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# The Perceptions versus Usage of Information and Communication Technology Tools Among High School Mathematics Teachers in The Northern Region of Ghana

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**Abstract:** This study explored the extent to which senior high school mathematics teachers in the Northern Region of Ghana use Information and Communication Technologies (ICTs) in teaching and learning mathematics. A descriptive survey design was employed for the investigation. Using a stratified sampling technique, 20 public high schools in the northern region of Ghana were selected for the study. A simple random sampling was used to select 100 teachers (i.e., 50 teachers from urban and 50 teachers from rural schools) from the 20 schools for the study. Questionnaires were used to collect data for the study. The findings revealed that the mathematics teachers' perceived knowledge of the benefits of ICT usage for instructional delivery, assessment, and professional learning networks in mathematics were low compared to their actual usage of the ICTs for the same purposes. The findings suggest that the participants utilize ICTs more for social networking than for instructional delivery, assessment, and professional development in mathematics. Further, the findings showed a positive relationship between the teachers' perceived knowledge of the benefits of ICTs usage for instructional delivery and their actual use of ICTs for instructional delivery. Mathematics teachers from urban schools use ICTs for all instructional purposes more than their peers from rural schools. Implications for ICT policies, teacher training, and professional development are provided.

**Keywords:** ICTs, Perceptions, Senior High School Mathematics Teachers, Mathematics Education, Ghana

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## Introduction

### Background

Information and Communications Technology (ICT) has become an integral part of all aspects of life in the last two decades and has transformed many sectors - including the educational sector (Abedi, 2023; Akram et al., 2022; Gnambs, 2021). Today, ICTs are increasingly used in education systems worldwide for instructional purposes (e.g., instructional delivery, student/teacher learning, assessment, and classroom management), and for administrative purposes (e.g., preparing administrative reports, textbook distribution, and taking students' attendance). Several previous studies have shown that the appropriate use of ICT can improve the quality of education and students' learning (e.g. Abedi, 2023; Jogezai et al., 2018; Liu et al., 2021; Viberg & Mavroudi, 2018; Xu et al., 2021). For example, with the availability of ICT tools, students can conduct independent research via the Internet to learn about current and specific topics of interest (Liu et al., 2021; Xu et al., 2021). ICT tools are also useful in helping students develop higher order thinking skills and increasing students' interest in specific school subjects such as mathematics (Abedi et al., 2023; Akram et al., 2021a; Chen et al., 2018).

The integration of ICT is also changing teachers' modalities of teaching and their pedagogical approaches – moving from teacher-centered to student-centered instruction, from traditional instruction to inquiry-based teaching, and adopting innovative assessment and feedback practices that enhance students' learning (Abedi, 2023; Chen et al., 2018; Liu et al., 2021; Ghana Ministry of Education [MoE, 2018]). Thus, by transforming the teaching environment into a learner-centered one, teachers are able to develop and implement innovative pedagogical approaches such as project-based learning, collaborative learning, inquiry-based learning, and use simulation tools to foster understanding, engagement, and motivation - thereby helping students develop relevant 21st- century skills that benefit themselves and society (Abedi, 2023; Liu et al., 2022; MoE, 2018; Viberg & Mavroudi, 2018).

The development and use of ICT tools are also enabling education systems and schools to provide inclusive education for students with disabilities and special needs in a safer environment (Alasuutari et al., 2020; World Bank, 2021, 2022). Specific examples include the provision of learning resources that allow special needs students to take part in learning interactions, offering opportunities for students to participate in classroom activities virtually when they cannot attend class in person, strengthening communities/families by providing them with out-of-school learning supports and training to facilitate education outside the school when needed, as well as, working with parents, and representative organizations to ensure they are involved in identifying the right ICT resources that will support their students in their communities (World Bank, 2021, 2022).

Another way ICT supports education is by bridging the divide between school and home by enabling schools/teachers to create online communities that foster communication between teachers and parents and among teachers from the same school and/or different regions. Communicating with parents can include disseminating information on the school website, communicating via e-mails, or through a dedicated online platform - such as school portals. It can also involve informing parents of their children's progress and difficulties, encouraging parents to help monitor their children's homework, and sharing tips/resources with parents to enable them to help their children with their homework assignments (Liu et al., 2022). All these allow for continuity of learning outside the school setting (World Bank, 2022).

**ICT Influence on Educational Policy Changes**

With the increasing importance of ICT tools in education (and the pressing need to equip students with digital competence to flourish in the present technological age), educational stakeholders and governments have been enacting policy in recent years to ensure that students are sufficiently skilled in using ICTs. In light of this, many educational systems have been restructuring their national curriculum to incorporate ICTs in education to develop students' ICT literacy (in general), and ICT competencies in specific subjects such as school mathematics (e.g., MoE, 2018; Vegas et al., 2019). Educational researchers have also been investigating factors that promote the effective use of ICTs for educational purposes, and examining questions on how students should engage with ICTs, the roles of ICTs in supporting different pedagogical and instructional practices, whether ICT tools are used by students/teachers mainly for learning, for social networking or leisure, and the implications different usages of ICTs have for students' proficiency in subjects such as mathematics (Abedi, 2023; Prestridge; 2017; Viberg & Mavroudi, 2018; Willermark, 2021).

**ICTs in Ghanaian Schools**

In Ghana, educational stakeholders and policymakers have moved remarkably in recent years towards introducing ICT into the Ghanaian education system at all levels of education to help teachers and students learn about ICTs, and to use ICTs to generate and share knowledge, as well as help students enhance their educational experiences (Abedi, 2023; MoE 2018; Tsapali et al, 2021). One of the major requirements of using ICT in educational reforms in Ghana was to ensure that all students in pre-tertiary institutions acquire basic ICT literacy skills (including efficient use of the Internet) and apply these in their studies, as well as in a variety of ways in their everyday life activities (Abedi, 2023; MoE, 2018). To this end, the government of Ghana (in collaboration with the Ministry of Education), has implemented measures to ensure that students in the Senior High School (SHS) have access to ICT resources to support their education (MoE, 2018). The maiden 2003 *ICT for Accelerated Development* (ICT4AD) and the 2015 *ICT in Educational Policies* are examples of such programs in Ghana that utilize ICTs to enable all Ghanaians, no matter where they live, to pursue high-quality, long-term educational opportunities intended to transform their lives, the educational sector, and the nation (MoE, 2018).

Consequently, ICTs are now expected to play a significant role in instructional practices in Ghanaian classrooms - ranging from teachers using ICT tools to search and adapt educational resources for students to using them in transforming their pedagogical practices towards constructivists approaches that promote deeper students' learning (Abedi et al., 2023). The availability of ICT tools also make it possible for teachers to provide grades and assessment reports for students, and for students to access their grades and other educational information from the comfort of their homes using the Internet. With this greater emphasis and investment, ICT education has been made a mandatory (core) subject for all SHS students in Ghana (MoE, 2018). Several studies (e.g., Abbasi et al., 2021; Abedi et al., 2023; Asad et al., 2021; Willermark, 2021) however, observed that despite the increased investment and policy recommendations for ICTs use in schools, there has not been a substantial change in teachers' pedagogical practices in using ICTs for teaching and learning. Instead, most teachers don't use ICTs in their classrooms at all, or for some who use ICTs, use them as an add-on in ways that only reflect/reinforce the traditional ways of teaching (Abedi et al., 2023; Engel & Coll, 2022; Li et al., 2019; Prestridge, 2017). In particular, Prestridge (2017) noted that the technology use of most teachers often revolves around replicating traditional and/or administrative tasks, rather than bringing about considerable change in student learning.

While many studies attributed the lag in ICT use for education in developing countries, including Ghana to inadequate ICT facilities in schools, poor internet connectivity, and unstable power supply (Aikins & Arthur-

Nyarko, 2019; Akram et al., 2021a), others noted that teachers' capacity to use ICT resources for teaching and learning depends on several other factors, including teachers' perceptions of the importance of ICTs in enhancing teaching and learning, teachers' ICT know-how and pedagogical competence in using these ICT resources, and the presence/absence of enabling environments such as school management support and cultural contexts that support the use of ICTs in schools (Abbasi et al., 2021; Abedi et al., 2023; Akram et al., 2022; Arhin et al., 2024; Asad et al., 2021). Aikins and Arthur-Nyarko (2019) pointed to unavailability of ICT resources and other related technologies such as Open Educational Resources (OER), reliable Internet, computer-assisted and television-assisted instructional programs, and constant power outage as some of the barriers to ICT use in Ghanaian classrooms. They observed, for example that, most Ghanaian schools in the rural areas have a computer-per-student ratio of about 1:150 (compared to 1:15 in most developed countries).

Studies by Buabeng-Andoh (2019), Abedi et al. (2023), and Arhin et al. (2024) investigated barriers to meaningful integration of ICTs in Ghanaian classrooms - with particular attention to teachers' capacity and nature of their technology integration practices. For example, Abedi et al. (2023) examined the perceptions of teachers, headteachers, and education officials in Ghanaian schools on the underlying beliefs that shape their decision-making and thinking regarding technology integration. Their findings indicated that while teachers are enthusiastic about using technology, their main beliefs for technology use are rooted in the notions of convenience and the extent to which it can support or supplement teachers' regular teacher-centered practices. Only a few of the participants alluded to the power in teachers' use of technology to engage students in authentic and collaborative learning and facilitate new ways of learning. These findings suggest that when deciding to use technology, most teachers do not prioritize constructivist pedagogy for knowledge creation, independent and deep student learning over basic traditional uses of ICTs for information retrieval, delivery and consumption, and skills acquisition.

**Research Questions**

The purpose of this study, therefore, was to explore the extent to which senior high school mathematics teachers in the Northern Region of Ghana perceive and use ICTs in teaching and learning mathematics. Specifically, this study examined SHS mathematics teachers' perceived knowledge of the benefits of ICTs in mathematics education, and their actual use of ICT tools for teaching and learning mathematics. It also explored the differences in the use of ICT tools between mathematics teachers in urban and rural schools in the region. Five questions guided this study:

1. How do SHS mathematics teachers in the northern region of Ghana perceive ICT tools in enhancing mathematics education?
2. How do SHS mathematics teachers in the northern region of Ghana actually use ICTs tools in mathematics education?
3. To what extent are there differences between the mathematics teachers' perception of the benefits of ICTs in mathematics education and their actual use of ICTs for teaching and learning mathematics?
4. To what extent are there differences between the mathematics teachers' actual use of ICTs for teaching and learning mathematics based on Age and Teaching Experience?

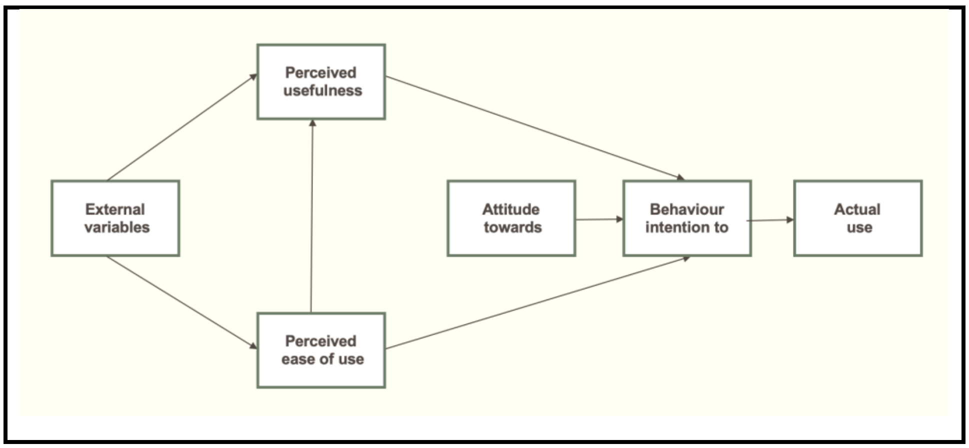
5. To what extent are there differences in the use of ICT tools for teaching and learning mathematics between urban and rural SHS mathematics teachers in the region?

## Theoretical Framework

This study draws on the Technology Acceptance Model (TAM) framework by Davis et al. (1989) to examine Ghanaian SHS mathematics teachers' perceived knowledge of the benefits of ICTs in mathematics education, and their actual use of ICT tools for teaching and learning mathematics. TAM was developed with the primary aim of identifying factors that explain why and how individuals use information technology, and why a user accepts or rejects information technology. Figure 1 presents the various components of TAM.

**Figure 1**

*Technology Acceptance Model (Davis et al., 1989)*




There are five major components of TAM: actual system use (ASU), behavioral intention to use (BIU), attitude towards use (ATU), perceived usefulness (PU), and perceived ease of use (PEU). ASU, which is the main variable in TAM, is defined as an individual's observable usage of a particular system. ASU is a direct function of behavioral intention to use (BIU) technology – describing the degree to which a person has made a conscious plan to execute or not to execute some explicit future behavior. BIU is in turn, a function of attitude towards using (ATU) and perceived usefulness (PU). ATU is a person's positive or negative sentiment about executing a target behavior, while PU is the extent to which a person perceives a particular system to enhance their job performance (Davis et al., 1989). According to Figure 1, PU is influenced by perceived ease of use (PEU) – which describes an individual's perception of the needed effort in using a particular technology. Davis et al. (1989) contended that if individuals find a particular technology system useful (i.e., having PU) and easy to use (i.e., having PEU), then they will develop a positive attitude towards using (ATU) that technology system. All these will eventually lead to the behavioral intention to use (BIU) the technology, and results in the actual use of it (ASU).

**Conceptual Framework**

Using Davis et al. (1989) TAM framework along with the objectives of the present study, the researchers develop the following conceptual framework to examine mathematics teachers' perceived knowledge of the benefits of ICTs in mathematics education and their actual use of ICTs for the purposes of teaching and learning (i.e., instructional delivery, assessment, social networking, and professional learning network).

**Figure 2**

*A Conceptual Framework of ICT use by Mathematics Teachers*

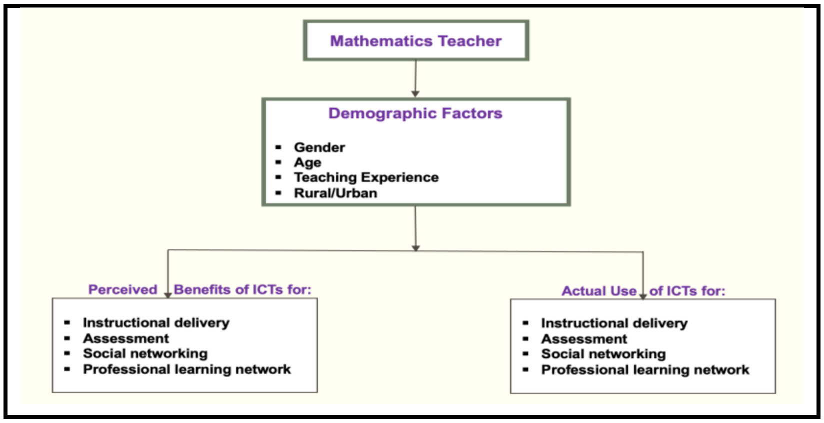



Figure 2 explains the conceptual framework used to determine how the mathematics teachers in this study perceive the benefits of ICTs and how they actually use ICT to enhance mathematics education. As displayed in the figure, the perceived benefits and actual uses of ICTs classify into *Instructional Delivery*, *Assessment Purposes*, *Social Networking*, and *Professional Learning Network* in mathematics. In particular, a mounting body of research points to the fact that teachers use ICT tools to enhance instructional delivery, assessment, social networking with colleagues, and for their own professional development (Abedi, 2023; Chen et al., 2018; Hooft-Graafland, 2018; Liu et al., 2022). Abedi (2023) indicated that the integration of ICT enable teachers to modify their teaching and pedagogical approaches from teacher-centered to student-centered instruction, and implement innovative pedagogical approaches such as project-based learning, collaborative learning, and inquiry-based learning that foster understanding, engagement, and motivation. This shift in in instructional delivery creates a more interactive and engaging environment for teachers and students, and thus, transforms the role of the teacher from a knowledge transmitter to a facilitator and a co-learner in the classroom (Abedi, 2023; Chen et al., 2018; Hooft-Graafland, 2018).

Teachers' use of ICTs also revolves around assessing students, adopting innovative assessment and feedback practices that enhance students' learning, and communicating assessment outcomes with parents and students (Chen et al., 2018; Liu et al., 2021; MoE, 2018). With ICTs, many mathematics teachers now use electronic reporting systems to process examination data and communicate results more quickly to students (Akram et al., 2022; MoE, 2018). ICTs also enable teachers to communicate with parents via e-mails, or through dedicated online school portals to inform parents of their children's progress and difficulties, encourage them to help monitor their homework assignments, and provide resources and support to parents to help their children do their homework (Liu et al., 2022; MoE, 2018; World Bank, 2022). With the proliferation of online resources and opportunities, the 21st-century has also seen a shift in the types of places, spaces, and modes of learning that were previously available. Teachers can now use ICTs to support their own professional learning outside of the classroom by engaging in supportive communication and collaboration with their peers ( Liu et al., 2022; MoE, 2018; World Bank, 2022). Mathematics teachers can benefit from the expertise of thousands of mathematics teachers worldwide by participating in professional learning networks (PLNs) – which have been shown to be very beneficial to teachers' professional development (Brown & Poortman, 2018; Poortman et al., 2021).

Social networking among teachers has also grown in popularity due to the widespread use of ICT - friends from both within and outside the school community can connect using ICTs (Hussain, 2018; Jogezai et al., 2021; Liu et al., 2022; Thaheem et al., 2021). Teachers and students spend substantial time on social networking sites such as Facebook, Twitter, WhatsApp, Instagram, and YouTube - mainly for entertainment or leisure. Teachers are often seen chatting and downloading music/videos on their phones in the classrooms (Akram et al., 2022; Hussain, 2018; Thaheem et al., 2021). The intended educational use of ICTs has been reported to frequently overlap with recreational use with some researchers wondering the extent to which social networking impacts educational productivity because of the length of time teachers spend on social networking sites (Hooft-Graafland, 2018; Martin et al., 2018). Many studies have highlighted the negative effect of so-called "digital distractions" on teachers' and students' productivity (e.g., Hooft-Graafland, 2018; Martin et al., 2018) due to the amount of time they spend on social media platforms. It is, therefore, not clear from the available literature about the 'what' and 'how' of ICT use by mathematics teachers in Ghanaian SHS mathematics classrooms. Could mathematics teachers use ICTs for social or recreational activities instead of for professional purposes? To inform tailored professional learning programs that can improve mathematics teachers' use of technology to foster learning engagement, it is essential to understand the perceptions that drive SHS mathematics teachers' decisions and thinking about technology use in mathematics classrooms. This constitutes the impetus for this study.

## Methods

### Research Design and Participants

This study employed a descriptive survey design using questionnaires to collect data on SHS mathematics teachers' perceived knowledge of the benefits of ICTs in mathematics education and actual use of ICT tools for teaching and learning mathematics (i.e., instructional delivery, mathematics assessment, professional learning, and social networking). Using a stratified sampling technique, 20 public high schools in the northern region of Ghana were selected for the study. A simple random sampling was then used to select 100 teachers from the 20 schools for the study. The teachers selected were 50 from urban and 50 from rural. There were 67 male teachers and 33 female teachers. The average age of the participants was approximately 34 years - ranging between 25 and 53 years. The average teaching experience of the participants was approximately 5 years - ranging from as low as 1 year to 26 years. Table 1 contains some demographic information on the participants.

**Table 1**

*Demographic Information of SHS Mathematics Teachers*

| Variable | Category | Frequency | % |
|---|---|---|---|
| Gender | Male | 67 | 67.0 |
| | Female | 33 | 33.0 |
| | Total | 100 | 100.0 |
| Age | 20-30 years | 38 | 38.0 |
| | 31-40 years | 50 | 50.0 |
| | 41-50 years | 11 | 11.0 |
| | 51-60 years | 1 | 1.0 |
| | Total | 100 | 100.0 |
| Teaching Experience | 1 - 5 years | 61 | 61.0 |
| | 6 years and above | 39 | 39.0 |
| | Total | 100 | 100.0 |
| Average ICT Usage Time | None | 3 | 3.0 |
| | 1 – 5 hours | 55 | 55.0 |
| | 6 hours or more, but less than 10 hours | 23 | 23.0 |
| | 10 hours or more | 19 | 19.0 |
| | Total | 100 | 100.0 |

Source: Field Data, Dogbey & Kpadin (2023)

### Data Collection Instrument

All the participants completed the questionnaire on perceived knowledge of the benefits of ICT and ICT usage for mathematics education. Items on the questionnaire were adapted from Lichty (2000), Sahin and Thompson (2006), and Srisurichan's (2012) instruments on teacher's level of ICT usage. The questionnaire used in this study consisted of 3 sections. The first section (*Section A*) consisted of 35 questions about the participants' perceived knowledge of benefits of ICTs in mathematics education. The second section (*Section B*) consisted of 40 questions about the participants' actual usage of ICT in teaching and learning mathematics. The last section (*Section C*) consisted of 4 questions about the participant's demographic profile such as gender, educational qualification, age, and years of teaching experience. A standard five-point Likert scale format was adopted for the questionnaire. These are: 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree) to collect the participants' responses to the questions in sections A and B of the questionnaire.

### Data Analysis

The data from the questionnaire were analyzed using mean, standard deviations, dependent t-test, independent t-test, and one–way analysis of variance (ANOVA). Correlation analysis was also conducted to explore relationships between SHS mathematics teachers' perceived knowledge of ICT usage and their actual use of ICTs with respect to age and teaching experience classifications.

# Results

## Perceived Knowledge and Actual Usage of ICTs

For the study, teachers' perceived knowledge of the benefits of ICTs in mathematics education and the actual usage of ICTs for teaching and learning mathematics were measured in terms of four main categories: *Instructional Delivery*, *Assessment*, *Professional Development/Networking*, and *Social Networking*. The following are sample of items in each category: *Instructional Delivery* (e.g., to explore mathematics concepts like graphs, to facilitate teaching through PowerPoint presentations, to store instructional resources, to enhance students authentic learning, to enhance collaborative learning, to promote students participation/motivation, to enhance students 21$^{st}$-century skills, to adhere to national curriculum requirement, etc.), *Professional Development/Networking* (e.g., to learn and solicit help from other professionals, to enhance one's content/pedagogical knowledge through researching different topics, to research on lesson planning, to enhance personal ICT skills, to share and receive resources from colleagues, to demonstrate knowledge through helping others, etc.), *Assessment* (e.g., to assign homework, to present assessment tasks, to prepare exams, to grade homework/exams, to provide feedback to students/parents/stakeholders, for diagnostic assessment, for formative assessment, etc.), *Social Networking* (to browse the Internet, to network with friends and family, for entertainment/pleasure, to be abreast with trending issues, to publish content, etc.).

To examine the data on how the participants rate the various perceived knowledge of the benefits of ICTs in mathematics education, means and standard deviations were calculated for the perceived knowledge of the benefits of ICT usage types. In general, the results indicated that the SHS mathematics teachers' overall perceived knowledge of the benefits of ICTs usage types was low ($M$ = 2.73, $SD$ = 0.51). Results from the comparisons among the various perceived usage types indicated that the participants' perceived knowledge of the benefits of ICT tools for social networking to enhance mathematics education had the highest mean score ($M$ = 3.86, $SD$ = 0.97). There was lower perceived knowledge of the benefits of ICT tools for instructional delivery ($M$ = 2.55, $SD$ = 0.82), professional learning networks ($M$ = 2.39, $SD$ = 1.08), and assessment ($M$ = 2.10, $SD$ = 0.74) to enhance mathematics education.

**Table 2**

*Means & Standard Deviations of Participants' Perceived Knowledge and Actual Usage of ICT Types*

| *ICT Perceived & Usage* | | Perceived Knowledge | | Actual Usage | |
|---|---|---|---|---|---|
| | *N* | *M* | *SD* | *M* | *SD* |
| Social Network | 100 | 3.86 | 0.97 | 4.36 | 0.75 |
| Instructional Delivery | 100 | 2.55 | 0.82 | 4.20 | 0.89 |
| Professional Network | 100 | 2.39 | 1.08 | 4.13 | 0.83 |
| Math Assessment | 100 | 2.10 | 0.74 | 4.21 | 0.89 |

In terms of the overall actual usage of ICT types to enhance the teaching and learning of mathematics, however, the results indicated an overall high usage ($M$ = 4.23, $SD$ = 0.68) for the combined ICT usage types (i.e., instructional delivery, professional learning networks, assessment, and social networking). Similar to the results from the perceived knowledge types, the most actual usage of ICT type reported by participating teachers was for social networking ($M$ = 4.36, $SD$ = 0.75). This was followed by assessment purposes ($M$ = 4.21, $SD$ = 0.89), instructional delivery ($M$ = 4.20, $SD$ = 0.89) and professional learning network ($M$ = 4.13, $SD$ = 0.83). Contrary to the results from the teachers' perceived knowledge of the benefits of ICTs in mathematics education for each of the usage types that were relatively low, the mean scores from each of the actual ICTs usage types were relatively high: social networking ($M_{perceived}$ = 3.86 vs. $M_{actual}$ = 4.36), assessment ($M_{perceived}$ = 2.10 vs. $M_{actual}$ = 4.21), instructional delivery ($M_{perceived}$ = 2.55 vs. $M_{actual}$ = 4.20), and professional learning network ($M_{perceived}$ = 2.39 vs. $M_{actual}$ = 4.13).

**Difference Between Perceived Benefits of Use and Actual Usage of ICT Tools**

To determine if there was a statistical difference between the mean scores of the overall perceived knowledge of the benefits of ICTs in mathematics education and the overall actual usage of ICTs for teaching and learning mathematics, a dependent t-test was conducted. The result showed that the mean score of the overall actual usage of ICT tools ($M$ = 4.23, $SD$ = 0.68) was significantly higher than the mean score of the perceived knowledge of the benefits of ICTs ($M$ = 2.73, $SD$ = 0.51), $t(198)$ = 17.65, $p < .0001$, with a high effect size (Cohen's $d$ = 1.68).

**Relationships Between the Respective Perceived Benefits and Actual Usages of ICT Tools**

A correlational analysis was conducted to explore the relationship among the various usage types (i.e., perceived knowledge of the benefits versus actual use of ICT tools in mathematics education) for social networking, instructional delivery, mathematics assessment, and professional learning networks. The results of the correlation analysis are presented in Table 3.

**Table 3**

*Correlations between perceived knowledge use type and actual usage of ICT*

| Key Variables | Actual Usage | | | |
|---|---|---|---|---|
| Perceived Usage | Social Network | Instructional Delivery | Professional Network | Math Assessment |
| Social Network | -0.09 | | | |
| Instructional Delivery | | 0.27* | | |
| Professional Network | | | 0.13 | |
| Math Assessment | | | | 0.22* |

Notes. *N*'s range from 92 to 100 due to occasional missing data. * $p < .05$.

The results indicated that the correlation between SHS mathematics teachers' perceived knowledge of the benefits of ICTs in mathematics education for instructional delivery and their actual usage of ICT for instructional delivery was positive and statistically significant ($r = 0.27$, $p < 0.05$), implying that there was a strong alignment between the participants' perceptions about the use of ICTs for instructional delivery in mathematics and how they actually used it in their instructional delivery practices. Similarly, there was a positive and statistically significant relationship between SHS mathematics teachers' perceived knowledge of the benefits of ICTs in mathematics education for assessment and their actual usage of ICT tools for assessment ($r = 0.22$, $p < 0.05$). The data also showed a negative relationship between teachers' perceived knowledge of the benefits of ICTs in mathematics education for social networking and their actual usage of ICT tools for social networking ($r = - 0.09$, $p > 0.05$), but this relationship was not statistically significant. Finally, the analysis revealed that the correlation between SHS mathematics teachers' perceived knowledge of the benefits of ICTs in mathematics education for professional learning networks and their actual usage of ICT tools for professional learning networks was positive, but also not statistically significant ($r = 0.13$, $p > 0.05$).

**Differences in the Various Uses of ICT Tools by Age Group**

To determine if younger SHS mathematics teachers (i.e., participants who are 30 years or younger) use ICT tools more/less than older SHS mathematics teachers (above 30 years) for the various uses of ICTs (i.e., instructional delivery, assessment, professional learning network, and social networking) in mathematics education, a one-way ANOVA was conducted. The results showed a statistically significant difference between the participants' actual usage of ICTs for social networking and age ($F = 5.328$, $p = 0.002$) - suggesting that the younger teachers (30 years or younger) used ICT tools more often for social networking than the older teachers (older than 30 years). There was, however, no statistically significant difference between the participants' actual ICT usage for instructional delivery, assessment, and professional learning network for teaching/learning mathematics for the two age groups.

### Differences in the Various Uses of ICT Tools by Teaching Experience

Similarly, to determine if SHS mathematics teachers with relatively fewer years of teaching experience (i.e., 1-5 years of teaching) use ICT tools more/less than the more experienced teachers (above 5 years of teaching) for the various uses of ICTs (i.e., instructional delivery, assessment, professional learning network, and social networking) in mathematics education, a one-way ANOVA was conducted. The results indicated a statistically significant difference for actual ICT usage for assessment and teaching experience ($F = 3.048$, $p = 0.021$) - suggesting that SHS mathematics teachers with fewer years of teaching experience (i.e., 1-5 years of teaching) use ICT tools for assessment more than the teachers with more years of teaching experience (above 5 years of teaching) for the same purpose. There was no statistically significant difference in the usage of ICTs between the less experienced teachers (i.e., 1-5 years of teaching) and the more experienced teachers (above 5 years of teaching) for instructional delivery, social networking, or professional networking.

### Differences Between Rural and Urban Teachers Use of ICTs for Mathematics Education

To determine if there was a statistical difference between rural and urban teachers' use of ICT tools for teaching and learning mathematics, an independent t-test was conducted. The result showed that the mean score of urban teachers' use of ICT tools for teaching and learning mathematics ($M = 4.32$, $SD = 0.39$) was significantly higher than the mean score of rural teachers' use of ICT tools for teaching and learning mathematics ($M = 4.04$, $SD = 0.28$), $t(98) = 4.09$, $p < .0001$, with a high effect size (Cohen's $d = 1.14$) in the Northern Region of Ghana.

## Discussions, and Conclusions

Recent educational reforms in Ghana (just like in many systems worldwide) have placed significant emphasis on ICTs as a crucial accelerator to improving educational outcomes and preparing students for the $21^{st}$-century economy (MoE, 2018). To this end, the government of Ghana has invested into the expansion of technological infrastructure in schools, enacted ICT policies, and implemented other programs to promote technology integration for teaching and learning at all sectors of education. Following the country's ICT in education policies (MoE, 2018), the SHS curriculum has been revised to require teachers to utilize ICTs as pedagogical tools to transform their classroom practices: changing from teacher-centered pedagogies to student-centered or social constructivist teaching and learning approaches.

While many have applauded these efforts and policy intentions of the government, others have expressed concerns that these policies are only conceived in theory, and that the necessary enabling environments are not in place to translate them into practice (Aikins & Arthur-Nyarko, 2019; Tsapali et al., 2021). Among others, critics pointed to inadequate ICT facilities in schools, poor internet connectivity, unstable power supply, and poor teacher ICT knowledge for education (Aikins & Arthur-Nyarko, 2019; Akram et al., 2021a).

Similar to the lack of resources and enabling environment, researchers have identified “teachers’ capacity” as one of the most important factors influencing their ability to translate ICT policies into classroom practice in senior high schools. Several researchers (e.g., Abbasi et al., 2021; Abedi et al., 2023; Akram et al., 2022; Arhin et al., 2024; Asad et al., 2021) noted that teachers’ capacity to use ICT resources for teaching and learning depends on factors such as their perceptions about the importance of ICTs in enhancing teaching and learning, and their pedagogical competence in using these resources. In efforts to understand how SHS mathematics teachers in the northern region of Ghana (one of the less-resourced regions in the country) view ICTs tools as a resource for enhancing teaching and learning of mathematics and the extent to which they use them, this study examined how SHS mathematics teachers in the region perceive the benefits of ICTs integration in mathematics education, and how they employ ICTs in teaching and learning mathematics.

The study discovered that the participants have very low perceptions on how ICT integration enhances mathematics education ($M = 2.73$, $SD = 0.51$). On the contrary to their low perception, they employ ICT tools relatively higher in teaching and learning mathematics ($M = 4.23$, $SD = 0.68$). The study also found that the participants use ICTs more for social networking than for instructional delivery, assessment, and professional development. Further, the findings revealed a positive and significant association between the participants’ perceived knowledge of the benefits of ICTs in mathematics education and their actual use of ICTs for *instructional delivery* ($r = 0.27$, $p < 0.05$). A similar association was observed between the participants’ perceived knowledge of the benefits of ICTs and their use for assessment purposes ($r = 0.22$, $p < 0.05$) in mathematics education. Younger and less experienced (in terms of years of teaching) participants use ICT tools more for *social networking* and *assessment* than their older and more experienced peers. The result also showed that the participants from urban schools in the region use ICT tools for teaching and learning mathematics more than their peers from schools in rural areas: $t(98) = 4.09$, $p < .0001$.

These results agree with prior findings (Amuko, Miheso & Ndethiu, 2015) that many mathematics teachers have poor knowledge on the benefits and use of ICT for enhancing teaching and learning. Given that the participants have very low perceptions on how ICT integration enhances mathematics education, such findings can be used to plan suitable and targeted interventions for mathematics teachers in the region to improve their ICT integration. For example, the government of Ghana, in collaboration with the MoE and the local school districts, can organize workshops/seminars that provide information and awareness to mathematics teachers in the school districts on the potential benefits and expected outcomes of the implementation of effective school-based ICT policies that align with national ICT policy objectives.

The findings also suggested that the SHS mathematics teachers utilize ICT more for social networking than for instructional delivery, assessment, and professional development in mathematics. The fact that the participants think that using ICT for social networking will enhance mathematics teaching and learning more than using it for instructional delivery, assessment, and professional development will enhance mathematics education was troubling. In light of this finding, one wonders which specific usage(s) of ICT for social networking the participants think will enhance teaching and learning. The results also pointed to age-related differences in the usage of ICTs for social networking and assessment. In particular, the younger and less experienced mathematics teachers in this study reported using ICT tools more for social networking and assessment than their older and more experienced peers. Thus, it appears that recent teacher graduates are more likely to have more access, knowledge, experience, and facility in using ICT tools than teachers who graduated from their training over a decade ago due to increased opportunities to engage with ICT tools during their training. This result can provide guidance for training and professional development needs for mathematics teachers in the region (i.e., in situations where there are limited resources for everybody, and decision must be made on which group has the higher professional development needs). Professional development in this area can be in the form of periodic workshops, seminars, targeted interventions, and in-service training to update teachers' knowledge and skills in ICT, and to help them became more conversant with ICTs for education (Abedi et al., 2023; Akram et al., 2022).

The results also point to differences between ICT usage by teachers from rural and urban schools. That is, participants from urban schools in the region use ICT tools for teaching and learning mathematics more than their peers from schools in the rural areas. Prior findings pointed to vast disparity in ICT recourses between rural and urban areas (Akram et al., 2022). Without these resources, schools in rural areas will always lag in implementing ICT initiatives. To address this, the government must ensure sufficient ICT resources in all schools, particularly, in the rural and remote areas of the country where these resources are scanty or non-existing. Additionally, since the integration of ICTs in mathematics education could also initially require a substantial time and effort investment on the part of teachers in preparing course materials, on how to manage the class during ICT usage (e.g., how to maintain a quiet, peaceful, and respectful classroom in which students can concentrate on the academic tasks and listen to the teacher and other students), and on how to measure the success of teaching approaches that employ ICTs for instructional delivery (Redecker, 2017; OECD, 2020), it is essential that teachers are allowed the flexibility in their teaching schedule to have time to experiment ideas, discuss ideas with colleagues, and contemplate without being penalized for not achieving the best results.

To conclude, it is worth pointing out in a broader sense that, although this study was conducted in Ghana, the researchers believe that its findings may not be unique to Ghanaian high school mathematics teachers only but can be applied to countries with comparable educational landscapes working towards a more impactful ICT integration. Thus, these results have the potential to inform discussions and initiatives in other countries with similar ICT integration challenges to address ICT policies, integration, and other practical issues to enhance mathematics education. Thus, these suggestions, coupled with sufficient ICT resources in schools, have the potential to support teachers in implementing classroom practices and fostering better alignment between national ICT policy recommendations and ICT integration in the classroom.

One of the limitations of the present study is that it relied solely on teachers' self-report on their perceived knowledge of the benefits of ICTs in mathematics education, and their actual use of ICTs for teaching/learning mathematics. While self-report data have a great potential to provide valid and reliable information, the researchers recognize that this type of data can sometimes be problematic in accurately capturing reality (Boyle et al., 2022) - as self-reported data often reflect personal convictions and social preferences, which may contain prejudices. Future research may expand on the scope of research methods to include on-site classroom observations to explore some of the issues investigated in this study, more accurately.

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