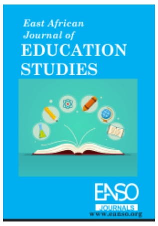

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Original Article

Integration of Information and Communication Technology in the Teaching and Learning of Mathematics in Junior High Schools in Tamale, Ghana

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Integration, Mathematics, Pedagogy, Innovation, Assessment, Knowledge, Teachers.

ABSTRACT

This research focused on assessing the integration of Information and Communication Technology (ICT) in the teaching and learning of mathematics by Junior High School (JHS) mathematics teachers in the Tamale Metropolitan Assembly of Ghana. The study assessed the proficiency of teachers' Technological, Pedagogical and Content Knowledge (TPACK) related to ICT and the extent to which ICT is employed in JHS mathematics lessons. The study utilized a questionnaire to collect the data. The participant pool comprised 44 JHS mathematics teachers who provided responses on a five-point Likert scale. Descriptive statistics was employed to analyse the data. The findings revealed that JHS mathematics teachers in the Tamale Metropolis possessed a solid understanding of pedagogy and subject matter content. However, they were deficient in the fundamental technological skills necessary for effectively integrating ICT into their instructional approaches. It was also found that majority of these teachers do not incorporate ICT into their mathematics lessons. It was therefore concluded that JHS mathematics teachers in the Tamale Metropolis do not possess the required blend of technology with content and pedagogy (TPACK) needed for successful ICT integration, and there is limited utilization of ICT among JHS mathematics teachers. The study therefore recommends that the Ghana Education Service (GES) and the Ministry of Education (MoE) should develop a comprehensive plan for enhancing teachers' professional development on ICT integration, allocate adequate resources for ICT infrastructure and materials, address barriers to effective ICT integration, and formulate strategies to promote ICT adoption among mathematics teachers at the JHS level.

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INTRODUCTION

In the ever-evolving landscape of education, the integration of Information and Communication Technology (ICT) has emerged as a powerful catalyst for enhancing teaching and learning processes (Sharma, 2022). Majority of current practices and policies reflect a ‘technocratic determinism’ in which technology is seen as a harmless ally since it gives educators and students quick-to-use tools, and its use generally necessitates the acquisition of technical skills (Varghese & Jana, 2019; Naumi, 2019).

As indicated by several legislative initiatives and reforms, the Ghanaian government's dedication to modernizing the educational system emphasizes the need for investigating ICT integration in mathematics instruction. The Ghanaian government has developed several ICT policies, one of which is the ICT in Education Policy 2015 introduced in August, 2015. The primary objective of this policy was to enhance the educational system by integrating ICT in teaching and learning and ensuring more comprehensive access to educational services in both pre-tertiary and tertiary institutions (National Pre-Tertiary Education Curriculum Framework, 2018).

The outbreak of the COVID-19 pandemic in March 2020 caused global school closures, affecting almost 1.58 billion students in 200 countries, including Ghana (World Bank Group, 2022). While some places used modern technology for distant education, many countries including Ghana failed to ensure continuous access to education due to weak ICT development. This pandemic highlighted the relevance of ICT in education and its potential for fostering resilience and learning progress.

The advent of ICT has significantly impacted mathematics education, transforming the teaching and learning approaches and how mathematical concepts are understood. According to Vermesan and Friess (2013), early efforts in ICT integration in mathematics involved using calculators, computer-based simulations, and educational software. Over time, the development of interactive multimedia, mobile devices, cloud computing, and the internet further expanded the possibilities for integrating ICT in mathematics classrooms. ICT integration in mathematics refers to the effective and seamless incorporation of ICT tools and resources into mathematics teaching and learning (Orlando & Attard, 2016).

The integration of ICT in mathematics education has brought about numerous benefits and advancements including; visualization and interactive learning, access to information and resources, remote learning, blended learning, and professional development for teachers (Joshi, 2017). ICT in mathematics education enhances student understanding of fundamental concepts and the effectiveness of the teaching process (Das, 2019). For example, the use of GeoGebra, Desmos, Spreadsheet, Cinderela, Autographs and Mathletics, contribute to mathematics learning by providing interactive and visual platforms for exploring mathematical concepts, promoting hands-on problem-solving, and fostering a deeper understanding of mathematical principles.

A dynamic geometry program's image-making feature can assist students in comprehending, resolving, and proving geometric problems. When

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students utilize ICT as a tool to aid in their research, problem-solving, or understanding of events, it generally enhances their capacity to use and apply mathematics.

The widespread establishment of ICT labs throughout various educational levels is seen as a testament to the successful incorporation of ICT into the education system, as Yidana and Asiedu (2001) noted. However, despite the potential benefits of integrating ICT into mathematics education, it has been observed that its implementation has faced challenges at the school level. For example, Kwakye and Ghartey (2019) conducted a study to investigate the impact of ICT on the academic performance of Senior High School students in Art and Design. Their findings suggest that barriers to effective ICT integration include a shortage of personal computers, insufficient computer software, limited ICT proficiency among teachers, and a lack of school internet access.

In agreement, Kennah (2016) notes that poor teachers' ICT knowledge and skills, insufficient digital infrastructure, and constrained time for learning were also mentioned as barriers to ICT integration. Mathematics education in Ghana has always depended mainly on traditional teaching techniques, with little use of technology (Agyei & Voogt, 2011). However, as the global educational scene advances, more people are becoming aware of the potential benefits that ICT integration may provide.

In the context of Junior High School (JHS) mathematics education in Tamale, incorporating ICT tools and resources holds the promise of transforming traditional pedagogical approaches into dynamic, interactive, and engaging experiences. As a vibrant urban centre in the Northern Region of Ghana, Tamale has seen significant advancements in ICT infrastructure and access in recent years (Kere, 2016). These developments have created a unique opportunity for educators to harness the potential of technology to improve the quality of mathematics education.

In this context, the assessment of ICT integration becomes crucial, as it sheds light on the current status of technology adoption among JHS mathematics teachers and provides insights into the challenges and opportunities that lie ahead. Mathematics teaching and learning are paramount in shaping students' cognitive development and problem-solving skills (Idris et al., 2023). Therefore, understanding the role of ICT in this process is essential for educators, policymakers, and researchers alike. This study delved into the practices, and competencies of JHS mathematics teachers in Tamale concerning ICT integration in mathematics instruction. Through a comprehensive examination of the knowledge and skills, and the extent of ICT usage in mathematics lessons, this research contributes a nuanced understanding of ICT integration in JHS mathematics classrooms. The findings of this study will inform strategies, interventions, and professional development initiatives that can support teachers in leveraging ICT effectively to enhance mathematics education in Tamale.

PROBLEM STATEMENT

The significance of Information and Communication Technology (ICT) in contemporary societies cannot be overemphasized. Numerous civilizations have experienced transformative shifts due to the widespread adoption of information technology (Ahiatrogah & Barfi, 2016). Globally, computer technology has reshaped the social fabric of traditional communities, as evidenced by extensive research (Buabeng-Andoh, 2012; Bariham, 2020). Moreover, this technological advancement has significantly enhanced the political and economic performance of modern economies (Bariham, 2020). Government policies, such as the ICT4AD plan and the 2015 ICT in Education policy, aim to establish a framework encouraging ICT adoption in teaching practices and as a career path for students. These regulations aim to ensure equal opportunities for lifelong learning for all Ghanaians, regardless of their location.

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Despite substantial investment in tools and infrastructure, it is imperative for educators to be well-versed and proficient in ICT use. However, as highlighted by Bariham et al. (2019), the shortage of trained ICT teachers poses a challenge to the effective utilization of available resources. Even though many mathematics teachers have an enhanced understanding of ICT, they often struggle to integrate technology effectively into their lessons (Buabeng-Andoh, 2015). Despite governmental efforts and technological advancements in Ghana, the Tamale Metropolitan Assembly faces challenges in achieving effective ICT integration by mathematics teachers. Barriers such as the scarcity of trained ICT teachers, limited training opportunities, and teachers adhering to traditional teaching methods hinder the efficient use of digital resources (Bariham et al., 2019).

The COVID-19 pandemic has underscored the crucial role of ICT in ensuring educational continuity during crises, emphasizing the urgent need for comprehensive empirical research. Mereku et al. (2009) argue that for Ghana and Africa as a whole to fully integrate ICT into teaching practices, there is a necessity for regular data collection and analysis to appropriately integrate ICT. Such research should explore teachers' knowledge and skills, their attitudes toward ICT usage, the extent of ICT integration in their lessons, and identify areas for improvement.

The primary objective of this study was to evaluate the integration of ICT by Junior High School (JHS) mathematics teachers in the teaching and learning of mathematics in the Tamale Metropolitan Assembly, Ghana. This assessment aims to evaluate teachers' knowledge and skills in ICT integration (TPACK) and the level of ICT adoption in JHS mathematics lessons. Policymakers can use the findings as a guide to address issues related to teachers' knowledge, skills, and contextual factors hindering successful ICT integration. By incorporating ICT in the classroom, students can develop 21st-century skills such as creative thinking, communication, collaboration, and digital literacy. Enhanced abilities of mathematics teachers will enable them to effectively employ ICT in classrooms, ultimately improving students' learning outcomes.

RESEARCH QUESTIONS

i Do JHS mathematics teachers possessed the required knowledge and skills (TPACK) necessary for effective ICT integration?

ii. To what extent do JHS mathematics teachers use ICT in their lesson delivery?

LITERATURE REVIEW

Theoretical Review

The Diffusion of Innovation Theory

The diffusion of innovation theory aims to explain how, why, and how quickly new concepts and technologies spread across civilizations (Rogers, 1995). According to Rogers, the diffusion of innovation theory proposes that new ideas or innovations spread over time through certain channels and within a specific social environment. According to this theory, individuals acquire innovations with varying degrees of zeal, which categorizes people into five groups depending on their willingness to adapt. They include; innovators, early adopters, early majority, late majority, and laggards.

Rogers emphasizes that a combination of human characteristics, organizational internal characteristics, and external forces influences adoption. These factors have an impact on the rate and extent of adoption. In the context of ICT integration in mathematics instruction, these elements are connected to the independent variables such as teacher and school-related variables. The researcher used this framework to collect data on all of these variables in order to better understand how they interact and how instructors influence the level of ICT integration in mathematics teaching. According to Oldenburg and Glanz (2008), the use of technology in the educational settings is best studied using the diffusion of innovations theory.

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Theory of Planned Behaviour

The Theory of Planned Behaviour was developed by Ajzen (1991) as a universal framework for predicting and explaining behaviour across a wide range of behaviour categories. The Theory of Planned Behaviour focuses on the desire to embrace novel technology, suggesting that a person's willingness to interact with an innovation is crucial to its acceptance. This hypothesis describes three main independent variables that impact the adoption of new technologies. It determines one's predisposition or aversion to the behaviour by first assessing one's attitude toward it. Second, it involves the subjective norm, which incorporates the perceived societal influence to engage in or refrain from engaging in the behaviour. The third component, perceived behaviour control, indicates the ease or difficulty of carrying out the action based on previous experiences and anticipated stumbling blocks (Ajzen & Holmes, 1976).

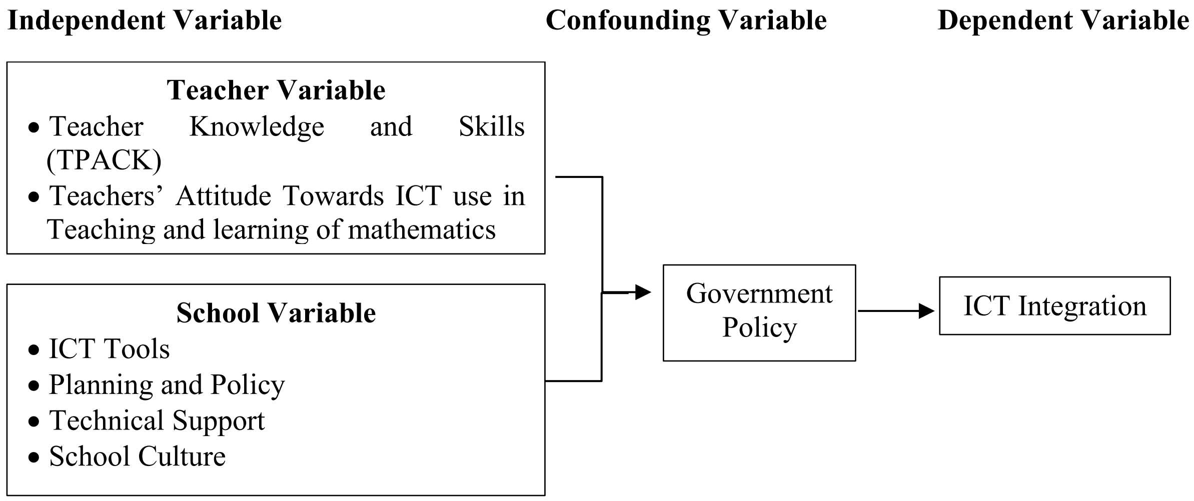
These independent variables, which pertain to both school and teachers, are intrinsically tied to the dependent variable of the study. Teachers' readiness to adopt ICT is determined by their proficiency in TPACK which serves as a pre-requisite. The availability of ICT resources put pressure on them to use these tools to improve their teaching and technical help instils confidence in teachers. Bridging the gap to the third component, perceived behaviour control. As educators see the benefits of ICT, their reservations become normative acceptance, which improves instructional quality and student learning outcomes.

Conceptual Review

In this study, the conceptual foundation was built upon variables related to the integration of ICT in mathematics education, with a particular focus on teacher and school characteristics. The teacher variables include teachers' knowledge and skills in ICT usage, their attitude towards teaching with technology, and their experiences and perceptions related to ICT integration in the teaching-learning process.

On the other side, school factors are those that the institution impacts. The school's culture or ICT policy, technical assistance in the form of available specialists, spare parts, and software needed to maintain the ICT tools' functionality and assistance provided to teachers by the school administration that affects access to ICT facilities is also included. Government policies have an impact on how quickly teachers and schools adopt new technologies, which has an impact on how much ICT is used in math instruction. The figure below illustrates the conceptual framework of the study.

Figure 1: Conceptual framework



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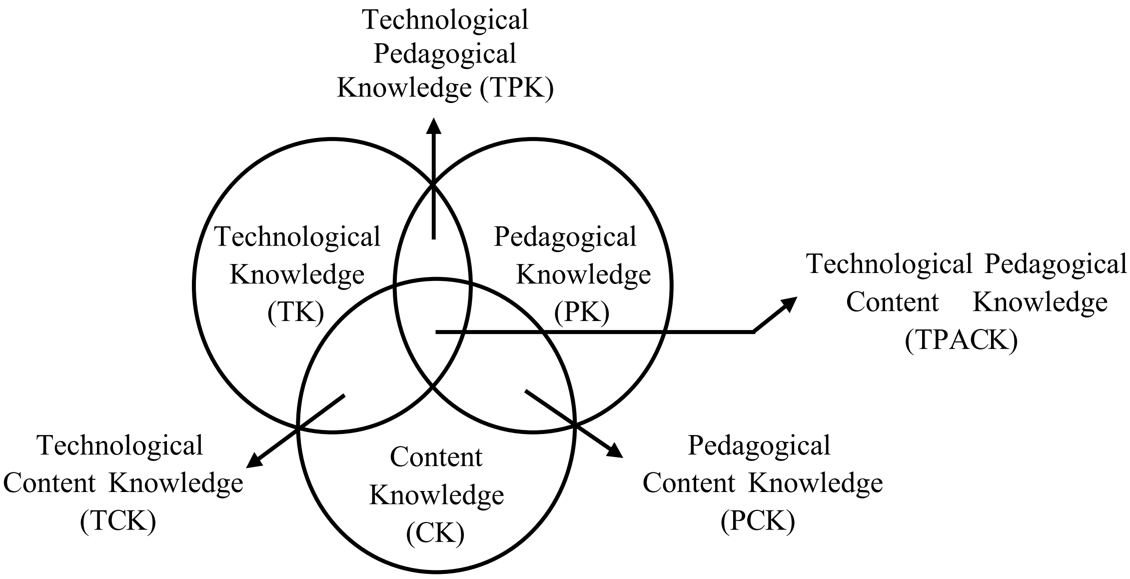
Teacher Technological, Pedagogical and Content Knowledge (TPACK)

In this study, the TPACK framework was used to evaluate mathematics teachers' technological, pedagogical, and content knowledge. Based on the TPACK theory, the hypothesis was that teachers with higher TPACK levels would exhibit more successful technology integration in their classrooms**.** Shulman (1987) emphasized the importance of pedagogical content knowledge (PCK) in effective teaching. PCK involves blending subject matter and pedagogy to understand how to present specific topics, problems, or issues in a manner that caters to students' diverse interests and abilities. It goes beyond simply having knowledge of the subject; PCK also encompasses developing appropriate instructional methods and skills tailored to the learners' needs.

The TPACK framework involves the intersections of technological knowledge (TK) with both content knowledge (CK) and pedagogical knowledge (PK), leading to three additional intersections (TPK, TCK, and TPCK). This extension of Shulman's model was proposed by Mishra and Koehler (2006) to account for the impact of new technologies, such as ICTs, on the classroom. Eventually, TPCK was revised to TPACK, emphasizing that these three-knowledge work together as a "Total PACKAGE" (Koehla & Mishra, 2006). TPACK, as described by Koehler and Mishra (2006), is a combination of TK, CK, and PK that enables teachers to effectively impart subject knowledge to students while incorporating the best pedagogy and available technology.

The TPACK Framework illustrated below, shows the essential integration of Technological, Pedagogical, and Content Knowledge for successful adoption of educational technology. Recognizing the significance of teachers' pedagogical content knowledge in mathematics, the researcher in this study chose to adopt the TPACK framework (Schmidt et al., 2009:124). The TPACK framework provides a structured approach for teachers to effectively integrate technology into their teaching practices by combining technological knowledge, pedagogical knowledge, and content knowledge, focusing on enhancing curriculum delivery and student learning outcomes.

Figure 2: TPACK FRAMEWORK



Technology, Content, and Pedagogy are the three key interwoven knowledge areas in the TPACK paradigm. Understanding of teaching material with suitable pedagogical techniques and technology lies at the intersection of these three knowledge areas. The TPACK model incorporates the seven components. They are defined as follows:

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Content Knowledge (CK): Mishra and Koehler (2006) define content knowledge as the information related to the subject area that teachers intend to teach or students are expected to learn. This knowledge encompasses facts, concepts, ideas, and the overall structure of the subject matter. It also includes evidence, proofs, theories, and accepted methods of acquiring information within that particular field of study, as described by Harbi (2014).

Technological Knowledge (TK): TK refers to an individual's understanding and familiarity with various technologies and their functionalities. It encompasses the knowledge of different technological tools, devices, software, and applications.

TK goes beyond simply knowing how to use specific technologies; it also involves a deeper comprehension of how these technologies work, their potential applications, and their relevance in different contexts.

Pedagogical Knowledge (PK): PK entails knowledge of instructional design, assessment, classroom management, student learning processes, reflective practices, and supportive teaching techniques. It focuses on the art and science of teaching, encompassing methods and strategies to effectively communicate subject matter or address learning challenges for students with different abilities, according to Nyamekye et al. (2022), PK also involves being aware of broader educational objectives, values, and aims, in addition to understanding different learning theories and the characteristics of the target audience, as highlighted by Koehler and Mishra (2006).

Technological Pedagogical Knowledge (TPK): TPK refers to the knowledge and skills related to using different technologies effectively in the teaching process and recognizing how technology can enhance learning. It entails the ability to incorporate instructional strategies that involve the systematic teaching of technical skills into lesson planning (Schmidt et al., 2009).

Technological Content Knowledge (TCK): In TCK, teachers use technology to support the teaching and learning process without being constrained by the functionalities of the tools. This means instructors are aware of how their use of specific technology can impact students' learning and retention of subject matter within a particular subject area (Schmidt et al., 2010).

Pedagogical Content Knowledge (PCK): PCK refers to a teacher combining pedagogical expertise with subject matter knowledge to effectively deliver the content to students. For effective ICT integration in mathematics teaching, educators need to possess TPACK, which stands for technological, pedagogical, and content knowledge. Teachers can navigate the intricate connections between these three essential knowledge components (CK, PK, and TK) by integrating appropriate methods and technology in topic instruction.

Empirical Review

By the research objectives of this study, the empirical review was organized as; evaluating mathematics teacher's TPACK proficiency, assessing the extent to which JHS mathematics teachers are using ICT in their lesson delivery.

Bariu et al. (2022), investigated the impact of teachers' competences on ICT adoption in Kenyan universities. The study established that despite the importance of teachers' abilities in ICT adoption, empirical research has identified a sizable study vacuum. Similarly, Edumadze and Owusu (2013) posited that the amount of ICT integration in lecturers' teaching was predicted by their prior knowledge and abilities in the field, and there was a substantial positive correlation between ICT-related courses and students' ICT competences.

A study by Kere (2016) on the ‘’knowledge and attitude of teachers towards the teaching of Information and Communication Technology in the Sagnarigu District in the Northern Region of Ghana found a connection between teachers' attitude and knowledge, on the one hand, and their use of ICT resources, on the other.

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According to the findings of Mwunda (2014), one of the factors responsible for low integration of ICT among secondary schools in Machakos Sub-County in Kenya was low ICT technical skills. The degree to which JHS teachers use ICT refers to the extent or level to which teachers incorporate ICT tools, resources, and digital technologies into their teaching practices and classroom activities. It measures how extensively teachers utilize digital technology to enhance and support their instructional methods.

According to Ertmer (2005) and Bariham (2020), the decision of whether and how to utilize ICT for academic use is heavily influenced by teachers and associated variables, such as beliefs, confidence, age, gender, and abilities in terms of ICT adoption. Mensah (2022) studied ‘’Assessment of Mathematics Tutors’ ICT Integration into Teaching and Learning of Mathematics in Colleges of Education (CoE) in Ghana’’ and revealed that mathematics tutors utilized ICT for general purposes to a great level, but that their usage of ICT for mathematics teaching and learning in CoE in Ghana was rather low. According to him lack of technical knowledge makes teachers more likely to worry about potential technological issues since they are less likely to understand how to solve such issues individually.

Bariham et al. (2019) analysed “teachers' use of CBI in social studies instruction in West Mamprusi Municipality in the North East Region of Ghana’’. The study reveals that despite teachers’ good perceptions of ICT integration, they did not use ICT in their teaching processes owing to an inadequate number of computers, the internet, and technical assistance, among other problems. The study further reveals that teachers' factors such as gender, age, and school location all substantially impacted their level of ICT implementation.

According to Artigue (2002), if teachers do not employ the necessary mathematical software tools, pupils' grasp of arithmetic may be hampered. The mathematical education paradigm includes inquiry processes into the representations of one's own and published information, rather than being restricted to a corpus of separate knowledge. The study of the relationships and connections between individuals, culture, social institutions, and other behaviours are included in the mathematical philosophy of theorems and proofs in addition to the study of just significant units (Brown & Porter, 1995; Ernest, 2018).

RESEARCH METHODS

Research Design

The study utilized a survey design to systematically collect quantitative data, with the aim of providing a numerical description of the knowledge and skills possessed by Junior High School (JHS) mathematics teachers in the Tamale Metro, and the extent to which they are integrating ICT in their mathematics lessons. The research philosophy was grounded in the post-positivist paradigm, emphasizing a quantitative approach. The quantitative method aligns with the post-positivist perspective, treating information as objective and acknowledging the inherent uncertainty in predicting human behavior. In the post-positivist view, causes are perceived as influencing effects or outcomes, prompting a focused effort on identifying and analyzing factors impacting results, as exemplified in experimental designs (Creswell, 2013).

The primary objective was to gain precise insights into the knowledge and skills of JHS mathematics teachers and the extent of ICT integration in their classrooms, enabling the derivation of statistically valid and meaningful generalizations.

Population and Sample

In the Tamale Metro, 96 public junior high schools were organized into fifteen circuits. Five circuits were randomly selected for the study, comprising 19 public junior high schools and 54 mathematics teachers. These selections were made using the Lottery Method, ensuring equal opportunity for each school to be chosen. Regarding mathematics teachers, there were 167 of them in the area during the 2022/2023 academic year. Five circuits were chosen using

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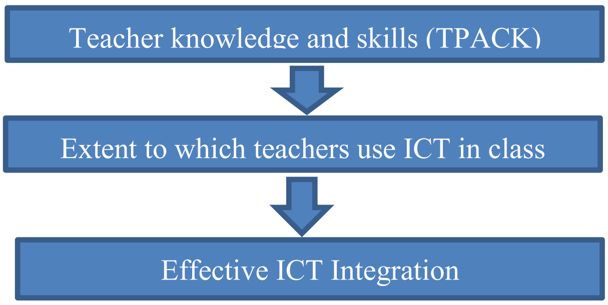
the same lottery method, resulting in a sample of 48 teachers out of the total 54 teachers from the five circuits, representing 88.89% of the population. The researcher employed Taro Yamane's statistical approach to ensure the sample accurately reflected the characteristics of the entire target population of mathematics teachers in the Tamale Metropolis.

The formular is stated as: $n=\frac{N}{1+N(e2)}$ where n=sample size, N=sample frame, 1=constant, e=margin of error

Research Instrument

Data collection for this research utilized a questionnaire, a cost-effective and efficient tool for gathering information from a large participant pool, as Fadi et al. (2020) noted. The researcher adapted and customized Adjei's (2018) five-point Likert scale questionnaire with closed-ended questions, offering a swift and user-friendly data acquisition and evaluation method. The questionnaire items were thoughtfully crafted and underwent review by subject experts and the researcher's supervisor before implementation for data collection. The questionnaire was designed to assess mathematics teachers' knowledge and skills (TPACK) and gauge the extent to which teachers incorporate ICT into their teaching methods.

Analytical Framework



In order determine the effective integration of ICT by JHS math teachers, the study examines the knowledge and skills (TPACK) of teachers and the extent to which they are integrating ICT into their math lessons.

The Technological Pedagogical Content Knowledge (TPACK) framework served as the basis for evaluating mathematics teachers' knowledge and skills, employing a five-point Likert scale along with standard deviations and coefficients of variation. The hypothesis posited that teachers with higher mean scores on the various TPACK components would demonstrate a more successful integration of technology in their classrooms. Additionally, the research investigated the extent to which teachers incorporated ICT into their lessons through a five-point Likert scale comprising five questionnaire items. The data was subjected to analysis using simple frequencies and percentages to provide insights into the levels at which teachers integrate ICT, facilitating meaningful generalizations.

RESULTS AND DISCUSSIONS

Return Rate

Based on the return rate of the questionnaire, 44 out of the 48 participants sampled completed and return their questionnaires resulting in 92% return rate. The results of the 44 participants were used to analyse the data.

Summarized questionnaire of participants and their responses

Teachers' competency on Technological Pedagogical Content Knowledge (TPACK) for ICT integration was examined using 29 items on a five-point Likert scale as shown below

Table 1: Participants Responses on TPACK Framework

		SD	D	N	A	SA	Total
TK	1. I possess the ability to independently resolve technical issues during instruction.	4	26	10	4	0	44
	2. I am adept at quickly grasping and learning new technologies.	2	14	20	5	3	44
	3. I continuously stay updated with significant advancements in technology.	2	17	6	13	6	44
	4. I regularly experiment and explore various ICTs.	7	19	6	7	5	44
	5. I possess knowledge about a wide range of ICTs.	7	24	4	4	5	44
	6. I am sufficiently skilled to effectively utilize technology.	7	15	12	6	4	44
	7. I have been provided with ample chances to work with diverse ICT tools.	21	15	0	7	1	44
CK	8. My understanding of mathematics is substantial and comprehensive.	0	3	0	23	18	44
	9. I am capable of employing a mathematical mindset to approach problems and challenges.	3	7	6	17	11	44
	10. I possess multiple approaches and tactics to enhance my comprehension of mathematics.	0	0	8	22	14	44
PK	11. I possess the ability to evaluate students' performance effectively in a classroom environment.	0	3	6	18	17	44
	12. I am skilled at adjusting my teaching methods based on students' current comprehension levels and areas of difficulty.	1	2	5	21	15	44
	13. I can modify my instructional approach to cater to the diverse learning styles of students.	2	0	0	29	13	44
	14. I have the proficiency to evaluate student learning through various assessment techniques.	0	0	3	26	15	44
	15. I am capable of employing a wide array of teaching methodologies in the classroom.	0	1	0	31	12	44
	16. I am knowledgeable about student understandings in the subject matter.	2	3	7	20	12	44
	17. I know how to organize and maintain discipline in my class.	0	0	0	19	25	44
PCK	18. I am proficient in choosing suitable teaching methods that effectively guide students' thinking and facilitate their learning in mathematics.	0	2	6	22	14	44
TCK	19. I am knowledgeable about the technologies available for practicing mathematics.	9	18	11	5	1	44
TPK	20. I possess the ability to select technologies that improve the effectiveness of my teaching methods during a lesson.	8	20	7	7	2	44
	21. I can identify technologies that enhance students' understanding.	7	20	10	7	0	44
	22. My knowledge in IT has prompted me to adopt various ICT tools in my lesson.	16	20	7	1	0	44
	23. I can alter the use of ICT in my lesson to bring about better understanding.	18	23	0	3	0	44
	24. I enjoy using ICT to deliver my lesson.	8	11	21	3	1	44
TPACK	25. I expertise in creating lessons that skilfully integrate mathematics, technology, and effective teaching methods.	11	19	7	5	2	44
	26. I possess the ability to carefully select appropriate technologies for my classroom, enriching both the content I teach and the way I deliver the lessons to enhance student learning.	11	21	6	6	0	44
	27. I confidently apply the knowledge and strategies acquired during my coursework, technology, to create a dynamic learning environment in my classroom.	9	13	19	3	0	44
	28. I take on a leadership role by assisting others in harmonizing the use of content, methodology and technology.	9	15	15	4	1	44
	29. I have the skill to choose technologies that complement and elevate the lesson's content, adding value and relevance to the educational experience.	7	24	7	5	1	44

Source: Field data 2023

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Research question one: Do JHS mathematics teachers possessed the required knowledge and skills (TPACK) necessary for effective ICT integration?

Teachers' competency on Technological Pedagogical Content Knowledge (TPACK) for successful ICT integration was examined using 29 items on a five-point Likert scale shown above. The results of the questionnaire constructs were combined and further grouped into seven components, namely TK, CK, PK, PCK, TCK, TPK and TPACK and the mean, standard deviation and coefficient of variation of each component was determined as shown in the table below.

Table 2: Teachers' TPACK Competency

TPACK	Mean	SD	CV (%)
TK	2.1	0.43	20
CK	3.4	0.52	15
PK	3.6	0.30	8
PCK	3.5	0.95	27
TCK	2.0	0.59	30
TPK	2.4	0.30	13
TPACK	2.4	0.51	21
Total	2.8	0.22	8

Source: Field Data, 2023.

Table 2 displays the TPACK (Technological Pedagogical Content Knowledge) levels of the participants, which represents their understanding of the intersection of technology, pedagogy, and content knowledge. The table includes mean, standard deviation (SD), and coefficient of variation (CV) for each TPACK category. The mean TK (Technological Knowledge) level from the table was 2.1 with a SD of 0.43 and a CV of 20%, indicating relatively lower TK levels among the respondents and less difference in the choice of the TPACK constructs.

On the other hand, from the table, the mean CK (Content Knowledge) level was 3.4, with a SD of 0.52 and a CV of 15%, indicating slightly high content knowledge (CK). The mean PK (Pedagogical Knowledge) level was 3.6, with a SD of 0.30 and a CV of 8%, and the mean PCK (Pedagogical Content Knowledge) level was 3.5, with a SD of 0.95 and a CV of 27%, suggesting high expertise in PK and PCK among the respondents and the choice of the TPACK constructs among the respondents of CK, PK and PCK was little variation indicated by SD of 0.52, 0.30 and 0.95 respectively.

However, from the table, the mean TCK (Technological Content Knowledge) level was 2.0, with a SD of 0.59 and a CV of 30%, the mean TPK (Technological Pedagogical Knowledge) level was 2.4 with a SD of 0.30 and a CV of 13%, and the mean TPACK (Technological Pedagogical Content Knowledge) level was 2.4 with a SD of 0.51 and a CV of 21%. These figures indicate that respondents have low knowledge of TCK, TPK, and TPACK. The majority of teachers somewhat agreed with the items related to the TPACK constructs, as evident from the total mean score of 2.8, a SD of 0.22, and a CV of 8%.

The findings suggested that JHS mathematics teachers' do not possess the required blend of technology with content and pedagogy (TPACK) needed for successful ICT integration. This is evident from the high mean scores reported by the respondents in terms of content knowledge (CK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK). However, the teachers recorded lower mean scores in technology knowledge (TK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and overall technological pedagogical content knowledge (TPACK). In essence, JHS mathematics teachers exhibit proficiency in pedagogy and content, but their understanding of ICT is limited.

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This aligns with Bariu et al.'s (2022) observation on the impact of tutors' competencies on university ICT adoption, where significant research gaps were identified. Similarly, Mwunda (2014) found low pedagogical use of ICT in secondary schools in Kenya due to inadequate ICT technical abilities among teachers. However, these findings contradict Adjei's (2018) study on assessment of basic school mathematics teachers' ICT integration in mathematics education where he asserted that mathematics teachers in primary and JHS schools displayed excellent TPACK proficiency necessary for ICT adoption in mathematics instruction.

Relationship between the TPACK Components

Table 3 provides a quick overview of the relationships between the TPACK components. Positive values indicate positive correlations, negative values indicate negative correlations, and the magnitude of the values represents the strength of the correlation.

Table 3: Relationship between the TPACK components

Component	TK	CK	PK	PCK	TCK	TPK	TPACK
TK	1.00	-0.12	0.01	0.11	0.00	0.02	0.21
CK	-0.12	1.00	0.02	0.08	0.05	-0.10	0.11
PK	0.01	0.02	1.00	-0.19	0.12	0.35*	0.19
PCK	0.11	0.08	-0.19	1.00	-0.01	-0.08	0.02
TCK	0.00	0.05	0.12	-0.01	1.00	-0.15	-0.05
TPK	0.02	-0.10	0.35*	-0.08	-0.15	1.00	0.26
TPACK	0.21	0.11	0.19	0.02	-0.05	0.26	1.00

NB: The asterisk (*) indicates a statistically significant correlation at the 0.05 level (2-tailed)

Source: Field data 2023

The correlation matrix of *Table 3* reveals the interplay among JHS math teachers' performance in different Technological Pedagogical Content Knowledge (TPACK) components. Notably, there is a weak but positive correlation between Technological Knowledge (TK) and TPACK ($r = 0.21$), suggesting that teachers with proficiency in technological tools may also possess a broader understanding of how to integrate technology with pedagogical and content knowledge. Moreover, the relationships between PK and TPK ($r = 0.35^*$) demonstrate a significant positive connection, suggesting that teachers with pedagogical knowledge are more likely to integrate technology effectively, contributing to a comprehensive TPACK. However, the correlations between TK and other components, such as Pedagogical Knowledge (PK) and Content Knowledge (CK), are either negligible or non-significant, indicating a lack of strong associations. While these findings provide valuable insights into the relationships among TPACK components for JHS math teachers, the non-significant correlations in certain instances caution against overgeneralizing the observed patterns, emphasizing the need for further investigation and contextual interpretation.

Research Question two: To what extent do JHS mathematics teachers use ICT in their lesson delivery?

The extent to which JHS teachers incorporate ICT into mathematics instruction was evaluated through a five-point Likert scale using five questionnaire items, the results of which were analysed using simple frequencies and percentages as shown below.

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Table 4: Extent to which JHS teachers utilize ICT in their lessons

Effective ICT Integration	Never	Rarely	Sometimes	Often	Always
During my lesson I utilize ICT tools	18 (40.9%)	13 (29.5%)	9 (20.5%)	3 (6.8%)	1 (2.3%)
I create mathematics teaching aids and notes using ICT	3 (6.8%)	0 (0%)	20 (45.5%)	17 (38.6%)	4 (9.1%)
In my class I use ICT to assess my lessons	2 (4.5%)	21 (47.7%)	13 (29.5%)	1 (2.3%)	7 (16%)
I usually utilize ICT in my lessons to pique and maintain my pupil's attention	10 (22.7%)	12 (27.3%)	17 (38.6%)	2 (6.8%)	3 (4.5%)
Within my classroom, I utilize ICT tools and resources to foster student creativity and promote critical thinking.	7 (15.9%)	27 (61.4%)	7 (15.9%)	2 (4.5%)	1 (2.3%)

The findings presented in *Table 4* indicate that a significant portion of teachers are not incorporating ICT in their teaching practices. Only a small percentage of teachers (2.3%) always use ICT during lessons, while about 20.5% use it occasionally, and 18 out of 44 teachers do not. Despite believing that ICT has the potential to enhance mathematics teaching and learning, most teachers do not frequently utilize it in the classroom.

Regarding the preparation of teaching materials using ICT, a moderate number of teachers (45.5%) use digital tools to prepare their materials, while a small fraction (6.8%) never uses them. Similarly, about 47.7% of respondents seldom use ICT for assessment purposes, with only 16% employing ICT to assess their students. Moreover, the results show that when it comes to using ICT to maintain students' attention only 3 out of 44 utilize ICT, 2 out 44 often use it and 27 out of 44 rarely use ICT. The results also show that most teachers (61.4%) rarely involve students in learning activities that require the use of technological tools. Only a small percentage (2.3%) of teachers consistently involve students in learning activities that require the use technological tools.

These findings indicated a very low level of ICT integration in mathematics teachers' teaching practices. A similar study conducted by Bariham et al. (2019) also found that despite teachers' positive perceptions about ICT integration, teachers do not integrate ICT in their lessons, because of challenges such as a lack of computers, internet access, and technical support, which limited the use of ICT in their teaching processes. Comparing these findings to Rogers' (1995) pathways of diffusion of innovations, it is evident that the teachers are in the early stages of technological adoption. At this stage, most teachers are sceptical about the benefits of innovation and may resist changing their established methods.

CONCLUSION

The study revealed that JHS mathematics teachers do not possess the required blend of technology with content and pedagogy (TPACK) needed for successful ICT integration, and there is limited utilization of ICT among JHS mathematics teachers. Based on the findings, the following recommendations were made:

The Ghana Education Service, working alongside education partners, should establish and implement a holistic professional development initiative tailored for Junior High School mathematics teachers. This initiative should primarily concentrate on augmenting their Technological Pedagogical Content Knowledge (TPACK) and equip them with the skills needed for proficiently integrating ICT tools into their mathematics teaching.

Furthermore, it should encompass provisions for teachers to participate in workshops, online courses, and receive mentorship to enhance their ICT competencies. Implement a structured strategy for promoting the adoption of ICT among JHS mathematics teachers in Tamale. This strategy should include: Providing ongoing training and technical support to build teachers'

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confidence in using ICT tools, creating incentives and recognition programs to motivate teachers to incorporate technology into their teaching, encouraging collaborative lesson planning and sharing of best practices among teachers to promote the effective use of ICT in mathematics education and regularly assessing the progress and impact of ICT integration efforts to make data-driven improvements.

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