three different research methods—quantitative, qualitative, and mixed methods—identifying the best approach enables the researcher to align the methodology to the research questions. This study was designed around the quantitative method using numerical data for analysis and justification of findings. This methodology's strength was to provide quantifiable data through standardized questionnaires, which included questions with numerical scores (Creswell, 2009). As a non-participant researcher, I collected the schools' archival data after all approvals had been granted for usage (Deng, Chai, So, Qian, & Chen, 2017).

Population

Three private schools provided archival data as secondary data (Table 2). These schools were located in Ogun State (southwest) and Niger State (north central). One school had both primary and secondary students, and the other two schools had only secondary students. There were 598 primary students and 73 primary teachers in School A who were excluded from this study. Additionally, 28 teachers were excluded from the study in secondary schools as they taught other subjects that excluded mathematics and ICT. Of the 139 teachers, 115 taught in the secondary schools, but some taught in other subjects in School A (i.e., art, English, and sports coaches) who were not included.

Table 2

School Population Data

		Students			Teachers	
	Location	Total Students	Secondary	Seniors (WASSCE)	Total Teachers	Mathematics and ICT Team
School A	Niger State	827	229	44	49	18
School B	Niger State	442	442	73	40	14
School C	Ogun State	172	172	22	26	6
Total		1,441	843	139	115	38

As a non-participant researcher, the choice of collecting archival data from identified private schools was based on ease of access, processes, and procedures available from secondary schools in different states and settings. The school system is comprised of state government-owned schools, 104 federal government schools, and privately-owned schools. In Nigeria, 19.3% of children are privately educated as at 2016 (UNESCO, 2019). Access to school data was subject to the stakeholder's approval, which varies across the country. Collecting data from private schools provided a more accessible opportunity to narrow down potential participatory schools. The schools that provided data for this study are all members of the Association of Private Educators of Nigeria.

The three schools are in two geopolitical zones: two schools in north-central and one school in southwest Nigeria. Each of the private schools enrolled students from different economic backgrounds. Private schools attain better results in WASSCE across the country; however, the number of students is significantly lower than the public and federal government schools nationally. Because this study focused on teacher technology use in mathematics classes, private schools were better equipped with varying technology, and teachers were more confident in teaching using various TPACK tools. The schools providing the sample data had access to a range of technology at different levels.

School A is in a small town in northern Nigeria. The school was founded in 1995 and offered both the Nigerian and English curriculum with a wide variety of extra-curricular activities. It is a private day and boarding school with 827 students and 49 teachers. There were 18 mathematics and ICT teachers with 44 students in the graduating class. All teachers are certified to teach and hold a degree or a post graduate diploma in education. All students pay tuition to attend. It is a mixed-gender school. Children in this school are either Christian or Muslim, and the school provides opportunities for them to practice their religion in a safe space.

School B is in north central Nigeria. This school is one of four schools founded by an Islamic education trust fund across Nigeria. It offers both the Nigerian and English curriculum with a wide variety of extra-curricular activities. It is a private day and boarding school with 442 students and 40 teachers at the time of the study. There were 14 mathematics and ICT teachers with 73 students in the graduating class. All teachers are certified to teach and hold a degree or a post graduate diploma in education. All students pay for school tuition. It is also a mixed-gender school. Children in this school are all from Islamic backgrounds.

School C is located in south west Nigeria. The school, founded in 2013, offers both the Nigerian and English curriculum with a wide variety of extra-curricular activities. It is a private boarding school with 172 students and 26 teachers. There are only six mathematics and ICT teachers and 22 students in the graduating class. All teachers are certified to teach and hold a degree or a post graduate diploma in education. All students pay for school tuition.

The three schools' total population for the study included 38 mathematics /ICT teachers and 843 students. The participating schools all completed the WASSCE as their final formal education assessment. Annually, the WASSCE is only given to the graduating or leaving seniors, which decreased the achievement population to nine mathematics/ICT teachers and their 72 senior students. From this population, two sample groups compared the extent of the difference in student motivation, attitudes, and achievement scores in classrooms taught by teachers with a low technology use compared to students taught by teachers with high-technology use.

Sampling and Sampling Procedures

The teacher and student samples were drawn from secondary classrooms in three private schools in Nigeria. The study used a sample retrieved from archival data that met the criteria for research questions one and two. However, only graduating/leaving students from all the schools were included in the achievement data set, which decreased the total number of teachers and students in this study's achievement component. With the input parameters, the output parameters supported an appropriate, quantifiable number for each research question, 198 students for motivation and attitude, whereas achievement was balanced into two groups of 37 and 35 students totaling 72 (Table 3).

Table 3

Teacher and Student Samples

	Secondary School Population	Mathematics and ICT Classes	Low Technology Use Lower 25th Percentile on TKB	High Technology Use Upper 25th Percentile on TKB
Motivation and Attitude Analysis				
Teachers	128	38	9	10
Students	843	843	198	200
Achievement Analysis				
Teachers	18	9	3	3
Students	139	139	35	37

The TKB provided the data on teachers' technology use, allowing them to be rank ordered based on their levels of response. The WASSCE achievement groups were smaller in all three samples because it represented only the leaving students. The lower 25th percentile of teachers formed the group with low technology use, whereas the upper 25th percentile of teachers formed the high technology use group. For the motivation and attitude analysis, the 38 mathematics/ICT teachers were divided into percentile groupings, with the upper 25th percentile group having 10 teachers and the lower 25th percentile group having nine teachers. Because the achievement analysis only used senior student data, three teachers were in the upper 25th percentile and three teachers in the lower 25th percentile.

After the teacher groups were formed from the upper and lower 25th percentiles, the student population of 843 was matched to their teachers in their respective groupings. The student sample to measure motivation (MSLQ) and attitude (ATMI) was 198 from the low technology use teacher group and 200 students from the high technology use teacher group. For the achievement data (WASSCE), the senior/leaving student population of 72 was grouped into their respective teacher groups for technology-use based on the teacher percentile ranking. The student sample to measure achievement was 35 students for the low technology use teacher group and 37 students for the high technology use group.

Procedures for Recruitment, Participation, and Data Collection

The archival data were provided by three private schools in Nigeria that were willing to participate in this study. The schools were approached by engaging with two school associations: the Association of Private Educators of Nigeria and the Association of International School Educators in Nigeria. Information on the nature of the research and the benefits to decision-making and leadership initiatives were sent to several schools that were members of the Association of Private Educators in Nigeria. Seven schools that used the questionnaires were identified, and contact was made with the school leaders to discuss their interest in participating in this study. A shortlist was then compiled, and only five schools had the data required for this study. A meeting was held with each school, and one school was determined not to be suitable because they did not offer the WASSCEs. Three schools met the requirements and agreed to participate. The schools were aware of the potential impact of the study on the Nigerian education structures and policies and how they align with their secondary data for planning.

Once each school agreed to participate, they signed a data agreement letter giving consent to gain access to the data for use in the study. The data were sent via e-mail in an Excel format from one of the schools, and the other two schools sent download access to the results for the 2018-2019 completed questionnaires. Access to the download file was provided for seven days. Additionally, appropriate consideration was made regarding the schools' requests for access to the final research report. Because the data collected by the schools were used to inform teaching, learning, and professional development, they were given assurance that the data would only be shared with me. Additionally, the findings would not identify the schools when published.

This study's data collection process was through access to archival data provided by the three private schools. The information was collected from the various schools in two states to ensure that sufficient data were available. Additionally, only schools that completed the MSLQ, ATMI, and TKB in mathematics were selected. Schools with similar socioeconomic students were also selected. The students were predominately in day and boarding environments except one school with only a boarding school option. Each of the three private schools used the WASSCE for achievement testing and completed the International General School Certificate, MSLQ for motivation scores, ATMI for attitude scores, and the TKB for teacher technology use. The schools had collected the data for internal purposes. Students completed the published questionnaires: MSLQ, ATMI, and TKB. The archival data included the MSLQ and ATMI survey results from all students, the WASSCE achievement scores from the graduating students only, and the TKB survey results from only the mathematics and ICT teachers. The TKB survey aimed to provide the means for identifying low and high technology use teachers as supported by the TPACK framework. All data is being kept securely for a minimum of 5 years, after which time it will be securely destroyed.

Instrumentation and Operationalization of Constructs

Quantifiable data were provided through standardized questionnaires and questions (Table 4), which had numerical scores using Likert Scales (Creswell, 2009). This study focused on the difference of motivation, attitudes, and achievement (dependent variables) in mathematics between students taught by teachers with low technology use and students taught by teachers with high technology use in three private schools in Nigeria. The independent variable was teachers' technology use with a low technology use group and a high technology use group. The published instruments were

MSLQ (Pintrich, Smith, Garcia, & McKeachie, 1991) and ATMI (Tapia & Marsh, 2004). The TKB instrument was an edited version of TPACK with all non-mathematics related questions removed. Students in the three private schools in Nigeria completed these questionnaires during the 2018–2019 school year.

Table 4

Constructs and Instrumentation

Construct	Instrumentation	Source	Purpose of Assessment	Sample
Teacher technology use	Technology Knowledge Base (TKB)	Koehler and Misha, 2008	A questionnaire on teachers' use of technology in mathematics classes. It focused on the technological, pedagogical, and content knowledge and how teachers use if the knowledge bases impact students.	Only the 19 teachers in two groups
Motivation	Motivational Strategies for Learning Questionnaire (MSLQ)	Pintrich et al., 1999	A questionnaire for students on their experiences while using technology in mathematics classes. The focus is on learning how students are motivated from the learner's perspective.	398 students in two groups
Attitude	Attitude Towards Mathematics Inventory (ATMI)	Tapia & Marsh, 2004	A questionnaire for students focusing on confidence, anxiety, value, enjoyment, motivation, and parent/teacher expectations in mathematics.	398 students in two groups
Achievement	West African Senior Secondary Certificate in Education (WASSCE)	WAEC	WASSCE is a standardized exam administered by the WAEC in five countries. Only final year students, predominantly 17-year olds, qualify to be entered for this exam as school leavers.	Only 72 senior students in two groups

Note. WAEC = West African Examination Council

Technology and Knowledge-Based Questionnaire

The TKB questionnaire scores were used to identify technology use levels for teachers. The students taught by teachers with a low technology use were compared with students taught by teachers in the high technology use groups. The TKB questionnaire had a 5-point Likert scale in two sections and six subsections. The survey had 54 questions focusing on TK, CK, and PK, in section A. In section B, TCK, PCK, TPK, and TPCK, there were only 27 mathematics -related questions incorporated in the participating schools' final version. These formed the basis for the teacher questionnaires and were administered to teachers of mathematics and ICT. TPACK was developed and published by Koehler and Misha (2008). The authors provided permission for the instrument to be used with clarity on the need to recognize it as a theoretical or conceptual framework when addressing the defined research or study questions.

Data were analyzed using a Mann-Whitney *U* test to determine the extent of any significant difference in classrooms taught by teachers with a low technology use versus students taught by teachers with high technology use. Due to violations of the statistical assumptions of *t* tests, Mann-Whitney *U* had to be used to test the differences for these data sets. The assumptions testing and resultant violations are explained in detail below. The TKB survey aimed to capture the teachers' views and perceptions of how technology integration supported teaching to raise student achievement.

The study had sub-domain scores focusing on TK, CK, PK, TCK, PCK, and an overall view on TKB. The reliability scores were essential to ensure the instrument was appropriate (Table 5). The domains (CK, PK, and TK) were the knowledge bases centered on how the teachers use and sustain technology integration to impact motivation, attitude, and influence achievement in the classroom. Technology use could influence student motivation, attitudes, and achievement, and the extent of the difference in low and high teacher's use of technology was central to the study.

Table 5

TPACK—Reliability of the Scores

TPACK domain	Internal consistency (alpha)
Technology knowledge (TK)	.86
Content knowledge (CK)	
Social studies	.82
Mathematics	.83
Science	.78
Literacy	.83
Pedagogy knowledge (PK)	.87
Pedagogical content knowledge (PCK)	.87
Technological pedagogical knowledge (TPK)	.93
Technological content knowledge (TCK)	.86
Technological pedagogical content knowledge (TPACK)	.89

Note. Reproduced by permission of the publisher, 2012 by tpack.org

Motivational Strategies for Learning Questionnaire

The dependent variables of motivation and attitude focused on how students perceive their learning experience while studying mathematics in a classroom setting. There was an assumption that the variables were inter-related or inter-linked with the three dependent variables comparing motivation, attitudes, and achievement. The archival data retrieved from the participating schools were collected through the MSLQ and the ATMI to measure student engagement and involvement. Students' motivation was a crucial factor in impacting student achievement, as it influences personal effects (Hamid & Singram, 2016). The MSLQ instrument has been used to understand the influence of motivation on student learning (Hamid & Singram, 2016; Khosim & Awang, 2020). The instrument was available for use by the public.

In aligning the dependent variables, the MSLQ had different sections. The data enables the various schools to oversee students' progress. The motivational strategies had 56 questions measuring both the learning and motivational scale. It had a 7-point Likert scale, but only 44 questions were used in this study to form the relevant five scales (Appendix C). It was a validated scale to assess motivation and learning within a classroom (Jackson, 2018; Ortega et al., 2019)

The MSLQ subgroups incorporate five motivational beliefs: self-efficacy, intrinsic value, test anxiety, cognitive strategy use, and self-regulation. MSLQ uses a 7 Point-Likert scale to measuring behavior in mathematics classrooms focused on the student's perspective of their learning experience and how it influenced motivation. The MSLQ instrument yielded an overall index score to group the students and ranked them from lowest to highest. All the categories measured the student's perspective on achievement within the two groups based on teachers' technology use. The MSLQ reflected a range of questions in the five categories. Two examples of self-efficacy survey questions were "Compared with other students in this class, I expect to do well" and "I think that what I am learning in this class is useful for me to know." At the same time, the anxiety questions included, "I am so nervous during a test that I cannot remember facts I have learned," and "I have an uneasy, upset feeling when I take a test" (MSLQ, 1995).

Attitude Towards Mathematics Inventory

Students' attitude was another dependent variable that concentrated on how students responded to mathematics teachers' learning experiences in a Nigerian classroom. The ATMI questionnaire, available in the public domain, had a 5-point Likert scale with 40 questions focused on attitude in a mathematics classroom (Appendix B).

Table 6

Attitude Towards Mathematics Inventory Scoring Range

Attitudes	Scoring Range				
	Composite score	Value score	Enjoyment score	Self-confidence score	Motivation score
Strongly negative	40-72	01-10	01-10	01-15	01-05
Negative	73-104	11-20	11-20	16-30	06-10
Neutral	105-135	21-30	21-30	31-45	11-15
Positive	136-168	31-40	31-40	46-60	16-20
Strongly positive	169-200	41-50	41-50	61-75	21-25

The scales were scored on value, enjoyment, self-confidence, motivation, and a composite experienced by learners and their attitude towards mathematics using the scoring range (Table 6). The questionnaire was completed by the students in the sample population at different periods within the 2018 – 2019 school year. The ATMI instrument is in the public domain and was initially published by Tapia and Marsh in 1996 (2000b, 2004). The standard deviation, variance, mean, and range were statistically calculated and measured from the five subscales groups' value, enjoyment, self-confidence, and motivation total scores per student. The scores were calculated using a sum of those agreeing or strongly agreeing. Using a five-point Likert scale range from 1 – 5, with 1 =

Strongly Disagree; 2 = Disagree; 3 = Neither Agree nor Disagree; 4 = Agree, 5 = Strongly Agree.

West African Senior Secondary Certificate Examination Results

The WASSCE results were used to measure the achievement of students from the sample schools. The WASSCEs are standardized and taken by every student in Nigeria in senior secondary and some high achievers in senior secondary school at the school's discretion. The West African Examination Council administers the WASSCE in only five West African countries. The exams are done yearly in May or June. Students are expected to achieve five credits, including mathematics and English, to qualify for higher education. There are over 20 subjects offered by the exam board in Nigeria with clearly defined options pathways. The core subjects are English Language, Mathematics, one science subject (Physics, Chemistry, Biology), one Art subject (History, Geography or Literature -in-English), and a vocational subject. All students are expected to do a minimum of eight subjects and a maximum of nine subjects. The table below provides a breakdown of the grade boundaries used to measure achievement in Nigeria (Table 7).

Table 7

West African Senior Secondary Certificate Examination Grading System

A1	Excellent	75 - 100%
B2	Very Good	70 – 74%
B3	Good	65 – 69%
C4	Credit	60 – 64%
C5	Credit	55 – 59%
C6	Credit	50 – 54%
P	Pass	45 – 49%
P	Pass	40 – 44%
F	Fail	0 - 39

Note. (Bosson-Amedenu, 2018)

Reliability Summary

The reliability of using the TKB instrument was important to this study. The reliability of the published TPACK for TK was 0.86, and for CK with a focus on Mathematics, it was 0.83 (Table 4). Additionally, the other instrument reliability scores were above 0.8 except in science, which was 0.78 but had no bearing on this study from the TPACK published consistency figures. The ATMI reliability coefficient for the entire instrument was .96. However, by dropping the weakest items, the reliability increased to 0.97 (Tapia & Marsh, 2004). The revised instrument scores continued to expand its reliability using the Likert scoring system showing a 0.95 coefficient (Tapia & Marsh, 2000b). The MSLQ reliability used the Cronbach's alpha coefficients were 0.88 for self-regulation, 0.81 for motivational beliefs, and self-regulation, indicating a sufficient level of reliability (Ilker, 2014).

Data Analysis Plan

The data analysis plan was a statistical form for presenting all the crucial components of a study aligned with the study design (Simpson, 2015). I had to access and review the archival data necessary for interpretation and presentation. Inferential statistics were used to make comparisons and draw conclusions. The data analysis provided the foundation to draw conclusions. The questionnaires that provided the archival data for this study were the MSLQ measuring student motivation, ATMI measuring student attitude, and WASSCE results to measure achievement. I used the Statistical Package for the Social Sciences (SPSS) to analyze the data. The research questions and the hypothesis tested were as follows:

1. What is the extent of the difference in student motivation scores as measured by the MSLQ for students taught by teachers with low technology use as compared to students taught by teachers with high technology use in mathematics classrooms?

    $H_0$1: There is no significant difference in student motivation as measured by MSLQ for students taught by teachers with low technology use as compared to students taught by teachers with high technology use in mathematics classrooms.

    H_a1: There is a significant difference in student motivation as measured by MSLQ for students taught by teachers with low technology use as compared to students being teachers with high technology use in mathematics classrooms.

2. What is the extent of the difference in student attitude scores as measured by the ATMI for students taught by teachers with low technology use as compared to students taught by teachers with high technology use in mathematics classrooms?

$H_0 2$: There is no significant difference in student attitude towards mathematics as measured by ATMI for students taught by teachers with low technology use as compared to students taught by teachers with high technology use in mathematics classrooms.

$H_a 2$: There is a significant difference in student attitude towards mathematics as measured by ATMI for students taught by teachers with low technology use as compared to students taught by teachers with high technology use in mathematics classrooms.

3. What is the extent of the difference in student achievement scores in mathematics as measured by the WASSCE for students taught by teachers with low technology use as compared to students taught by teachers with high technology use in mathematics classrooms?

$H_0 3$: There is no significant difference in student mathematics achievement in mathematics as measured by WASSCE between teachers with low technology use as compared to teachers with high technology use.

$H_a 3$: There is a significant difference in student achievement in mathematics as measured by WASSCE between teachers with low technology use as compared to teachers with high technology use.

This study provided quantitative data enabling the researcher to draw conclusions and report on the findings. The Mann-Whitney *U* was used to ascertain differences between the motivation, attitude, and achievement scores. The Mann-Whitney *U* was used as a hypothesis testing tool.

Threats to Validity

Validity is the degree to which the results can measure what is supposed to be measured (Nardi, 2018). The need to ensure clarity on validity, reliability, and generalization in a quantitative study was pivotal to this study. Validity signifies all the benefits drawn from the conclusions resulting from the findings from the data analyzed. The emphasis is on how well the results align with other theories and considerations for additional measures of the same assumptions. The MSLQ and ATMI instruments have been suggested to be valid and reliable, as evidenced in various studies (Banks, 2015; Hamid & Singram, 2016; Muis et al., 2015; Tapia & Marsh, 2004; Wang & Degol, 2017). Using a valid measurement is deemed reliable if accurate results can be produced (Nardi, 2018).

Validity in quantitative studies focuses on whether a relationship can be accurately observed as it aligns with the research questions. The construct validity aimed to validate the scores achieved in this study to predict a theoretical attribute and generalized the outcomes when in a different setting (Creswell, 2009; Nardi, 2018). The main dynamics for consideration concentrated on the group threat, social relationship threats, and the threats to any limitations of the study (Ejsing-Duun, Hautopp, & Hanghøj, 2016).

The decision to undertake quantitative research was to ensure the archival data were reliable, thereby guaranteeing minimal interference from any external factors (Deng et al., 2017). The questions' preciseness presented a few challenges in measuring the participants' low and high technology skill levels. While consideration of validity was essential, the reliability was dependent on each survey. Reliability outlines the consistency derived from the findings. Understanding the implications of validity and reliability are crucial components of quantitative studies.

Ethical Procedures

To ensure the study's validity, I observed ethical standards of expectation for conducting research, including neutrality, caution, discretion, and respect for intellectual property (Nardi, 2018). A completed IRB application requesting permission to undertake the study and the approval for retrieving the secondary data were made before the data collection process began. The data retrieved did not identify any of the participants. The schools collected the data from all mathematics and ICT teachers and their students who completed the questionnaires. The reliability of participants' feedback enhanced the collection process as all parties were aware that the data used was relevant to their schools and the entire study. The schools granted their consent to use the data as it was archival data, and it was accessible on completion of an approved Data Agreement Form received from each school.

Three schools participated in this study and provided the permissions and access to the necessary data. It was fundamental to ensure that all participants (schools and researchers) benefit from the study, and there was respect for each party who provided the archival data (Creswell, 2009). The benefits of engagement by the schools were to support them with the findings that enhance their assessment of challenges and successes to support a review of their strategic school improvement plan. The data will be kept for 5 years after the publication of this study.

Summary

This chapter provided details on the data accessibility, analysis plan, and interpretation strategies, including a description of how to use the instruments to measure technology's impact on student motivation, attitude, and mathematics achievement. Using archival data enhanced the opportunities to generate new insights, and this might support the participating schools in streamlining their needs when comparing the findings from this study. The research design aligned with the goals and expectations based on the research questions. The next chapter focuses on the findings from the statistical analysis of the data. It shares the analysis of the data using SPSS. The MSLQ, ATMI, WASSCE, and TKB results statistically compared student motivation, attitudes, and achievement scores of students in classrooms taught by teachers with a low technology use versus students taught by teachers with high technology use. I will present and explain the findings and the hypothesis, which will either be accepted or rejected. I will provide a conclusion and recommendations from the results derived in the final chapter.

Chapter 4: Results

The purpose of this study is to compare the difference in student motivation, attitude, and achievement scores in mathematics classrooms with a low level of technology use compared to high technology use. The three key research questions focused on the difference between students taught by teachers with either low or high technology use on student motivation scores as measured by the MSLQ, attitude as measured by the ATMI, and achievement as measured by the WASSCE scores in mathematics classes. This chapter provides a comprehensive description of the findings. It includes how and when the data were collected and the process for grouping based on archival data as well as the sample's characteristics, a detailed statistical analysis answering each research question, and a summary of the results.

Data Collection

The archival data from the 2018-2019 school year was retrieved from the participating Nigerian schools. The completion rate was 100% in all the schools because they were all boarding schools and had the archival data required for both teachers and students. On receipt of Walden University's IRB approval (03-31-20-0339586), all data were retrieved from the three schools via e-mail. All data were saved in an Excel spreadsheet, any personal identifiers were removed, and then the teacher data were ranked.

Percentiles were used to create the groupings of low and high technology use teachers. Teachers' scores on the TKB were ranked from low to high. The rankings enabled identifying the upper 25th percentile and lower 25th percentile from the group data of the teachers. The low technology use and high technology use teacher groups were created by ranking the data. The teachers in the upper 25th and lower 25th percentile were approximately equal. The low technology use teacher group based on the TKB scores had 198 students forming the lower 25th percentile and below. Simultaneously, the high technology use teacher group, also based on the TKB scores, had 200 students formed the upper 25th percentile.

The total student population from three schools was n = 843 students who completed the motivation and attitude questionnaires. The student sample of n = 398 was comprised of only students enrolled in the teacher sample groups for low and high technology use in the mathematics classes. For the data sets on motivation and attitude, there was n = 198 in the low technology use group and n = 200 in the high technology use group.

For the achievement variable relevant to research question three, the population of School C final year students only who completed the WASSCE was n = 139, which was divided among nine teachers. There were six teachers' students sampled: three in the low technology group and three in the high technology group. These senior students' teachers were not re-ranked and retained their original ranking assigned based on their low and high technology use group scores as measured by TKB and used to examine motivation and attitude. Three of the seniors' teachers were found to be in the lower 25th percentile, and three were found to be in the upper 25th percentile. The remaining three teachers' results placed them between the lower 25th and upper 25th percentiles, which meant that they were not included in the study. Therefore, their students' scores were disregarded.

The students of these six teachers created a total student sample of $n = 72$ for the two groups. There was $n = 35$ in the low technology use group and $n = 37$ in the high technology use group.

From the post hoc power analysis, the sample size used was $n = 198$ and $n = 200$, totaling 396 students required for comparing the means between the two groups for the motivation and attitude data for independent groups at the medium effect size (d = .5), alpha of .05, and power of 0.99. Because the achievement data had a smaller sample size of $n = 35$ and $n = 37$ totaling 72 students, the larger effect size (d = .8) was used for an independent group with an alpha of .05 and power of .92. It is necessary to note that the difference in sample size is because only those students who were graduating or leaving took the WASSCE. In contrast, all students took the attitude and motivation surveys, resulting in a smaller sample for the achievement measure.

All the data provided was de-identified with each student's MSLQ and ATMI scores. The surveys focused on attitudes, motivation, and technology use, while the achievement data was based on WASSCE scores in mathematics. The 843 students completed the attitude and motivation questionnaire, the 38 mathematics /ICT teachers completed the TKB questionnaire, and WASSCE was based on student achievement grades for the 139 graduating or leaving seniors. There were no missing data in any of the groups. For this study, the questionnaire instruments collected the archival data in a small sample of three private schools to measure students' progress in mathematics, focusing on the effect of technology use on achievement in mathematics classrooms.

Results

Research Question 1

What is the extent of the difference in student motivation scores as measured by the MSLQ for students being taught by teachers with low technology use compared to students being taught by teachers with high technology use in mathematics classrooms?

The Shapiro-Wilk normality test was used to test the assumption of normality. The sample was first analyzed using the Shapiro-Wilk test, and the results indicated that they were not normally distributed ($p < .05$). The test indicated, with 95% confidence, that the groups were not normally distributed. Therefore, the data did not fit a normal distribution. Due to non-normal distribution, a *t* test should not be used to analyze the difference in means.

Levene's Test for Equality of Variances was then used to determine the difference between the two groups' variances. The test indicated that as there was a difference of less than .1. The test was statistically significant ($p = .00$); therefore, the null hypothesis that the variance between the two groups would be equal was rejected. There was a difference in the variances between the low- and high- technology use groups as measured by the MSLQ.

As a result of non-normality and non-equivalence of variance, the non-parametric Mann-Whitney U test was used instead of a *t* test to compare differences in motivation between two independent groups students taught by teachers with low technology scores compared to students taught by teachers with high technology use (Table 8).

Table 8

Mann-Whitney U Test – Motivation Rank Results

		n	Mean Rank	Sum of Ranks
MSLQ Group	Low Tech	198	99.50	19701.00
	High Tech	200	298.50	59700.00
	Total	398		

There were N = 398 students used to measure the mean differences between the two groups (n = 198 students in the low technology group and n = 200 students in the high technology group). The mean rank for both groups was significantly different. From the data, students taught by teachers with high technology use group were statistically significantly higher than students taught by teachers with low technology use (*Mdn* = 398), U = .00, $N1$ = 99.50, $N2$ – 298.50, p = .00. Given that U = 0 is highly unusual, the value was confirmed by a visual inspection of the data set. The inspection looked for missing data, data in the different teacher categories, and the grouping for low technology use and high technology use from the rankings. Therefore, I reject the null hypothesis that there was no difference in motivation between students of low technology use teachers and high technology use teachers. The groups were different based on the mean ranks. The students' motivation scores in the low technology use teacher group were significantly lower than that of the students in the high technology use teacher group.

Research Question 2

What is the extent of the difference in student attitudes scores as measured by the ATMI for students being taught by teachers with low technology use compared to students being taught by teachers with high technology use in mathematics classrooms?

The Shapiro-Wilk normality test was used to test the assumptions of a normal distribution. The normality was explored using the Shapiro-Wilk test on ATMI scores, and the results indicate that they were not normally distributed ($p < .05$). The results indicated with 95% confidence that the groups were not normally distributed. Therefore, the data on ATMI also did not fit a normal distribution, and a *t* test would not be appropriate for analysis.

Levene's Test for Equality of Variances was then used to determine if there was a significant difference between the two group variances. The test indicated that as there was a difference of less than .1. The test was statistically significant ($p = .00$); therefore, the null hypothesis of the two groups having equal variance was rejected. There was a difference in the variances between the low- and high- technology use groups as measured by ATMI for students being taught by teachers with low technology use as compared to students being taught by teachers with high technology use.

As a result of non-normality and non-equivalence of variance, the non-parametric Mann-Whitney *U* test was used instead of a *t* test to compare differences in attitude between two independent groups of students taught by teachers with low technology scores as compared to students taught by teachers with high technology use (Table 9).

Table 9

Mann-Whitney U Test – Attitude Ranks Results

		n	Mean Rank	Sum of Ranks
ATMI Group	Low Tech	198	101.10	20018.50
	High Tech	200	296.91	59382.50
	Total	398		

There were *N* = 398 students used to measure the mean differences amongst the two groups (*n* = 198, students in the low technology group) and (*n* = 200, students in the high technology group). The mean rank for both groups was significantly different. From the data, it can be concluded that student taught by teachers with high technology use group were statistically significantly higher than students taught by teachers with low technology use (*Mdn* = 398), *U* = 317.50, *N1* = 101.10, *N2* = 296.91, *p* = .00. Therefore, I reject the null hypothesis that there was no difference in motivation between students of low technology use teachers and high technology use teachers. The groups were different based on the mean ranks for students' attitudes towards mathematics. The students' attitudes toward mathematics scores in the low teacher technology use group were significantly lower than that of the students in the high teacher technology use group.

Research Question 3

What is the extent of the difference in student achievement scores in mathematics as measured by the West African Secondary School Certificate of Examination (WASSCE) for students being taught by teachers with low technology use as compared to students being taught by teachers with high technology use in mathematics classrooms?

The Shapiro-Wilk normality test was used to test the assumptions of a normal distribution. The normality was explored using the Shapiro-Wilk test on WASSCE scores, and the results indicate that they were not normally distributed ($p = .00$). The results indicated with 95% confidence that the groups were not normally distributed. Therefore, the data on WASSCE also did not fit a normal distribution, and a *t* test would not be appropriate for analysis.

The Levene's Test for Equal Variance was then used to determine any significant difference in variance between the low technology use and high technology use groups. Levene's test results indicated that $t = .56$, which is different greater than .1; therefore, an equal variance was not assumed, and I failed to reject the null hypothesis as there was a significant mean difference. The mean variance of students' scores taught by teachers with high technology was significantly different from the mean score for students taught by teachers with low technology scores. The data did not fit a normal distribution, and a *t* test would not be used for analysis. From the results, I could not assume equality of variance, nor could I assume a normal distribution; therefore, I chose to use a non-parametric Mann-Whitney *U* test as a more appropriate way to analyze my data.

As a result of non-normality and non-equivalence of variance, the non-parametric Mann-Whitney *U* test was used instead of a *t* test to compare differences in achievement between two independent groups of students taught by teachers with low technology scores as compared to students taught by teachers with high technology use (Table 10).

Table 10

Mann-Whitney U Test – Ranks

		n	Mean Rank	Sum of Ranks
Achievement Groups	Low Tech	35	24.81	868.50
	High Tech	37	47.55	1759.50
	Total	72		

There were *N* = 72 students used to measure the mean differences between the two groups (*n* = 35, students in the low technology group) and (*n* = 37, students in the high technology group). The mean rank for both groups was significantly different. From the data, it can be concluded that students taught by teachers with high technology use group were statistically significantly higher than students taught by teachers with low technology use (*Mdn* = 72), *U* = 238.50, *N1* = 24.81, *N2* = 47.55, *p* = .00. Therefore, I reject the null hypothesis. The students' achievement in the low teacher technology use group was significantly lower than that of the students in the high teacher technology use group.

Summary

In all three research questions, the Shapiro-Wilk tests rejected all three hypotheses of normality. Similarly, Levene's tests showed a non-equivalence of variance between all three samples, and the null hypothesis was likewise rejected. Since a *t* test was considered inappropriate for the sample, the non-parametric Mann-Whitney *U* test was then used to analyze the findings. The Mann-Whitney *U* test revealed a significant difference between the two groups of students taught by teachers with low technology use and students taught by teachers with high technology use in all three areas (motivation, attitudes, and achievement) analyzed. The students in the low technology use teacher groups performed significantly lower on the scales for motivation, attitude, and achievement than the students in the high technology use teacher groups. In the next chapter, I will summarize the findings of the results and interpret them in the context of the theoretical framework, identify limitations of the study impacting future research, make recommendations from the findings as it aligns to the scope of this study, underline any implication for research, highlight the implications for positive social change in Nigeria, and provide a conclusion to the study.

Chapter 5: Discussion, Conclusions, and Recommendations

The high failure rate in mathematics across Nigeria led this study to focus on understanding the influence teachers' technology skills have on student motivation, attitude, and achievement. Teachers were grouped after percentile ranking into low technology use and high technology use groups based on their responses to the TKB questionnaire. An analysis of the data led to the rejection of the null hypothesis in all three variables tested: motivation, attitude, and achievement. There was a significant difference in the scores for each variable. The students taught by teachers in the low technology use group performed significantly lower on motivation, attitude, and achievement than the students taught by teachers in the high technology use group. Evidence from the findings showed that the significant mean difference between low and high technology use might be ascribed to the differing use of technology integration in their classrooms.

This study shed light on the challenges of motivation and attitude as they are related to mathematics achievement. These findings make a case for further study and the development of a national strategic plan to address the gap impacting teachers' technology use. This research is important because teachers' use of technology can influence students' motivation, attitude, and achievement in mathematics. This study's findings support the Nigerian national education drive to improve teaching and learning for all and promote a positive social change initiative in the future.

Interpretation of the Findings

In this study, I compared the difference in student motivation, attitude, and achievement scores in mathematics classrooms taught by teachers with a low level of technology use compared to classrooms taught by teachers with high technology use. The archival set contained data regarding 38 teachers' technology use, 398 students on motivation and attitude, and a subset of 5 teachers and 72 students for mathematics achievement data. The data analysis for all research questions showed a significant difference between low technology use and high technology use groups. Students taught by teachers with low technology use performed significantly lower on measures of motivation, attitudes, and achievement. The difference between students taught by teachers with low technology use compared with students taught by teachers with high technology use in mathematics classes was reported in the results and analysis.

Research has shown the implications of technology integration and how it empowers educators with relevant skills to promote an enriched learning environment. This study supported the relevance of technology integration in Nigeria (Badmus, 2018; Carver, 2016). Instructional resources, including technology, have been deemed to positively affect student achievement in mathematics as it allows for flexibility in acknowledging students' differences in learning styles and teacher engagement (Ameen et al., 2019; Sung et al., 2016). This study further demonstrated how teachers' technology use might influence student motivation, attitude, and achievement scores. The role of technology integration by teachers on students' motivation, attitude, and achievement in mathematics was central to this study.

The data confirmed that motivation, attitude, and achievement scores of students exposed to higher levels of instructional technology might have benefited from the integration of the technology into the curriculum, which aligns with the TPACK framework. This recognition is crucial to appreciating students' learning experiences. Technology use enhances the classroom and allows learning to take place beyond the classroom walls bringing the world into the students' learning space. A high level of technology use in the classroom also creates different opportunities for assessing and measuring progress through varied assessments (Chen, 2015; Sung et al., 2016).

Based on these findings, there is a need for further research on how technology integration influences students' motivation, attitude, and achievement when measured in other learning environments such as public schools, private schools, or federal schools (Adedokun, 2016; Ajai & Imoko, 2015). Further research could provide additional data to contribute to positive educational change impacting achievement in mathematics. Improved motivation, attitude, and achievement could foster positive social change, which is important in Nigeria by using technology to engage the out-of-school children (Sohngen, 2017).

Limitations of the Study

As with any study, there are limitations to the research and results. The scope of this study was limited in geography, school type, and sample size. Findings could differ between states and from private to public schools. Findings may also vary with a larger or smaller sample size in the low technology group and the high technology group of students in the different mathematics classrooms. Other factors that could be considered a limitation: teachers' qualifications, socioeconomic status, the learning environment, or teaching resources were not included as variables in this study.

This study only focused on technology integration in three Nigerian schools' mathematics classrooms. If motivation, attitude, and achievement are impacted by technology use as reflected in the findings, there may be a need to investigate other kinds of relevant and current technologies or examine which technologies have the most significant influence on learning. Knowing what these technologies can do in the learning environments is also an area for further review.

The timings for administering the surveys during the 2018-2019 academic year for teachers and students were unknown and might have impacted the results. If schools implemented the questionnaires at different points in the academic year, students would have had different time in the classroom. Some students could have had a full year of content, while others might have had only a half of a semester.

Teachers responses could also lead to limitations of the study. The teachers' views on using technology might have influenced their responses to the TKB questions based on their confidence to use technology in the classroom. Additionally, teachers' suspicions on the schools' data collection could affect their responses.

Recommendations

This study points out the need for further review and additional research with different questions and larger sample sizes to understand the significant differences in motivation, attitude, and achievement for students in classrooms with low technology use compared with students in classrooms with high technology use. Additional research is expected to add to the body of research focusing on technology use in mathematics classrooms in Nigeria.

From the findings aligned with the scope, there is a need to further review the assessment procedures, processes, and strategies teachers use to incorporate technology and consider comparing these with technology integration practices in Africa. Recognizing that other factors influence teachers' ability to impact student motivation, attitudes, and achievement needs to be further developed in various educational settings in Nigeria (Awofala & Lawani, 2020; Kalagbor, 2016; Obijekwu & Muomah, 2018; Oviawe, 2016).

Implications

To minimize the continued failure by students in mathematics classrooms, there is a need to improve mathematics achievement as measured by the WASSCE. Evidence has suggested that technology integration in the classroom could influence students' motivation and attitudes (Awofala, 2017; Oyedeji, 2017). Teacher technology usage highlighted the need for an overhaul and review of current practices in teacher training to positively impact social change within the education sector, trickling down all other streams of learning (Aja, 2020; Ezumah, 2020; Suleiman, Yahya, & Tukur, 2020). The findings of the United Nations Educational, Scientific and Cultural Organization (UNESCO) showed that education funding in Nigeria is below 10% of the nation's budget. The low funded budget negatively impacts societal progression for a quality education service provider and the teacher's quality in the classroom (Junaid & Maka, 2015; Ker, 2016; Solomon & Fidelis, 2018). With flexible and creative teaching pedagogies and instructional methodologies incorporated into learners' experiences, Nigerian students could finish school with numeracy skills and a strong foundation for future employment.

Education in Nigeria should be driven by evidence from research to influence positive social change in the sector. The desire to improve mathematics in schools across Nigeria is a collective responsibility of the teacher, policymakers, central and state government, administrators, schools' owners, and leaders. It is essential to implement technology strategies in Nigeria, which then positively impacts social change in the country (Obiakor & Adeniran, 2020; Ozili, 2020). When teachers understand technology integration, they are more likely to embed the technology in teaching and learning to transform the students' learning experiences. This transformation highlights the notion that blending technology and using various teaching strategies could augment conservative teaching methods to promote learners' motivation, attitude, and achievement (Obiakor & Adeniran, 2020; Ozili, 2020).

Research suggested that effective technology integration embedded in teaching pedagogy produced higher academic performance in mathematics achievement (Muhammad, 2017; Oviawe, 2016). Students in this study's high technology group could have been exposed to a broader range of well-integrated approaches and progressive differentiated knowledge acquisition through effective technology use. With positive reinforcement and active engagement, teachers need to be encouraged to differentiate the instructional strategies that are adapted to the needs of the diverse groups of learners aimed at raising achievement through the effective use of technology in mathematics classrooms (Ameen et al., 2019, Yaman, Dündar, & Ayvaz, 2017). Resilience in the mathematics classroom align with students' ability to progress academically if the environment embeds skills that enhance student motivation and attitude (Johnston-Wilder et al., 2016; Junaid & Maka, 2015; Lehtinen, Nieminen, & Viiri, 2016).

Recruiting teachers who are skilled in using technology to raise the stakes for all learners through better motivation, improved attitude, and higher achievement at WASSCE in mathematics across the nation is a good starting point. Technology integration in the classroom continues to provide students with opportunities for independent learning within the school setting. It also promotes collaboration, working in groups, discussions, and presentations. Teachers need to be change agents to ensure positive changes in the learners' lives, required in developing countries with a lack of necessary infrastructure (Awofala & Lawani, 2020; Ozili, 2020).

Finally, it is critical for Nigeria to develop a national plan to address the gaps in teachers' technology use in the classroom. The National Economic Empowerment and Development Strategy should identify strategies for progression, solutions to impact achievement and attitude, and best practices in the education sector, especially when making links with the private sector to improve collaboration by all stakeholders (Ifinedo et al., 2019; Muhammad, 2017; Oviawe, 2016). The lack of technology access and use has resulted in the Nigerian government's inability to provide all children in Nigeria equal access to educational resources, opportunities, and necessary funding (Adeniran, 2017). Policies can affect positive social change by providing literature, training, recommendations, and supporting evidence reviewing the socioeconomic status of learning for education initiatives in Nigeria. This study added to the existing data, findings, and summations to inform decision-makers in the education sector, lawmakers, and policy reviewers.

To summarize, the recommendations for practice and policy are as follows:

1) Embed the need for transparent, comprehensive, and robust discussions on technology integration into mathematics classes among all stakeholders.

2) Develop strategies to enrich the embedding of technology integration for teachers in Nigerian schools.

3) Create implementation groups locally and nationally to positively affect student motivation, attitude, and achievement through the increased use of technology in lesson planning and implementation.

4) Ensure funding of quality resources for teachers in technology skills development to make progress within the sector in Nigeria and across Africa.

5) Promote and celebrate the impact of hardworking teachers as they foster positive social change through stimulating engagement, motivation, and an optimistic attitude, noting the effect of technology use to facilitate this happening.

6) Carefully design professional development programs for teachers at all levels that embeds using technologies easily accessible irrespective of the societal challenges in Nigeria.

7) Develop a national plan to narrow the gap in teachers' use of technology in a mathematics classroom at higher levels and review technology funding in the education sector.

These recommendations could provide a platform to develop a plan that would enable stakeholders to engage in technology integration reform in Nigeria.

Conclusion

This study highlighted the positive influence on mathematics students' motivation, attitude, and achievement when technology is embedded in classroom instruction. With approximately 35,000 students in private schools in the research site states of Niger and Ogun, developing strategies to improve mathematics motivation, attitude, and achievement is pivotal to reducing poverty in Nigeria. An extensive literature review aligned with this study's findings of the positive influence teachers' higher technology use had on students' motivation, attitudes, and achievement (Awofala, & Lawani, 2020; Deng, Chai, So, Qian, & Chen, 2017; Msila, 2015; Voogt, & McKenney, 2017). Improving students' academic experiences ensures they could have a better life through literacy, numeracy, and technological skills development, thereby reducing the potential for poverty in developing countries (Oduwole, 2015; Suleiman, Abubakar, & Akanbi, 2019). In developing countries, the TPACK assessment is a relevant tool to support further research development endorsing embedded technologies at the heart of its teaching and learning initiatives. Embedded technology in the classroom could make a difference in education and in the lives of children across Nigeria and the African continent, which highlights my concerns and fuels a desire to drive social change in education. This study opened my eyes to the depth of research required to effect educational initiatives and policymaking at the local, national, and international levels when driving social change to impact the learners.

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