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Perceptions and readiness of high school mathematics teachers for integration of ICT tools in the teaching and learning of mathematics

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ABSTRACT

This paper seeks to gain insights into teachers' perceptions, and readiness to integrate information and communication technology (ICT) tools in mathematics instruction. A mixed-methods approach was employed, involving surveys and interviews with a sample of high school mathematics teachers. The study involved 90 mathematics teachers working in three senior high schools in Kumasi metropolis in Ghana. The study revealed that teachers generally hold positive perceptions of the benefits of ICT tools in mathematics teaching. They strongly agree that ICT tools enhance students' understanding of mathematical concepts and improve their engagement and motivation in mathematics classes. Teachers also recognize the potential of ICT tools in promoting problem-solving skills and providing opportunities for differentiation and personalized learning. However, opinions regarding student-centered learning, exploration, and creativity through ICT tools were more varied, suggesting a need for further investigation and support in these areas. In addition teachers expressed the need for continuous training on specific tools, curriculum alignment, and assessment methods.

Keywords: perceptions, readiness, high school mathematics teachers, integration, ICT tools, teaching and learning, mathematics

INTRODUCTION

The integration of information and communication technology (ICT) tools in education has become increasingly important in the digital age, as it offers potential benefits for enhancing teaching and learning experiences. In the context of mathematics education, research has indicated that the effective integration of ICT tools in mathematics education can enhance student engagement, promote active learning, and improve mathematical understanding (Akcay, 2017; Cheung & Slavin, 2013). By leveraging technology, teachers can create dynamic learning environments that allow students to explore mathematical concepts, visualize abstract ideas, and engage in interactive problem-solving activities. Furthermore, ICT tools can provide opportunities for personalized learning, facilitate collaborative work, and support the development of higher-order thinking skills (Hoyles & Lagrange, 2010; Joubert, 2013).

Teachers' perceptions towards the integration of ICT tools in mathematics instruction play a critical role in the successful implementation of such tools. Research has shown that teachers' attitudes, beliefs, and opinions significantly impact their willingness to adopt and effectively use ICT tools in the classroom (Ertmer, 2005). Teachers who perceive ICT integration positively are more likely to embrace technology and employ innovative teaching strategies (Das, 2019). Conversely, negative perceptions can hinder the effective integration of ICT tools in mathematics education (Mouza, 2008). Understanding teachers' perceptions is crucial for identifying the factors that contribute to their attitudes towards ICT integration and can inform strategies to address any barriers. Several studies have examined the perceptions and readiness of teachers towards ICT integration in various educational contexts. For example, Agyemang and Mereku (2015) conducted a study on teacher perceptions and attitudes towards the use of ICT tools in mathematics instruction in Ghanaian senior high schools. They found that while teachers recognized the potential benefits of ICT integration, there were concerns about technological challenges, lack of resources, and inadequate training.

Teachers' readiness to integrate ICT tools in mathematics instruction is influenced by their technological skills, knowledge, and pedagogical practices. Research has shown that teachers who possess high levels of technological literacy and competence are more likely to effectively integrate ICT tools into their teaching practices (Hew & Brush, 2007). However, teachers' readiness extends beyond technical skills and encompasses their awareness of ICT tools, familiarity with educational software, and

understanding of how to align technology with instructional goals (Teo, 2009). Adequate training and professional development opportunities can enhance teachers' readiness and support their effective integration of ICT tools in mathematics education (Venezky, 2004). Similarly, Agyei et al. (2022) investigated the factors influencing teachers' readiness for technology integration in secondary schools in Ghana. They highlighted the importance of teachers' technological skills, knowledge, and pedagogical practices as essential components of readiness for ICT integration.

Furthermore, Amuko et al. (2015) explored the barriers and challenges to the integration of ICT tools in the teaching and learning of mathematics in senior high schools in Ghana. They identified limited access to technology, inadequate infrastructure, lack of technical support, and time constraints as significant obstacles to successful ICT integration.

To address the gaps in the existing literature and provide insights specific to high school teachers' perceptions and readiness in Ghana, this study aims to investigate the perceptions and readiness of high school teachers for integrating ICT tools in the teaching and learning of mathematics. By exploring teachers' perspectives, technological competencies, and identifying barriers and effective pedagogical strategies, this research can contribute to the development of targeted interventions and policy recommendations for promoting successful ICT integration in Ghanaian high schools.

Statement of the Problem

The integration of ICT tools in the teaching and learning of mathematics has become increasingly important in today's educational landscape. Ghana education service (GES) recognizes the potential benefits of integrating ICT tools in mathematics education to enhance students' mathematical understanding and promote critical thinking skills (Ministry of Education [MOE], 2015). However, the successful implementation of ICT tools requires a thorough understanding of teachers' perceptions and readiness, as they play a crucial role in shaping instructional practices and student experiences.

While previous studies have explored the integration of ICT tools in education in Ghana (Mensah & Nabie, 2021), there is a dearth of research specifically examining the perceptions and readiness of high school mathematics teachers for ICT integration. Understanding their perceptions, attitudes, and level of readiness is essential to inform educational policymakers, curriculum developers, and professional development providers on how to effectively support teachers in integrating ICT tools. There is limited research specifically focusing on the perceptions and readiness of high school teachers in Ghana regarding the integration of ICT tools in mathematics instruction. This study aims to investigate the perceptions and readiness of high school teachers in Ghana for integrating ICT tools in the teaching and learning of mathematics, with a focus on understanding their attitudes, technological competencies, and the challenges they encounter.

Objectives

The study aims to investigate the perceptions and readiness of high school mathematics teachers in Ghana for integrating ICT tools in the teaching and learning of mathematics. Based on this aim, the following objectives are proposed:

1. To examine the perceptions of high school mathematics teachers in Ghana regarding the integration of ICT tools in the teaching and learning of mathematics.
2. To assess the readiness of high school mathematics teachers in Ghana for integrating ICT tools in their instructional practices.

Research Questions

1. What are the perceptions of high school mathematics teachers in Ghana regarding the integration of ICT tools in the teaching and learning of mathematics?
2. How ready are high school mathematics teachers in Ghana for integrating ICT tools in their instructional practices?

THEORETICAL FRAMEWORK

The study employs the technological pedagogical content knowledge (TPACK) framework as the theoretical foundation. TPACK, proposed by Mishra and Koehler (2006), provides a comprehensive framework for understanding the complex interplay between technology, pedagogy, and content knowledge (CK) in educational contexts.

Technological knowledge (TK) refers to understanding the available ICT tools, their functionalities, and their potential applications in educational settings. It involves knowledge of different hardware and software tools, digital resources, and their suitability for specific instructional purposes (Koehler & Mishra, 2009). In the context of this study, TK encompasses the understanding of various ICT tools applicable to mathematics instruction, such as mathematical software, online simulations, and educational websites.

Pedagogical knowledge (PK) relates to the understanding of effective instructional strategies, learning theories, and teaching methods. It involves knowledge of how to engage students, facilitate learning, and promote meaningful experiences in the classroom (Koehler & Mishra, 2009). In this study, PK focuses on the pedagogical approaches, instructional designs, and student-centered strategies that integrate ICT tools in mathematics education.

CK refers to the subject-specific knowledge that teachers possess. In the case of this study, it encompasses the understanding of mathematical concepts, procedures, and problem-solving strategies. Teachers' CK enables them to effectively connect the content to the appropriate pedagogical strategies and leverage ICT tools to enhance students' understanding of mathematics (Koehler & Mishra, 2009).

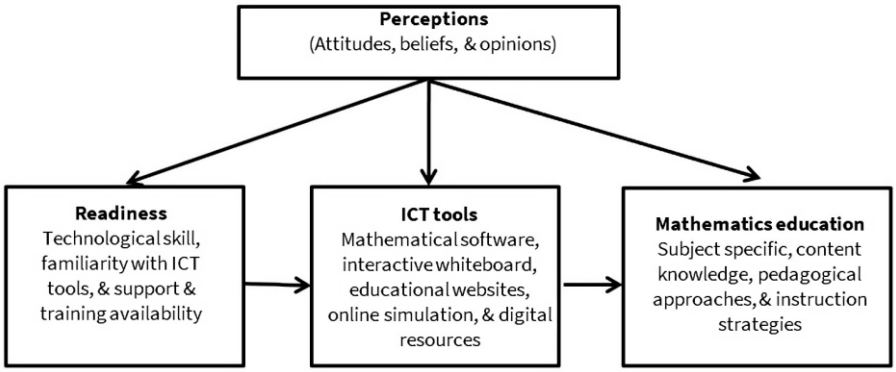

Figure 1. Conceptual framework diagram (Source: Authors' own elaboration)

Pedagogical content knowledge (PCK) represents the integration of PK and CK. It focuses on the knowledge of how to teach specific subject content effectively. In the context of this study, PCK entails the understanding of how to teach mathematics using appropriate instructional strategies, examples, and activities that align with students' learning needs and facilitate the integration of ICT tools (Koehler & Mishra, 2009).

TPACK is the integration of TK, PK, and CK, resulting in a specialized knowledge that helps teachers make informed decisions regarding technology integration in specific subject areas. TPACK emphasizes the importance of balancing technology, pedagogy, and CK to create meaningful learning experiences for students (Mishra & Koehler, 2006).

TPACK framework serves as a lens to examine the perceptions and readiness of high school teachers in Ghana for integrating ICT tools in the teaching and learning of mathematics. It helps in assessing teachers' technological competencies (TK), pedagogical approaches (PK), and CK as they relate to the integration of ICT tools. By analyzing TPACK framework, the study aims to identify the specific areas of strength and areas for improvement in teachers' readiness for ICT integration.

Conceptual Knowledge

Conceptual framework on perceptions and readiness of high school teachers for integrating ICT tools in the teaching and learning of mathematics in Ghana is illustrated in **Figure 1**.

The conceptual framework for the study illustrates the key elements and relationships that will be explored to understand the perceptions and readiness of high school teachers in Ghana for integrating ICT tools in the teaching and learning of mathematics. The framework includes four main components: perceptions, readiness, ICT tools, and mathematics education.

Perceptions: This component focuses on the attitudes, beliefs, and opinions of high school teachers towards the integration of ICT tools in mathematics instruction. It encompasses their perceptions of the benefits, challenges, and potential impact of ICT tools on students' learning outcomes. The perceptions component is influenced by factors such as personal experiences, professional development opportunities, and contextual factors.

Readiness: The readiness component assesses the preparedness of high school teachers to integrate ICT tools in their instructional practices. It includes technological skills and competencies, familiarity with ICT tools specific to mathematics education, and the availability of support and training for teachers. Readiness is crucial for effective and successful integration of ICT tools in the classroom.

ICT tools: This component represents the various technology tools that can be utilized in mathematics instruction. It includes mathematical software, interactive whiteboards, educational websites, online simulations, and other digital resources. ICT tools component highlights the range of tools available to enhance teaching and learning experiences in mathematics.

Mathematics education: Mathematics education serves as the foundation of this conceptual framework, emphasizing the importance of effective mathematics instruction. It encompasses the subject-specific CK, pedagogical approaches, and instructional strategies employed by high school teachers to teach mathematics. The integration of ICT tools within mathematics education aims to enhance students' understanding, engagement, and critical thinking skills.

Perceptions of High School Mathematics Teachers Regarding ICT Integration

In literature, perception has been utilized to suggest one's ideas on various topics (Al Meslamani, 2019). Teachers' opinions on a subject are essentially their perceptions of the subject. According to Naidoo and Kapofu (2020), perception is the process by which the mind analyzes information in order to make sense of the world around us and our senses. Because each learner has different exposures, their understanding of a situation is highly subjective. Though attitude transcends one's mental view, perception toward ICT integration refers directly to one's mental view on the teaching and learning integrating ICT. Due to their inequality, teachers have varying perspectives on the integration of ICT, and these perspectives can influence how they behave when it comes to ICT integration (Naidoo & Kapofu, 2020). Teachers' perceptions of ICT integration may have something to do with their prior ICT experiences as well as their current viewpoints. In support, Lewis (1999) demonstrates how an individual's past and present experiences might shape their perspective on ICT. Teachers' judgments are influenced by a variety of factors, including prior experiences with their instruction, the teacher, the classroom atmosphere, and many more. This study's perceptions center on how high school mathematics teachers feel about integrating ICT.

The potential of technology to teach and study mathematics is well acknowledged (Tabach & Trgalová, 2019). It is imperative that educators embrace a student-centered approach to learning and modify their instructional strategies accordingly. Under student-centered education, the instructor directs the learning process' design and concentrates on methodical planning for the efficient use of educational technology and equipment in the classroom (Motschnig-Pitrik & Holzinger, 2002; Muganga & Ssenkusu, 2019). Prior research has demonstrated that, despite investments and international standards being created, technology integration in schools is not at the required level (Hew & Brush, 2007; Keengwe et al., 2008). As an illustration, according to the teaching and learning international survey of educators in OECD nations, just 38.0% of educators include technology into their lesson plans (OECD, 2015). The targeted pace is not being met at this time. Ertmer (2005) classified barriers into two categories: main barriers resulting from external influences like technical resources, school culture, and infrastructure, and secondary barriers resulting from internal influences like teachers' attitudes and beliefs. Additionally, according to Ertmer and Ottenbreit-Leftwich (2013), instructors' preferred technology use and teaching strategies in the context of teaching and learning processes are influenced by their pedagogical ideas toward technology integration. In other words, educators employ ICT resources and programs in accordance with their educational philosophies (Liu, 2011; Tajibayeva et al., 2023).

Previous research has highlighted the global discourse on integrating ICT tools in mathematics education. Scholars such as Hohenwarter and Preiner (2018) emphasize the positive impact of ICT tools on student engagement and achievement in mathematics. A study by Boateng and Agyei (2017) explored the general landscape of ICT integration in education in Ghana. While their study does not specifically focus on mathematics teachers, it provides insights into the broader challenges and opportunities for ICT integration in the Ghanaian educational context, which can serve as a backdrop for understanding the specific challenges faced by mathematics teachers in Kumasi. Ogunniyi (2016) conducted a study in an African context, exploring mathematics teachers' perceptions of ICT integration. The findings shed light on common challenges faced by mathematics teachers in integrating technology and can offer insights into potential barriers faced by teachers in Kumasi.

Readiness of High School Mathematics Teachers for ICT Integration

According to earlier studies (Asiedu-Addo et al., 2016; Powers & Blubaugh, 2005), teacher education programs are the main source of preparation for teachers using technology in the delivery of lessons. Conversely, Hudson and Porter (2010) agreed with Kafyulilo et al. (2015) that teacher professional development training programs could improve instructors' readiness to employ technology in mathematics instruction. Teachers need to be ready to embrace the paradigm shift of integrating technology into lesson delivery because they are change agents and the main players in the teaching process. In order to increase teachers' competencies in incorporating technology into the delivery of lessons, teacher preparation is essential (Cheal et al., 2012; Hero, 2020). The importance of teacher education programs that support educators in developing their technological proficiency to apply a variety of teaching strategies to successfully integrate technology into the curriculum has been highlighted by research (Lock & Redmond, 2010).

The study by Kyndt et al. (2016) investigated the impact of professional development programs on teachers' readiness to integrate ICT in their teaching practices. Understanding the importance of training and professional development can provide insights into the specific needs of mathematics teachers in Kumasi regarding ICT integration. Exploring the work of Ertmer (1999) on barriers to adopting technology in education can provide a theoretical framework for understanding the challenges high school mathematics teachers in Kumasi may face. Identifying these barriers is crucial for developing targeted interventions to enhance teachers' readiness. A study by Adu-Gyamfi et al. (2020) examined the current state of ICT integration practices in Ghanaian schools. While not specific to mathematics teachers, this study can provide insights into the broader educational context in Kumasi, informing the readiness of mathematics teachers for ICT integration. Agyei et al. (2022) conducted a study in – service mathematics teachers' preparedness, knowledge, skills, and self-efficacy beliefs of using technology in lesson delivery in Kumasi, Ghana. Their findings indicated that mathematics teachers possessed high technology knowledge and self-efficacy, but they had relatively low preparedness and ICT skills in using technology in their lessons. In addition, ICT skills and teacher preparedness emerged as the best predictors for technology usage in mathematics lesson delivery.

Perception & Achievement

Research on the relationship between achievement and perception has traditionally examined causes or effects. For example, Ahmad et al. (2017) investigated the relationship between students' perceptions of ICT integration and achievement, and the results indicated a negative relationship between the two. Instead, some research has looked into the relationship between perception and achievement as well as the relationship between perception and achievement (Maat & Zakaria, 2010). In a research by Hagan et al. (2020), mathematics achievement was used as the criteria, and perception was created a predictor variable in order to evaluate the impact of perception on students' mathematics achievement. Despite a small negative correlation between the two variables, the results indicated that perception did not significantly impact mathematical achievement. Hagan et al. (2020) concluded that students' perceptions had no discernible impact on how well they performed in the subject.

Essence of Perception & Readiness in Integration of ICT Tools in Teaching Mathematics

Numerous studies have highlighted the perceived benefits of integrating ICT tools in mathematics education. Teachers recognize the potential of ICT to enhance student engagement, promote active learning, and facilitate deeper understanding of mathematical concepts (Kay & Kletskin, 2012, Wachira & Keengwe, 2011). ICT tools are viewed as valuable resources that can provide interactive and visual representations, promote collaborative learning, and cater to diverse learning styles (Picciano, 2017; Yelland, 2013). Teachers perceive that ICT integration can enhance students' problem-solving skills, critical thinking abilities, and overall academic achievement (Mensah, 2017). Even though previous studies have identified factors such as limited access to technology, internet connectivity, inadequate ICT infrastructure, and insufficient resources as significant barriers to ICT

integration (Chigona & Chigona, 2012; Tay & Mensah-Wonkyi, 2018). Teachers also express concerns about their own technological competencies, lack of training, and time constraints in learning and effectively utilizing ICT tools (Kay, 2012; Zengin et al., 2012). Additionally, perceived resistance to change and skepticism about the effectiveness of ICT integration in mathematics education are common among teachers (Hew & Brush, 2007; Tondeur et al., 2017).

The perceptions of high school teachers towards ICT integration in mathematics instruction are influenced by various factors. Studies have identified the role of personal experiences with technology, prior exposure to ICT tools, and the level of comfort and confidence in using technology (Kay, 2012; Tondeur et al., 2017). Teachers' beliefs about the value of technology, their pedagogical beliefs, and their understanding of how ICT tools can support learning also shape their perceptions (Ertmer et al., 2012; Wachira & Keengwe, 2011). Furthermore, contextual factors, including school support, access to professional development opportunities, and policy frameworks, impact teachers' perceptions towards ICT integration (Hebebci & Ertuğrul, 2022; Mouza, 2022). Research also emphasizes the significance of targeted professional development and ongoing support to address teachers' concerns and enhance their perceptions towards ICT integration. Studies have shown that comprehensive and sustained professional development programs that focus on both technological and pedagogical aspects of ICT integration can positively impact teachers' perceptions (Greenhow et al., 2020, Hew & Brush, 2007). Collaboration and sharing of best practices among teachers, access to technical support, and availability of adequate resources are also essential for fostering positive perceptions (Tondeur et al., 2016; Wachira & Keengwe, 2011).

MATERIALS & METHODS

Research Design

The study employed pragmatism research paradigm. A mixed-method approach was used in this study to assess the perceptions and readiness of senior high School mathematics teachers on integration of ICT tools in the teaching and learning of mathematics in Ghana. A mixed method involves combining both quantitative and qualitative data to draw certain conclusions from them to clarify the research question (Creswell, 2014). The quantitative and qualitative data were collected simultaneously using a concurrent triangulation design (Creswell, 2014). The use of mixed-methods approach in this study was in line with the recommendations of Creswell and Plano Clark (2018) who emphasized the value of combining quantitative and qualitative methods to gain a comprehensive understanding of research phenomena. A cross-sectional survey design was used as the research design. It involves collecting data from a sample of participants at a single point in time (Creswell, 2013).

Population

The population for this study was high school mathematics teachers from three public high schools (Kumasi Anglican Senior High School, T. I. Ahmadiyya Senior High School, and Kumasi Technical Institute) in the Kumasi Metro area in the Asem circuits of Ghana.

Sample & Sampling Technique

The researcher used probability sampling technique. Stratified random sampling was used to select 90 high school mathematics teachers with 95% confidence interval and 5.0% margin of error. Stratification involved dividing the population into subgroups or strata based on relevant characteristics (such as school level) using simply random techniques and then randomly selected participants from each stratum in proportion to its size. A simple random sampling technique was used to select mathematics teachers from each stratum based (school) on the proportion of teachers in each stratum relative to the total population of teachers. These teachers were selected based on their involvement in teaching mathematics and their relevance to the research topic of integrating ICT tools in the teaching and learning of mathematics.

Research Instruments

To investigate the perceptions and readiness of high school mathematics teachers in Ghana for integrating ICT tools in the teaching and learning of mathematics, the following research instruments was utilized:

Questionnaire

A structured questionnaire was developed to collect quantitative data from the participants. The questionnaire was made up of a series of closed-ended questions, including Likert-scale items. The questionnaire assessed teachers' perceptions of ICT integration, their readiness to incorporate ICT tools in their instructional practices, and factors that may influence their attitudes towards ICT integration. Additionally, the researcher gathered information on teachers' technological skills, familiarity with ICT tools, access to training and support, and their beliefs about the value of technology in mathematics education. The questionnaire was designed based on previous research and literature on ICT integration in mathematics education. The designed questionnaire was reviewed and modified at various intervals. Two experts in the field reviewed the final design of the questionnaire to ensure its content reliability and validity. The finalized questionnaire was administered electronically to the participants for data collection.

Semi-structured interviews

Semi-structured interviews were conducted with a subset of teachers to gather qualitative data and gain in-depth insights into their perceptions and readiness for ICT integration. The interview was guided by a set of predetermined open-ended questions that cover various aspects related to teachers' attitudes towards ICT integration, their experiences with ICT tools, and the factors

influencing their readiness. The interviews provided an opportunity for participants to share their perspectives, elaborate on their responses, and offer additional insights that may not be captured through the questionnaire. The interviews were audio-recorded with the participants' consent and transcribed for analysis. The qualitative data obtained from the interviews was analyzed using thematic analysis to identify common themes, patterns, and subthemes related to the research objectives. Both the questionnaire and the interview guide was pilot-tested with a small group of teachers to ensure clarity, comprehensibility, and relevance to the research objectives. Feedback from the pilot study was used to refine and improve the research instruments before full-scale data collection.

Data Collection Procedure

The researchers in consultation with the supervisor and expert in the field of mathematics education designed questionnaire for the study. After a complete design of the questionnaire, the researchers sought the approval from Department of Mathematics Education of the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development in the Ashanti Region of Ghana. The questionnaire was converted into an online survey using Google Forms. Additionally, the researchers, sought permission from GES, Kumasi Metro directorates to enable the researchers to visit the schools and be able to administer the questionnaires. The private emails and social media group pages of mathematics teachers from the targeted population were used to circulate the questionnaires.

Data Analysis

Quantitative analysis was conducted on the data obtained from the structured questionnaire. The Likert-scale items were analyzed using descriptive statistics, such as frequencies and percentages, to determine the overall perceptions of teachers towards ICT integration. The frequencies and percentages of the responses to the Likert-scale questions by the High School mathematics teachers in the context of integrating ICT in teaching mathematics in high schools in Ghana were calculated. Additionally, the means and standard deviations of the responses to the Likert-scale questions by the High School mathematics teachers in the context of integrating ICT in teaching mathematics in high schools in Ghana were also calculated. This analysis provided an overview of the teachers' attitudes, beliefs, and opinions regarding the use of ICT tools in mathematics education. After the frequency analysis, reliability analysis was performed for reliability coefficients. Moreover normality analysis were performed according to kurtosis and skewness values, it was determined that the values of the distribution are in the range of ±1.5 and that it has a normal distribution (Tabachnick & Fidell, 2007).

The skewness coefficient and kurtosis coefficient of mathematics teachers' responses for the questionnaire were -1.370 and -1.300, respectively. Moreover, the z statistics obtained by dividing the skewness and kurtosis coefficients by their standard errors yielded -1.370 and -1.563, respectively. Most of the variables examined in the study showed values between -1.000 and +1.500 in terms of skewness and kurtosis. These variables were gender (skewness: -1.430 to -1.280; kurtosis: -0.610 to -0.210), qualification (skewness: -1.330 to -1.640; kurtosis: -1.380 to 1.560), type of school (skewness: 1.450 to 1.420; kurtosis: -1.320 to 1.220), and age (skewness: -1.420 to 1.130; kurtosis: -1.210 to 1.210). According to both George and Mallery (2010) and Tabachnick and Fidell (2007), if the range of a distribution is within the limits (-1.0 to +1.0; -1.5 to +1.5; -2.0 to +2.0), the data are accepted to have a normal distribution. Since the data had a statistically normal distribution, the t-test for independent samples was used for pairwise comparisons, and one-way analysis of variance (ANOVA) was used for comparisons of more than two variables. SPSS version (24.0) was employed to analyse the data. The level of significant difference was accepted as $p<.05$ in the interpretation of the analyses.

Thematic analysis was employed to identify recurring themes, concepts, and perspectives related to ICT integration. The interviews were transcribed, coded, and categorized into meaningful themes and subthemes. By analyzing the qualitative data, the researchers gained insights into the specific reasons, experiences, and concerns expressed by the teachers regarding the integration of ICT tools in mathematics instruction.

RESULTS

The study's results were categorized into themes that corresponded to the research questions, which focused on the perceptions and readiness of high school mathematics teachers for integrating ICT tools in the teaching and learning of mathematics in Ghana.

To explore "what are the perceptions of high school mathematics teachers in Ghana regarding the integration of ICT tools in the teaching and learning of mathematics?", five Likert-scale type statements were provided for participants to indicate their level of agreement to the statements. Frequency counts of respondents' level of agreement to each statement were determined and converted to percentages, as shown in **Table 1**.

Table 1 and **Figure 2** presents the high school mathematics teachers responses on integrating ICT tools in teaching and learning mathematics. The results indicated that, high school mathematics teachers have varied perception on the integrating ICT tools in teaching and learning of mathematics. For the item that ICT tools enhance students' understanding of mathematical concepts, approximately 66.7% of teachers either strongly agree or agree. However, significant portion (27.8%) agrees, while only a small percentage (5.5%) strongly disagrees. Similarly, for the item regarding the improvement of students' engagement and motivation, about 66.7% of teachers express positive sentiments while a smaller percentage (11.1%) strongly disagrees. Items related to student-centered learning and problem-solving skills show more varied responses. For facilitating student-centered learning, only 38.9% of teachers strongly agree or agree, while a significant 48.9% fall into the neutral category. Regarding the enhancement of problem-solving skills, opinions are divided, with approximately 47.8% in the positive categories and 30.1% in the neutral category.

Table 1. Mathematics teachers' perception in integrating ICT tools in teaching & learning of mathematics

Statement	n (%)				
	SA	A	N	DA	SDA
The use of ICT tools enhances students' understanding of mathematical concepts.	35 (38.9)	25 (27.8)	15 (16.7)	10 (11.1)	5 (5.5)
ICT tools improve students' engagement and motivation in mathematics classes.	39 (43.3)	21 (23.3)	5 (5.6)	15 (16.7)	10 (11.1)
Integrating ICT tools in teaching mathematics facilitates student-centered learning	20 (22.2)	15 (16.7)	12 (13.3)	23 (25.6)	20 (22.2)
The use of ICT tools in mathematics instruction enhances students' problem-solving skills.	23 (25.6)	20 (22.2)	20 (22.2)	15 (16.7)	12 (13.3)
Use of ICT tools in math teaching allows for differentiation & personalized learning teacher.	35 (38.9)	19 (21.2)	13 (14.4)	12 (13.3)	11 (12.2)
ICT tools support the exploration and discovery of mathematical concepts.	19(21.2)	12 (13.3)	35 (38.9)	11 (12.2)	13 (14.4)
ICT tools provide opportunities for collaborative learning in mathematics classes.	35 (38.9)	25 (27.8)	15 (16.7)	10 (11.1)	5 (5.5)
Integrating ICT tools in mathematics instruction helps students develop critical thinking skills.	39 (43.3)	21 (23.3)	5 (5.6)	15 (16.7)	10 (11.1)
The use of ICT tools in teaching mathematics promotes creativity and innovation.	20 (22.2)	15 (16.7)	12 (13.3)	23 (25.6)	20 (22.2)

Note. SA: Strongly agree; A: Agree; N: neutral; DA: Disagree; & SDA: Strongly disagree

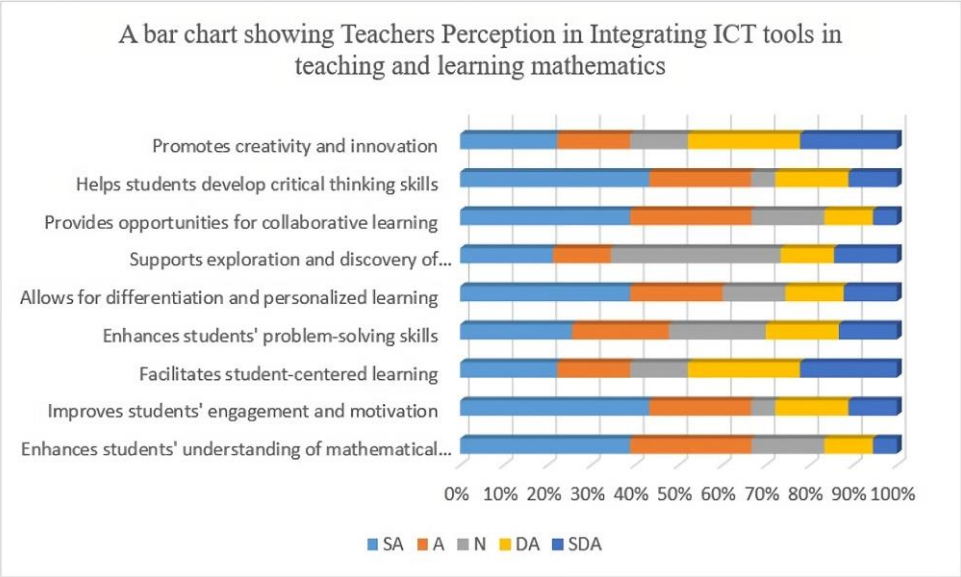

Figure 2. A bar chart showing teachers responses on integrating ICT tools in teaching & learning mathematics (Source: Authors' own elaboration)

The item about ICT tools allowing for differentiation and personalized learning has a positive response from 60.1% of teachers. Teachers generally agree that ICT tools support exploration and discovery (60.1% in positive categories), collaborative learning (66.7% in positive categories), and critical thinking skills development (66.7% in positive categories). Regarding promoting creativity and innovation, approximately 39.9% strongly agree or agree, while 38.9% fall into the neutral category. Items related to student-centered learning and problem-solving skills show a more diverse range of opinions, with a significant number of teachers in the neutral category. Given that approximately 48.9% of teachers are neutral about student-centered learning, providing targeted professional development in this area could be beneficial. Engaging with the 30.1% of teachers who are neutral about the enhancement of problem-solving skills to understand their concerns and address any challenges they might be facing. Highlighting success stories becomes crucial, especially for the 38.9% of teachers who are neutral about the impact of ICT tools on promoting creativity and innovation. The mean score of those that agreed to the items on the questionnaire were 22.40, while the mean score of those that stayed neutral were 4.40 and the mean score of those that disagreed to the items were 4.16. Based on the mean scores of the respondents' agreement, the data suggests that high school mathematics teachers in Ghana generally have positive perceptions of the integration of ICT tools in the teaching and learning of mathematics. They recognize the potential benefits in terms of enhancing understanding, engagement, problem-solving skills, collaboration, and critical thinking. However, there are variations in opinions regarding student-centered learning, differentiation, exploration, and promoting creativity. These findings indicate the need for further exploration of teachers' experiences, training, and support related to the integration of ICT tools in mathematics instruction.

Readiness of High School Mathematics Teachers for Integrating ICT Tools

In this study, "readiness" referred to the degree of preparedness of high school mathematics teachers' in integrating ICT tools in teaching and learning mathematics. To explore Readiness of high school mathematics teachers for integrating ICT tools five Likert-scale type statements were provided for participants to indicate their level of agreement to the statements. The determination of the high school mathematics teachers readiness for integrating ICT tools was done using researchers–made mean intervals: very high (4.21-5.00), high (3.41-4.20), moderate (2.61-3.40), low (1.81-2.60), very low (1.00-1.80) and not ready (<1.000). Frequency counts of respondents' level of agreement to each statement were determined and converted into mean, standard deviation and standard error, as shown in **Table 2**.

Table 2. Readiness of high school mathematics teachers for integrating ICT tools

Readiness of high school mathematics teachers for integrating ICT tools	n	M	SD	SEM	LR
I am familiar with a variety of ICT tools that can be used in teaching mathematics.	90	1.19	1.27	.22	VL
I have received adequate training on integrating ICT tools in mathematics instruction.	90	1.13	1.07	.34	VL
I have access to the necessary ICT tools for integrating them into my mathematics classes	90	1.60	1.30	.12	VL
I feel confident in my ability to effectively use ICT tools in teaching mathematics.	90	1.25	1.10	.13	VL
I believe that integrating ICT tools in mathematics instruction will improve student learning outcomes.	90	2.10	1.60	.12	L
I am willing to invest time and effort to learn how to integrate ICT tools in my mathematics classes.	90	3.42	1.10	.13	VL

Note. M: Mean; SD: Standard deviation; SEM: Standard error mean; LR: Level of readiness; VL: Very low; L: Low; & HR: Highly ready

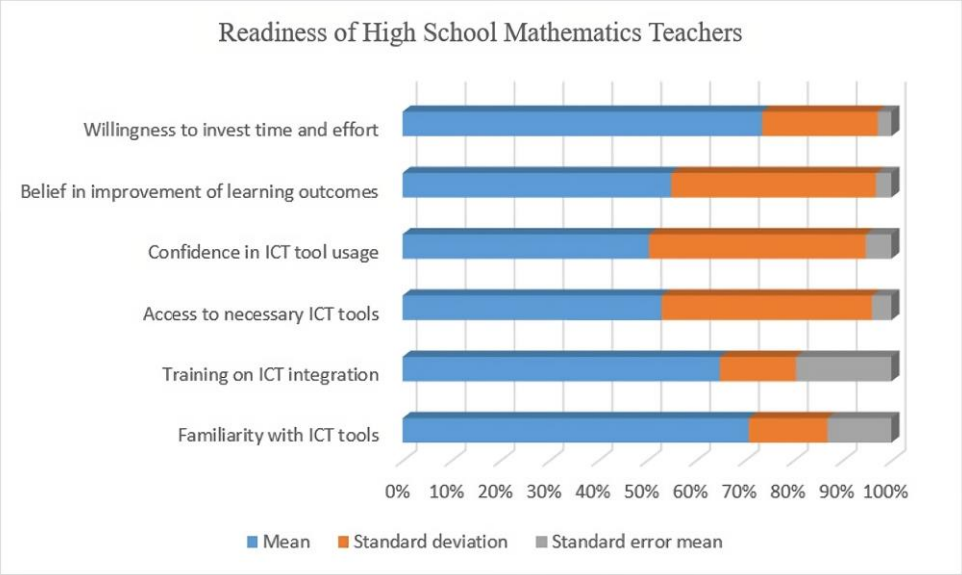

Figure 3. A bar chart showing high school math teachers readiness on integrating ICT tools in teaching & learning mathematics (Source: Field work, 2023)

The results from **Table 2** and **Figure 3** indicated that mathematics teachers express a very low level of familiarity with a variety of ICT tools (mean=1.19). The standard error suggests some variability in responses. Teachers also report a very low level of received training on integrating ICT tools into mathematics instruction (mean=1.13), with a higher standard error indicating varied responses. The mean of 1.60 suggests a very low level of access to the necessary ICT tools for integration. However, the lower standard error implies a bit more consistency in responses. Teachers feel a very low level of confidence in their ability to effectively use ICT tools in teaching mathematics (mean=1.25). The standard error indicates some variation in the reported confidence levels. The mean of 2.10 suggests a low level of belief among teachers that integrating ICT tools will improve student learning outcomes. The standard error indicates variability in this belief. On a positive note, teachers express a high level of readiness to invest time and effort in learning how to integrate ICT tools into their mathematics classes (mean=3.42). The standard error suggests some variability but overall a strong willingness. Teachers seem to be less ready in terms of familiarity, training, access, and confidence in using ICT tools. There is a mixed belief among teachers regarding the potential improvement of learning outcomes through ICT integration.

Despite low readiness in some areas, there is a notably high level of willingness among teachers to invest time and effort in learning how to integrate ICT tools. Implement targeted training programs to enhance teachers' familiarity with a variety of ICT tools and improve their confidence in using these tools. Ensure that teachers have access to the necessary ICT tools by providing resources or support to acquire them. Address teachers' beliefs about the impact of ICT tools on student learning outcomes through workshops or discussions showcasing successful implementations. Capitalize on the high willingness of teachers to invest time and effort by providing continuous professional development opportunities.

Teachers' Responses from Semi Structured Interviewed

The interviews aimed to gain in-depth insights into their practices, challenges, and perceptions regarding the use of ICT tools in the classroom. The responses of the teachers were grouped themes below.

Benefits of ICT tools in teaching mathematics

> **T1**: "ICT tools have greatly enhanced students' understanding of mathematical concepts. The visual representations, interactive simulations, and real-world applications provided by these tools make abstract concepts more tangible and engaging for students."

T3: "Using ICT tools in mathematics classes has significantly improved students' motivation. They are more actively involved in the lessons, as the tools allow for hands-on exploration and collaborative problem-solving. Students are excited to discover new ways of approaching mathematical problems."

Challenges in integrating ICT tools

T3: "One of the challenges I face is the limited access to ICT resources. Although there are computer labs in our school, they are often overcrowded or have technical issues. It becomes difficult to plan lessons and ensure all students have sufficient access to the tools."

T4: "Sometimes, I find it challenging to align the use of ICT tools with the curriculum and assessments. There is a need for more training and support to help teachers integrate ICT tools effectively without compromising the curriculum objectives and assessments."

Professional development & support

T5: "Professional development programs on ICT integration in mathematics instruction are crucial. We need continuous training on how to effectively use specific tools, align them with the curriculum, and assess student learning. It would be helpful to have workshops and resources tailored specifically for mathematics teachers."

T1: "Having technical support readily available would be beneficial. Sometimes, we encounter technical difficulties during class, and it can disrupt the flow of the lesson. Having on-site technical support or a dedicated helpdesk for troubleshooting would save time and ensure smooth implementation of ICT tools."

Pedagogical shift & teacher confidence

T2: "Integrating ICT tools requires a shift in our teaching approaches. We need to move from a traditional lecture-based style to a more student-centered and inquiry-based approach. It can be challenging for some teachers to adopt this new pedagogical approach, but with proper training and support, we can build our confidence."

T3: "As a teacher, I feel the need for more opportunities to exchange ideas and collaborate with other teachers who are integrating ICT tools. Sharing best practices, lesson plans, and success stories would be valuable in building our confidence and improving our teaching practices."

These thematic responses provide a glimpse into the experiences and perceptions and readiness of High School mathematics teachers in Ghana regarding the integration of ICT tools. The data highlights the benefits of ICT tools, challenges faced by teachers, the importance of professional development and support, and the need for pedagogical shifts and teacher confidence. By addressing these aspects, stakeholders can work towards creating a conducive environment for effective integration of ICT tools in mathematics teaching and learning in Ghana.

DISCUSSION

The results from the data indicate that high school mathematics teachers in Ghana generally hold positive perceptions regarding the integration of ICT tools in the teaching and learning of mathematics. These findings are consistent with previous research conducted in the field. The majority of teachers (66.7%) strongly agree that the use of ICT tools enhances students' understanding of mathematical concepts. This aligns with studies that have demonstrated the effectiveness of ICT tools in promoting conceptual understanding in mathematics (e.g., Mensah & Nabie, 2021).

Similarly, a significant proportion of teachers (66.6%) strongly agree that ICT tools improve students' engagement and motivation in mathematics classes. This finding is supported by research that highlights the positive impact of ICT tools on student motivation and active participation (e.g., Keengwe et al., 2008).

Teachers also generally hold positive views on ICT tools enhancing students' problem-solving skills, with a larger portion (47.8%) agreeing. This finding aligns with studies that have demonstrated the effectiveness of ICT tools in promoting problem-solving abilities and higher-order thinking skills in mathematics (For instance Lee et al., 2020). Furthermore, a considerable number of teachers (60.1%) strongly agree that ICT tools in mathematics teaching allow for differentiation and personalized learning. This finding is supported by research that emphasizes the potential of ICT tools to cater to diverse student needs and provide individualized learning experiences (e.g., Ertmer & Ottenbreit-Leftwich, 2010).

However, there are variations in teachers' opinions regarding student-centered learning, exploration, and creativity. These variations suggest the need for further exploration and understanding of teachers' experiences, training, and support related to these aspects of ICT integration in mathematics instruction. Research has shown that effective implementation of student-centered learning, exploration, and creativity through ICT tools requires appropriate pedagogical training and support for teachers (e.g., Drijvers et al., 2010; Keengwe et al., 2008).

The majority of teachers (34.5%) strongly agree that the use of ICT tools enhances students' understanding of mathematical concepts. This finding aligns with previous research that has demonstrated the potential of ICT tools in providing visual

representations and interactive simulations, making abstract mathematical concepts more accessible and comprehensible to students (Hoyles et al., 2010).

A significant portion of teachers (66.6%) strongly agrees that ICT tools improve students' engagement and motivation in mathematics classes. This result is consistent with research that has shown how the use of technology, such as educational games and interactive apps, can increase student engagement and interest in learning mathematics (Drijvers et al., 2010; Shuler, 2009). Conversely, only 16.6% of teachers strongly disagree, suggesting that most teachers recognize the motivational potential of ICT tools in the mathematics classroom.

Regarding student-centered learning facilitated by integrating ICT tools, the data shows a more varied perception among teachers. The distribution of responses across the Likert scale indicates that opinions are not overwhelmingly positive or negative in this area. This finding may highlight the need for further investigation into the specific practices and approaches used by teachers when integrating ICT tools to promote student-centered learning.

Teachers generally hold positive views on ICT tools enhancing students' problem-solving skills, with a larger proportion (25.6%) agreeing, followed by 22.2% strongly agreeing. This outcome is in line with research that has demonstrated how ICT tools can provide opportunities for students to engage in exploratory and problem-solving activities (Wachira & Keengwe, 2011). The recognition of ICT tools as enhancers of problem-solving skills is essential, as problem-solving is a critical aspect of mathematical proficiency and real-world applications of mathematics. A considerable number of teachers (38.9%) strongly agree that ICT tools in mathematics teaching allow for differentiation and personalized learning, while 12.2% strongly disagree. This finding highlights the potential of ICT tools to cater to individual student needs and learning styles, which can be particularly beneficial in diverse classrooms (Mensah & Nabie, 2021).

However, the disagreement among some teachers indicates that challenges may exist in effectively implementing differentiation strategies using ICT tools. Opinions on ICT tools supporting the exploration and discovery of mathematical concepts are divided, with 38.9% agreeing and 21.2% strongly disagreeing. This result suggests that while some teachers see the value of ICT tools in facilitating exploration and discovery, others may not yet fully recognize their potential in this aspect of mathematics instruction.

The majority of teachers (66.7%) believe that ICT tools provide opportunities for collaborative learning in mathematics classes, while a smaller portion (16.6%) strongly disagrees. Collaborative learning with ICT tools can encourage students to work together, share ideas, and engage in group problem-solving, fostering a positive and supportive learning environment (Cuban et al., 2001). The disagreement from some teachers may indicate the need for further exploration of effective strategies for integrating ICT tools to promote collaborative learning in mathematics. Similar to engagement and motivation, a significant proportion (66.6%) strongly agrees that integrating ICT tools helps students develop critical thinking skills. This finding underscores the potential of ICT tools in fostering higher-order thinking and problem-solving abilities (Lim & Hang, 2003). The recognition of ICT tools as promoters of critical thinking is crucial, as critical thinking is a vital skill for students to develop in order to become mathematically literate and prepared for future challenges.

Summary

In summary, the data indicate that high school mathematics teachers in Ghana generally hold positive perceptions of the integration of ICT tools in mathematics instruction. However, variations exist regarding certain aspects such as student-centered learning, differentiation, exploration, and creativity. These findings highlight the importance of providing targeted training and support to teachers to enhance their understanding and implementation of ICT tools in these specific areas. The outcome also suggests that while some teachers recognize the potential of ICT tools to stimulate creativity and innovation, others may not fully embrace this aspect or have not yet explored the full range of possibilities.

CONCLUSIONS & RECOMMENDATIONS

Based on the findings and discussions, the following conclusions and recommendations can be made regarding professional development and support for the integration of ICT tools in mathematics instruction:

1. Professional development programs: Professional development programs specifically tailored for mathematics teachers should be provided to enhance their knowledge and skills in integrating ICT tools effectively. These programs should focus on training teachers on how to use specific tools, align them with the curriculum, and assess student learning. The programs should be ongoing and provide opportunities for hands-on practice, collaboration, and reflection.
2. Workshop and resource availability: Workshops and resources dedicated to the integration of ICT tools in mathematics instruction should be made readily available to teachers. These workshops should provide practical guidance and support, showcasing best practices and innovative approaches. Additionally, a repository of high-quality digital resources, lesson plans, and instructional materials should be established to assist teachers in implementing ICT tools effectively.
3. Technical support: Teachers should have access to technical support to address any technical difficulties or issues that may arise during the implementation of ICT tools. This support can be in the form of on-site technical assistance or a dedicated helpdesk that teachers can reach out to for troubleshooting and guidance. Quick and efficient resolution of technical problems will ensure smooth implementation of ICT tools and minimize disruptions in classroom instruction.
4. Pedagogical shift and teacher confidence: Teachers need support in making the pedagogical shift from traditional lecture-based instruction to student-centered and inquiry-based approaches. Professional development programs should provide

training and guidance on implementing student-centered learning, promoting exploration and creativity, and facilitating collaborative activities using ICT tools. Opportunities for teachers to collaborate, share ideas, and learn from each other's experiences should also be encouraged to build their confidence in integrating ICT tools effectively.

5. Research and evaluation: Continued research and evaluation should be conducted to investigate the impact of ICT integration in mathematics instruction. This research should explore the effectiveness of different ICT tools, instructional strategies, and approaches in improving student learning outcomes in mathematics. The findings from such research can inform the design and improvement of professional development programs and support initiatives.
6. Policy support: Policymakers and educational leaders should recognize the importance of ICT integration in mathematics instruction and provide the necessary policy support. This support can include allocating resources for professional development programs, establishing guidelines for the use of ICT tools in mathematics classrooms, and creating a supportive infrastructure for technology integration in schools.

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