ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XI Issue V May 2024

Exploring Senior High School Teachers' Technological Pedagogical Content Knowledge in The Greater Accra Region of Ghana.

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DOI: https://doi.org/10.51244/IJRSI.2024.1105006

Received: 04 April 2024; Revised: 16 April 2024; Accepted: 27 April 2024; Published: 30 May 2024

ABSTRACT

The study explored Senior High School teachers' level of Technological, Pedagogical and Content Knowledge (TPACK) in Senior High Schools in the Greater Accra Region and examined the differences in teachers' level of TPACK on the basis of some demographic variables using the mixed methods approach. The study employed sequential explanatory mixed methods design. Simple random sampling technique was used to select 248 teachers and proportionate sampling technique was also used to select the participants for the interview session. Questionnaire was used to gather quantitative data whilst interview guide was used to gather qualitative data. Mean and standard deviation was used to examine teachers' level of TPACK. Moreover, Independent samples t-test was used to examine whether differences exist in teachers' TPACK and gender. One-way (ANOVA) was used to examine whether differences exist in teachers' TPACK based on age, teaching experience and academic qualification. The thematic analyses of the qualitative data were done to explain the teachers' moderate level of TPACK. The finding showed that teachers possessed higher Content, Pedagogical and Pedagogical Content Knowledge and moderate Technological Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge and TPACK. The study found that there was statistically significant difference in teachers' TK, TCK and gender in favour of the male teachers. The study concluded that teachers' moderate Technological Knowledge did not reflects in teaching and had negative toads on the use of emerging technologies. The study recommended that the Ministry of Education through GES and government should organise refresher courses for in-service teachers on technology integration in teaching.

Keywords: Content Knowledge; Pedagogical Knowledge; Pedagogical Content Knowledge; Educational Technology; Information and Communication Technology; Technological Content Knowledge; Technological Knowledge; Technological Pedagogical Content Knowledge Technological Pedagogical Knowledge

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INTRODUCTION

The use of technology in schools in recent years has become an important priority in both developed and developing countries (Jhurree, 2005). Technology in education is gradually changing the traditional methods of teaching whereby teachers deliver instructions to the students without the aid of technology (Guthrie & Evans, 2013). The use of technology in Education makes the teaching easy for both teachers and students (Blankley, Kerr & Wiggins, 2018). The use of ICT in teaching can raise the quality of education and make the lessons relevant to real life situations, assist learners to understand even the difficult concepts (Nyambane & Nzuki, 2014; Anyanwu, 2014). In addition, the integration of technology in teaching can assist the learners to acquire the skills and knowledge needed to survive in a complex, highly technological World (Iivari, Sharma & Ventä-Olkkonen, 2020).

The use of technology in teaching is not merely by using ICT resources (Manzano, 2023) Teachers need to consider the connections of technology integration to content and pedagogy, which is commonly known as technological pedagogical content knowledge (TPACK). Mishra and Koehler (2006) defined technological pedagogical content knowledge as a framework on the interrelatedness of technology, content, and pedagogy for developing good teaching. However, Govender and Govender (2014), as cited in Liu et al. (2015), chronicled that "most teachers with access to technology and competency skills in computers fail to integrate technology in their teaching" (p. 161). Manzano (2023) found that need for effective ICT integration requires well-trained individuals to use 21st-century technology knowledge vis-à-vis content and pedagogy to measure teachers' efficacy in integrating technology.

Technology has become important part of students' lives within the classroom and beyond. In the classroom, it assists in increasing students understanding of complex concepts and encourage collaboration among them (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012).The use of educational technology has had a profound effect on teachers' access to and dissemination of information. A study by Tarhini, Hone, Liu and Tarhini (2017) showed that the use of educational technology in teaching improves student participation in the lessons, arouse students interest, increases the professional knowledge of teachers and enables teachers to plan and execute quality teaching. Technology can help teachers meet the individual needs of students, provides alternate ways to represent curriculum to facilitate teaching (Ertmer et al., 2012). Technology assists students develop critical thinking and problem-solving skills, promotes collaboration and lifelong learning among students (Akinlove, Adu, Adu & Olawumi, 2020; Hawedi & Abdullah, 2020; Qaddumi, Bartram & Qashmar, 2021). Modern teachers need to incorporate technology into their teaching in order to become effective and efficient teachers (Ghavifekr & Rosdy, 2015).

Buabeng-Andoh (2012), indicated that the significance of technology in education has led many Governments to invest in information and communication technology infrastructure in education to improve teaching and learning. The use of educational technologies has become a natural part of classroom life as it enhances learning, facilitates problem-solving, communication, research skills, and decision-making processes (Tang, Vezzani & Eriksson, 2020). Several researchers (Chee, Yahaya & Ibrahim, 2017) noted that effective use of technologies during instructional delivery could transform the traditional teaching and can assist in preparing students to acquire the knowledge required in this 21st century.

Studies conducted by some Scholars (Abdulai, 2021; Mensah, Poku & Quashigah, 2021) showed that most Ghanaian Senior High Schools, teachers do not use ICT in their classroom instruction. This is believed to be due to teachers' lack of specific knowledge on technology, content, pedagogy and how this knowledge interact to ensure effective teaching (Agyei & Voogt, 2012). Moreover, teachers can integrate technology into their instruction only if they are technology competent professionals (Can et al., 2017; Sanchez & Sarmiento, 2020). Teachers would be capable and competent in integrating ICT into their teaching, given

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that they acquire the necessary knowledge to teach with technology (Apau, 2017).

Scholars (e.g., Afari-Kumah & Tanye, 2009; Chidiebere, 2020; Ugwuogo, 2013) claim that underutilisation of technologies is due to inadequate knowledge and skills of teachers on how to operate them. Gómez-Trigueros & Yáñez de Aldecoa, 2021; Tseng, Chai, Tan & Park, 2020) showed that teachers have inadequate knowledge in TPACK. Malubay and Daguplo (2018) conducted a cross-sectional correlation study to investigate secondary mathematics teachers' technological pedagogical content knowledge. According to the result, mathematics teachers with technological pedagogical content knowledge in technology and integration are generally novice, young, and single female teachers who are also knowledgeable in content and pedagogy. However, when Keçeci and Zengin (2017) observed the TPACK of science teacher candidates, they revealed that the teacher candidates' technological pedagogical content knowledge level was moderate

In Ghana, Yalley (2016) paid attention to Social Studies teachers whilst Mensah, Poku, Quashigah (2021) focused on geography teachers. These studies found that teachers had good content and pedagogical knowledge but low technological knowledge hence integration of technology in teaching and learning was low. The missing link is knowledge about senior high school teachers in general TPACK, which serve as the focus of this current study. There are also inconsistencies in the findings about the influence of teachers' demographic characteristics (gender, age, teaching experience and educational qualification) on their level of TPACK.

Also, the review indicated that most of the international studies examined the influence of teachers' demographic variables on TPACK and came out with conflicting findings. For instance, some researchers (Chai et al., 2016; Jang & Tsai, 2013a; Koh et al., 2014; Ozudogru & Ozudogru, 2019a) found that demographic variables (e.g., gender, age, teaching experience and level of education had a significant influence on teachers' level of TPACK. However, other researchers (Hsu et al., 2017a; Koh et al., 2014; Özgür, 2020) found that gender, age, teaching experience, level of education do not influence teachers' level of TPACK.

The review of literature also revealed that studies on teachers' level of TPACK and the influence of their demographic variables have received little attention (Castéra, Marre, Yok, Sherab, Impedovo, Sarapuu & Armand, 2020; Nelson, Voithofer & Cheng, 2019). It is, therefore, necessary to bridge these knowledge gaps by exploring factors influencing the teachers' level of TPACK and to examine whether their demographic characteristics (e.g., gender, age, level of education and years of teaching experience) could influence their level of TPACK. The purpose of the study was to explore senior high school teachers' level of TPACK in Senior High Schools in the Adenta Municipality and to examine the differences in teachers' level of TPACK based on some demographic characteristics.

Research Objectives

The specific objectives of the study were to:

1. explore business teachers' level of Technological Pedagogical Content Knowledge (TPACK).
2. examine the teacher knowledge components which contribute much variance in the business teachers' Technological Pedagogical Content Knowledge framework.
3. examine whether differences exist in business teachers' level of TPACK based on gender, age, teaching experience and educational qualification.

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Research Questions

The following research questions guided the study:

1. What is senior high school teachers' level of Technological Pedagogical Content Knowledge (TPACK)?
2. What teacher knowledge components contribute much variance in the senior high school teachers' Technological Pedagogical Content Knowledge framework?
3. What are the effects of senior high school teachers' demographic characteristics on technological pedagogical content knowledge?

Research Hypotheses

The following research hypotheses were formulated and tested to examine the effect of senior high school teachers' demographic characteristics on technological pedagogical content knowledge.

1. H_0: There is no statistically significant difference in senior high school teachers' level of TPACK based on gender.
2. H_0: There is no statistically significant difference in senior high school teachers' level of TPACK based on age.
3. H_0: There is no statistically significant difference in senior high school teachers' level of TPACK based on teaching experience.
4. H_0: There is no statistically significant difference in senior high school teachers' level of TPACK based on the level of educational

EMPIRICAL LITERATURE

Technological Pedagogical Content Knowledge (TPACK) Framework was proposed by Koehler and Mishra (2006) to describe the knowledge teachers' need for effective teaching with technology. The framework was built upon the work of Shulman (1986)'s Pedagogical Content Knowledge (PCK). Shulman' framework links teachers' content and pedagogical knowledge. The Model argues that teachers' knowledge of pedagogy and content cannot be considered solely in isolation. According to Shulman teachers need to master the interaction between the pedagogy and content in order to implement approaches to ensure effective teaching and assist student to fully understand the content.

Koehler and Mishra (2006) proposed that a new type of knowledge, known as technological knowledge to Shulman (1986) idea about pedagogical content knowledge in order to construct the type of knowledge required for teachers ensure effective teaching with technology (Koehler & Mishra, 2009). The TPACK framework describes the kind of knowledge that teachers need to achieve effective teaching with technology, and the complex ways in which these bodies of knowledge interact with each other.

TPACK framework comprised three main areas of knowledge: Content, pedagogy and technology. Technological knowledge (TK) defined the teachers' knowledge about latest technologies used in the educational environments. The content knowledge (CK), refers to the teachers' knowledge about subject matter to be learnt or taught (Koehler & Mishra, 2006) . The pedagogical knowledge related to teachers' knowledge about teaching and learning practices, processes, strategies, procedures, methods of teaching and learning (Koehler & Mishra, 2005, p.133). This kind of knowledge requires a deep understanding of theories of learning and how they apply to the students in classroom settings.

The framework noted that combining these three core types of knowledge results in four additional types of

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knowledge: Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical content Knowledge (PCK, and Technological Pedagogical Content Knowledge (TPACK).

Often contextual knowledge is also included as a part of the model (Mishra & Koehler, 2006b). Mishra and Koehler stressed that effective technology integration depends on teachers understanding of the relationships among these components of knowledge. Thus, teachers are required to develop competencies not only in each of these three main knowledge domains, but also in the interrelationships of them to ensure effective teaching.

Mishra and Koehler (2006) stated that TPACK framework would serve as the basis for effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content. Teachers should have knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones.

In recent times, some researchers have stressed the importance of teachers having a solid conceptual understanding of the interactions that occur among technology, pedagogy, and content when planning instruction (J. B. Harris & Hofer, 2011; Mishra & Koehler, 2006b). The structure of TPACK was described by Mishra and Koehler (2006), as shown in Figure 1, in a Venn diagram with overlapping circles representing seven major components.

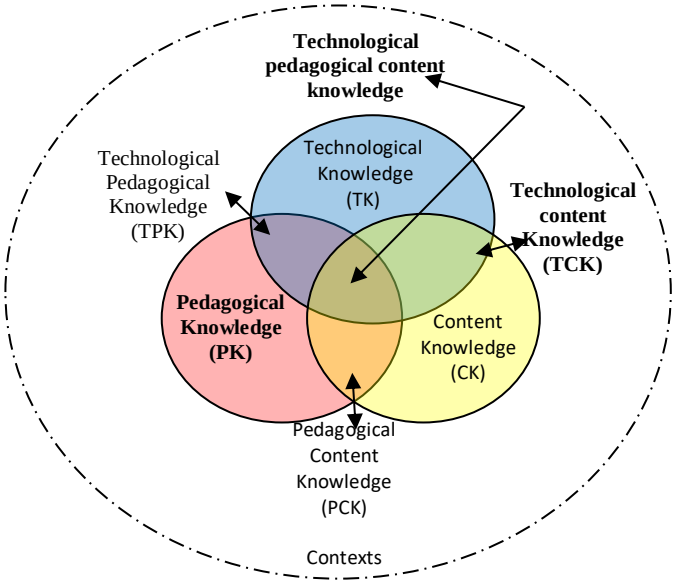

Figure 1: TPACK components adopted from (Koehler & Mishra, 2009).

The notion of TPACK encompasses an integrative knowledge base of technological knowledge and skills and knowledge of the subject matter content learners' profile established practices and the pedagogy necessary for teachers to become competent to teach with IC in the classroom (Koehler & Mishra, 2009). Since its formal introduction as a theoretical concepts TPACK has been transformed into a promising framework to assist ICT integration into school practices. There is an extensive evidence that TPACK, allows researchers, teachers and in-service teachers to focus on the connections among technology, pedagogy and content as they correlate in specific educational contexts (Koehler, eta l., 2007; Koehler & Mishra, 2009)).

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According to Koehler, Mishra and Cain (2013) the TPACK model enables teachers to truly reflect upon the teaching and learning process and integrating technology in teaching the content. The model emphasized the relationship between continuously changing technology and teachers' competence to use technology in teaching the content (Koehler, Mishra & Cain, 2013). This implies that teachers should have the skills and knowledge required for its effective application of these technologies in the classroom.

Teachers' level of (TPACK)

Hosseini and Kamal (2013) conducted a study on 236 pre-service and in-service teachers to measures the Technological Pedagogical Content knowledge (TPACK). The findings showed that participants had low Technological Pedagogical Knowledge (TPK) and high Pedagogical Knowledge (PK). The study indicated that there was no effect of age and gender on TPACK and its components. On other hand teaching experience and participant's field of study were significantly related to their TPACK. Furthermore, study also examined that there was no significant relationship between participants' attitude toward using technology and TPACK.

Appiah (2016) examined RME teachers' level perception of TPACK in the Aowin District of the Western Region. The author employed a descriptive survey design. The population included 131 teachers and students. The study used frequencies table, percentages and means and standard deviation were used to examine teachers' perception of TPACK. The results showed that Teachers also possessed adequate CK, PK and had low TK.

In Ghana, Yalley (2016) investigated Social Studies teachers' perception of TPACK. The study used descriptive survey design and questionnaire was also used to collect the data and was measured on five points Likert scale type. Frequency table and percentages, mean and standard deviation were used to analyse teachers' perception of TPACK. The findings showed teachers possessed higher TK, CK, PK, PCK and TCK.

Ntim (2017) measured the perspectives of teacher trainees, classrooms teachers and stakeholders in teacher education regarding factors that could enhance teaching and quality teacher education in Ghana. Findings from the survey indicated that teachers' content knowledge was considered appreciable, but more emphasis needed to be paid to cultivating critical and inquiry skills among Ghanaian teachers. In Ghana, Asare-Danso (2017) assessed the TPACK of Religious and Moral Education (RME) tutors in College of Education in Ghana. The study surveyed 50 tutors from 38 public colleges of education in Ghana. The study gathered data measured on five-point Likert-type questionnaire with forty-five questions. Mean and standard deviation were used to analyse the data collected to examine teachers' level of TPACK. The finding showed that tutors had good TK, PK, CK, TCK, and TPK. This was due to the fact that teachers did not face problem with the selection of instructional resources. The finding also showed that tutors did not face difficulty with the use of technology in teaching RME. However, the study found that the instructional resources were not often available for the tutors to use them in teaching RME. The results revealed that tutors had high content knowledge of the RME syllabus topics.

In Tanzania, Mtebe and Raphael (2018b) examined in-service teachers' TPACK. The sample size for the study was sample 152 teachers. The study used self-reported survey to gather data and measured on five-point Likert. Mean and standard deviation was used to examine teachers' level teachers' TPACK. The findings showed that teachers' level of CK, PK and PCK were high. Also, the finding revealed that teachers' level of TK, TCK TPK and TPACK were moderate.

In Greek, Roussinos and Jimoyiannis (2019) examined primary education teachers' perceptions of TPACK. The study employed survey to gather data from the teachers and measured on five points Likert scale type. The data was analysed using mean and standard deviation to examine the teachers' perception of level of

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TPACK. The finding showed that the majority of teachers possessed CK, PK, PCK and TK. However, the study found that teacher have lower TCK, TPK and TPACK.

Aniq and Drajati (2019) investigated how EFL teachers' perceptions of competences in their TPACK development. The study design was a case. The study used semi-structured interview to gather qualitative data. The population was 20 EFL teachers. The study used mean and standard deviation to examine teachers' level of TPACK. The findings indicated that most EFL teachers rated their PK, CK, and PCK higher than TK, TCK, TPK, and TPACK components.

Appiah and Mfum-Appiah (2019) examined Religious and Moral Educational teachers' level of TPACK in the Aowin District in the Western Region, Ghana. The author employed descriptive a survey design. The population included 131 teachers and students. The study used Frequencies, percentages, mam and standard deviation. The finding showed that though teachers have adequate skills in blending technology, pedagogy and content, they do not often practice these skills in the classroom.

Sariçoban, Tosuncuoglu and Kirmizi (2019) measured English teachers' perception of TPACK. The study was a survey design. The population were 77 pre-service EFL teachers. The mean and standard deviation was used to analyse the data on teachers' perception of TPACK. The finding revealed that pre-service EFL teachers have a satisfactory level of competence in TPACK yet, there are also some areas in which they need development. In another study, Juhji and Nuangchalerm (2020) assessed that prospective teachers' level of TPACK. The study was survey cross-sectional design. The data collection instrument was questionnaire, analysis of lesson plans, and observation sheet. The finding showed that teachers possessed good TK, moderate PK, CK, PCK, TCK TPK and TPACK.

In another study, Wulansari, Adlim and Syukri (2020) examined the Junior High School Science teachers' level of TPACK in District Aceh Besar and differences in demographic variables. The TPACK data were collected using a survey design. The population was 104 teachers. Questionnaire was employed in gathering data and was measured on five-point Likert scale type. The findings showed that teachers possessed higher PK, PCK and medium CK, TPK, TCK. However, TK and TPACK were rated low by teachers.

Huang, Chen and Jang (2020) examined in-service teachers' level of TPACK. The study was TPACK survey. The study population was 415. The study employed questionnaire in gathering data measured on five points Likert scale type. The finding established that teachers knew content knowledge and teaching strategies better, however, they were less knowledgeable about technological tool applications. Jalani, Hussain, Amin and Hussain (2021) investigated the in-service teachers' Pedagogical Technological and Content Knowledge (TPACK). The purpose of the study was to explore the level of Technological Pedagogical Content Knowledge of teachers. The population of the study was 85 in-service teachers. The mean and standard deviation were used to examine the level of pre-service teachers' level of TPACK. The study found that teachers' PK was the highest, TPK recorded the second highest, TK was the third highest, and PCK also obtained the fourth highest. The finding showed that TPACK of the teachers were lowest followed by CK.

Faithi and Yousefifard (2019) assessed Iranian EFL perception of their TPACK. A total of 148 Iranian English teachers participated the study. The data were collected through administering a previously validated TPACK questionnaire to the participants of the study. The findings obtained from the survey indicated that most EFL students perceived that their EFL teachers TK, PK CK and PCK were above average level. However, teachers' TCK, TPK and TPACK were low.

Lamminpaa (2021) explored teachers' perceived level of (TPACK). The study was descriptive survey and Questionnaire was used to gather data from the teachers. A total of 69 teachers participated in the study. The

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finding showed that finish EFL teachers' perceived level of TPACK was high in all the components.

Furthermore, the majority of the participants reported teachers had improved their ICT skills. Furthermore, Alharbi (2020) studied Saudi EFL teachers' knowledge of the TPACK components CK, PK, and TK. The results indicated that the knowledge of EFL teachers in Madinah city (n=199) was relatively high in all three components, with mean scores varying from 3.45 to 3.79 out of 5 (SD approximately 0.50 in all domains). Statistically significant differences were also found between gender and TPACK, namely indicating that male participants had a higher CK, whereas females had higher scores in both PK and TK. However, no statistical significance was found between the participants' amount experience and their TPACK.

Nazari, Nafissi, Estaji, and Marandi (2019) used mixed methods to examine novice and experienced EFL teachers' differences in their perceived TPACK and its influences on their professional development. The used quantitative approach and a sample of 427 EFL teachers comprising of both male and female with different teaching experiences were selected. In the qualitative phase, 16 EFL teachers were selected for a structured interview. The quantitative results indicated that experienced teachers were of significantly higher scores in terms of pedagogical content knowledge subscales.

The Influence of Demographic Variables on TPACK

Teacher TPACK are very complex because they are influenced by many factors. Each teacher has different characteristics that influence the learning process that will be carried out. The teacher's personality can influence teacher teaching methods including gender, age, teaching experience, character, and beliefs (Ifinedo, Rikala & Hämäläinen, 2020). Gender was one of the factors that could influence the teacher's TPACK mastery (Astuti, Subali, Hapsari, Pradana & Antony 2019). Research into the influence of gender on TPACK has been carried out in several countries and shows diverse results. Some studies show gender was a factor that influences teacher TPACK and there were significant differences in TPACK towards teacher gender where male have higher TPACK than female (Lin et al, 2013; Luik, Taimalu & Suviste, 2018; Jang & Tsai, 2013) have argued that gender can influence teachers' level of TPACK. This is due to the male's knowledge of ICT better than female (Berber & Erdem, 2015). Some studies have shown the contradictory findings that gender does not have significant influence on TPACK (Ay, Karadag & Act 2016; Ersory, Mehmet, Yurdakul & Ceylan 2016). However, other researchers; did not find any significant difference gender and teachers' level of TPACK.

Teachers' level of (TPACK)

METHODS

Research Design, Population and Sampling

The sequential explanatory mixed methods design was implemented by this study. The sequential explanatory mixed method research design consists of both quantitative and qualitative approaches. The design allowed the study to first gather quantitative data and analysed the data for a general picture and understanding of the research problem. The collection of qualitative data was done to explain or built upon the initial quantitative statistical results that needed further explanation on Senior High School teachers' moderate level of TPACK.

The population for the study comprised 653 Teachers from Senior High Schools in the Greater Accra Region, Ghana. In all there were 75 Public Senior High schools. The sample size for the study was 248. It was calculated by using the Yamane (1967) formula for calculating sample sizes. The sample size was calculated at 95% confidence level and P = 0.5. Where n is the sample size, N is the population size, and δ is the critical value of the confidence level (0.05).

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$n = \frac{N}{1+N(e)^2} n = \frac{653}{1+653(0.05)^2} n = \frac{653}{1+653(0.0025)} = 248.05.$

Selection of the Participants for the Interview

The study employed proportionate sampling technique to select respondents for the interviews. To ensure that the schools where the teacher-participants were drawn from are adequately distributed and represented, proportionate sampling technique was used in the selection of teachers from each of the schools in the Greater Accra Region (Moore & McCabe, 2005).

Data Collection Instruments

The study used both questionnaire and interview guide to collect primary data in line with research questions. In this study, the researchers used structured questionnaire adapted from Mishra and Koehler (2006) to gather quantitative data. The adaptation of the instrument was important because the items in it were used in different context outside Ghana and for that matter could not completely suit the Ghanaian context. The questionnaire consists of eight sections. Section A of the questionnaire captured the demographic characteristics (gender, age, teaching experience and educational qualification of the respondents). The section B, C, D, E, F, G and H captured items which measured in-service teachers' level TPACK. Each Section was structured on a 5-point Likert-type scale. The response scales were Strongly Disagree (1), Disagree (2), Not Sure (3), Agree (4), and Strongly Agree (5). The data about teachers' attitudes in technology integration were obtained using a Likert scale questionnaire that consist of 9 questions. Each statement refers to five aspects, namely strongly Agree, Agree, Neutral, Disagree, Strongly Disagree (Sugiyono, 2016).

The interview guide was also used to assist in gathering of the qualitative data to explain the moderate TPACK of the in-service business teachers. Interviews were conducted using semi-structured questions and open-ended question face-to-face interviews in one-on one setting at the same time (Patton, 2015). The face-to-face interview process allowed the interviewer to check the authenticity of participants' responses and whether to ask for follow questions or not (Singh, 2014; Yin, 2014).

The results of the Cronbach's Alpha test are presented in Table 1

Table 1: Cronbach's Alpha test

Variables	Cronbach's Alpha	
	Pilot Data	Actual Data
Technological Knowledge (TK)	.884	.947
Pedagogical Knowledge (PK)	.890	.942
Content Knowledge (CK)	.920	.948
Technological Pedagogical Knowledge (TPK)	.932	.878
Technological Content Knowledge (TCK)	.921	.926
Pedagogical Content Knowledge (PCK)	.900	.960
Technological Pedagogical Content Knowledge (TPACK)	.920	.956

Source: Field Survey (2024)

As seen in Table 1, the specific sub-constructs; (TK, PK, CK, TPK, TCK, PCK and TPACK) have been

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reported. The lowest was .878 and the highest was .960. By inference from the threshold provided by (McNeish, 2018) and (Pallant, 2010), the sub-construct are all highly reliable.

Data Processing and Analyses Instrument

After the questionnaires were collected, the researchers edited and screened the data. The editing and screening were to ensure that data was accurate and complete. The researchers coded and fed the data into the Statistical Product for Service Solution (SPSS) version 22.0. The descriptive statistics (percentages, frequencies, mean and standard deviations) and inferential statistics (independent samples t-test, and ANOVA) were used to analyse the data collected. For the inferential statistics, significant results were determined at $p < .05$.

Research Questions One focused on teachers' level of TPACK. Data gathered on these variables was at the interval level of measurement. Hence the Mean and standard deviation were considered the most appropriate statistical tools to describe the teachers' level of TPACK.

Research Hypothesis One examined differences in teachers' level of TPACK based on gender. The dependent variable was TPACK and the independent variable was gender (categorical variable at two levels). Therefore, independent samples t-test was appropriate to test this hypothesis since it focuses on differences in dependent variables when the categorical variable is at two levels. Research Hypotheses Two to Four focused on differences in teachers' level of TPACK based on age, teaching experience and academic qualification. Age, teaching experience and academic qualification were all categorical variables with more than two levels. Therefore, One-Way Analysis of variance (ANOVA) was used to test the hypotheses.

RESULTS AND DISCUSSIONS

Demographic Characteristics of the Respondents

The demographic profile of the respondents was gender, age, teaching experience and level of education. These demographic characteristics were necessary for the formulated hypothesis. In essence, they helped to determine if Senior High School teachers' technological pedagogical content knowledge is influenced by such characteristics. Table 2 presents the results.

Table 2: Characteristics of Business Teachers

Variable	Subscale	Freq. (n)	Percent (%)
Gender	Male	144	58.1
	Female	104	41.9
Age (in years)	20-25	43	17.3
	26-30	77	31.0
	31-35	70	28.2
	36-40	37	14.9
	40+	21	8.5
Highest Academic Qualification	Degree	188	75.8
	Master's	55	22.2
	Doctorate	5	2
Teaching Experience (in years)	1-5	70	28.2
	6-10	75	30.2

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	11-15	58	23.4
	16-20	25	10.1
	21+	20	8.1

Source: Fieldwork (2024)

The majority (n = 144, 58.0%) of the respondents were male teachers. The number of male teachers was slightly higher than the female by 16.2%. The results show that the majority (n = 77, 31.0%) of the respondents were within the age range of 26-30 years. The respondents (n = 70, 28.0%), were within the age range of 31-36 years. The respondents (n = 43, 17.3%) were within the age range of 20-25 years. In addition, the respondents (n = 37, 14.9%) were within age range of 36-40 years and respondents (n =21, 8.5%) were above 40 years. The results also showed that most of the teachers were within the age range of 26-30 years, followed by those within the age range of 31-36 years. The results showed that most of the teachers in Senior High Schools in the Greater Accra Region were matured enough to give valid responses to the research questions.

In addition, the study examined the highest level of academic qualification of the respondents. The results show that the majority (n=144, 75.8%) of the respondents have obtained Bachelor's Degree as the highest qualification. Some of the respondents (n = 55, 22.2%) have their Masters' Degree and others (n = 5, 2.0%) have their Doctorate degree. The results mean that the respondents hold the requisite academic qualifications that qualify them to teach in the Ghanaian Senior High Schools. The basic qualification for teaching in Senior High School in Ghana is the First Degree.

In relation to the teachers' teaching experience, the results show that (n=75, 30.2%) the respondents have 6-10 years teaching experience. The results showed that some of the respondents (n = 70, 28.2%) have worked for 1-5 years. The results further showed that the respondents (n = 38, 23.4%) have 11-15 years teaching experience, the respondents (n = 25, 10.1%) have 16-25 years teaching experience and some of the respondents (8.1%, n = 20) have 21 years teaching experience in teaching. It can therefore, be seen that majority of the respondents had 6-10 years teaching experience while the minority had 1-5 years teaching experience.

Research Question one: What is Senior High School Teachers' Level of Technological pedagogical content Knowledge?

It is necessary to examine senior high school teachers' level of technological pedagogical content knowledge because teachers with good knowledge in emerging technology and their uses can select the appropriate technologies that suit lessons and enhances students understanding. In order to address the research question data was gathered on teachers' level of technological pedagogical content knowledge. The responses were coded on Likert Scale; where 5 = Strongly Agree, 4 = Agree, 3 = Uncertain,2 = Disagree 1 = Strongly Disagree. The mean scores of 4.5-5.00 was considered as very high, 3.50-4.49 (high), 2.50-3.49 was considered as moderate, 1.50-2.49 was low, and 1.00-1.49 was Very Low. The interpretation of the mean results was based on Bangsri and Phusawisot (2020). The results are presented in Table 3.

Table 3: Senior High School teachers' level of TPACK of the seven constructs

Variables	*M*	*SD*	Interpretation
Content knowledge	4.17	0.88	High
Pedagogical Knowledge	4.17	0.92	High
Pedagogical Content Knowledge	3.89	1.13	High
Technological Pedagogical Content Knowledge	3.45	1.25	Moderate

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Technological Knowledge	3.30	1.33	Moderate
Technological Pedagogical Knowledge	3.14	1.37	Moderate
Technological Content Knowledge	2.97	1.38	Moderate

Source: Field survey (2024)

The results in Table 3 show that Senior High School teachers possess high level of Content Knowledge *(M* = 4.17, *SD* = 0.88), Pedagogical Knowledge (*M*= 4.17, *SD* = 0.92), Pedagogical Content Knowledge (*M* = 3.89, *SD* = 1.13). On the other hand, teachers rated themselves moderate on TPACK (*M* = 3.45, *SD* = 1.25), TK (*M* = 3.30, *SD* = 1.33), TPK (*M* = 3.14, *SD* = 1.37), and T CK (*M* = 2.97, *SD* = 1.38). In summary senior high school teachers' levels of PK, CK, and PCK were high whilst their level TK, TPK, TCK and TPACK were moderates.

Analysis of Qualitative Data

The interview guide was used to complement data that was obtained with the use of the questionnaire in order to ascertain the authenticity of the responses that were gathered from the respondents. The interview guide was also used in order to obtain in-depth information concerning the findings that were gathered from the questionnaire. The interview sessions sought to find out the content knowledge, technological knowledge, pedagogical knowledge pedagogical content knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge of teachers in senior high school. Details of the interview results are presented in the subsequent paragraphs. The results represent the themes that emerged from the thematic analysis conducted

Senior High School Teachers' Content Knowledge

Interview sessions were conducted where the researchers interviewed some of the teachers to explain their high content knowledge in teaching. Two major factors which were identified and captured as sub-themes were:

1. The quality of initial teacher preparation
2. The experiences gathered from teaching.

Quality of Initial Teacher Preparation

The teachers indicated that they had enough knowledge of the concepts and theories of the subject they teach. This was credited to the quality initial teacher preparation they went through. They explained that the initial teacher preparation programme exposed them to the concepts, principles, and theories in their content areas. Hence, teaching content at the SHS level was an effortless activity for them. They merely taught based on the knowledge gathered from their initial preparation. These are some of the explanations they offered to support their high content knowledge.

I have enough content knowledge in my subject area and I don't struggle to teach the subject. In my undergraduate study I learnt a lot of content, theories and concepts, as well as classroom management. (Respondent 1).

Another teacher also said that,

My brother, I have gone through the undergraduate programmes in the University where I was taught enough content and pedagogy in teaching. I will say Yes, I am an expert in the subject that I teach. So I have content knowledge, I know the concepts, theories and principles that relate to the subject that I teach. The content knowledge helps me to teach the subject easily without any difficulty.

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(Respondent 3).

Another teacher recognised the important role content knowledge plays in teaching and emphasised the source of such knowledge.

I will say yes, I am well rooted in the content knowledge. You see content knowledge is very important. Without adequate content knowledge, it will be very difficult for the teacher to explain concepts to students. My brother, I have received enough content knowledge from the University I attended. (Respondent 4).

Experiences Gathered from Teaching Content

Teaching content over time also contributed to rich content knowledge of the teachers. Such teaching experiences had deepened their understanding of content issues that had facilitated their teaching. In a non-hesitant utterance, one participant stated that,

I will say, yes, I have rich content knowledge in my subject area. I am the head of my department with experience and mastery of the subject that I teach. (Respondent 2).

The rich content knowledge and experience they possessed served as key assets to teach the courses. This creates the impression that quality initial teacher preparation and experiences gathered in teaching content greatly contribute to a high content knowledge.

Senior High School Teachers' Moderate Technological Knowledge

The quantitative evidence highlighted teachers' moderate technological knowledge. This moderate knowledge was as a result of their limited knowledge about the use of emerging technologies in schools and lack of in-service professional training. This contributed to their non-use of the technologies to teach lessons.

Lack of in-Service Professional Training

Undoubtedly and unarguably, professional training enhances ones' intellectual capacity to perform on their job. To the senior high school teachers, they never had professional training on how to use computers. This limited their knowledge base as far as their technological knowledge was concerned. In the voice of a participant,

I will say no I have not received teacher professional development training on how to teach with technology. I am learning how to use them myself; I am prepared to use them if professional development training is given to teachers on the use of technology in teaching. I will be glad to use the technology for teaching if teacher professional development training on ICT is organised for teachers on the fields to equip us with the necessary skills and knowledge on how to use the technology for teaching (Respondent 1).

Such technological training is likely to be appreciated by them, and this will enhance their knowledge and probably boost their interest to use them. It seems the capacity for the teachers to learn the technologies on their own is not enough for them to fully acquire the knowledge and possibly use them.

Senior High School Teachers' Views on their High Pedagogical Knowledge

Responses were gathered from the teachers on their pedagogical knowledge. It was realized that, most of the teachers had adequate pedagogical knowledge in teaching. The teachers indicated that, they can develop and use a variety of teaching strategies to develop understanding among students and can also use various assessments strategies to determine their students' understandings of content. In line with this, one of the

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teachers said that:

I am a professional teacher who has read pedagogy as a course during the undergraduate courses which prepared me in my professional career as a teacher so I have knowledge in pedagogy. Therefore, I am able to assist, link and integrate core concepts from various subject areas in order to help students appreciate and understand the concepts I teach in my subject area. (Respondent 1).

Another teacher also said that:

I have pedagogical knowledge and I show that by employing varieties of teaching approaches and strategies to teach in my subject area. For instance, I have learned how to organise and manage classroom for effective teaching. So, my knowledge in classroom management helps me a lot when teaching. I sometimes put students in groups so that students can learn in groups especially when I give the students group work (Respondent 2).

Finally, one teacher indicated that,

I have knowledge in several teaching approaches. In my lesson, I use variety of teaching methods such as cooperative learning, problem-solving approach, active learning and discovery learning. These approaches assist students to gain better understanding of the lessons that I teach. I am also able to select the appropriate methods suitable for the content. Brother, one thing we should not forget is that, for a teacher to teach the content well, he/ she must have knowledge in the methods of teaching so that he/ she can select the right teaching approach to teach. (Respondent 3).

Their use of varied pedagogies to teach was impressive to address the unique learning needs of students.

Senior High School Teachers' Moderate Technological Pedagogical Content Knowledge (TPCK)

The interview results highlighted obvious reasons that showed that some of the senior high school teachers lacked TPCK. This was because some schools did not have the technologies for teaching. When teachers were asked whether they could select the right technology and pedagogy to teach the contents, most of them indicated that they could not. In line with this, two of the teachers indicated that;

I am not perfect to select the appropriate technology to blend with the pedagogy and content. However, I am learning to blend the technology with the content and pedagogy to facilitate my teaching. (Respondent 1).

It will be quite difficult for me to say I can do it since even the technologies are not in the school. We are not used to teaching content with technology. (Respondent 1).

Indeed, some of the teachers did not have adequate technological pedagogical content knowledge. They did not know how to blend technology with the pedagogy and subject content for teaching. They indicated that they were still learning and would welcome any workshop for them in that regard.

The results indicated that they had enough knowledge of the concepts and theories of the subject they teach. This was credited to the quality initial teacher preparation they went through. They explained that the initial teacher preparation programme exposed them to the concepts, principles, and theories in their content areas. Hence, teaching content at the SHS level was an effortless activity for them. They merely taught based on the knowledge gathered from their initial preparation. Teaching content over time also contributed to rich content knowledge of the teachers. Such teaching experiences had deepened their understanding of content issues that had facilitated their teaching. In a non-hesitant utterance, one participant stated that. The rich content knowledge and experience they possessed served as key assets to teach the courses. This creates the

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impression that quality initial teacher preparation and experiences gathered in teaching content greatly contribute to a high content knowledge. The quantitative evidence highlighted senior high school teachers' moderate technological knowledge. This moderate knowledge was as a result of their limited knowledge about the use of emerging technologies in schools and lack of in-service professional training. This contributed to their non-use of the technologies to teach.

It was realized that, most of the teachers had adequate pedagogical knowledge in teaching. The teachers indicated that, they can develop and use a variety of teaching strategies to develop understanding among students and can also use various assessments strategies to determine their students' understandings of content. In line with this, one of the teachers said that:

Research Question Two: What teacher knowledge components contribute much variance in the Senior High School Teachers' Technological Pedagogical Content Knowledge framework?

The purpose of this research question was to examine which of the Knowledge contribute most to Senior High School Teachers' Technological Pedagogical Content Knowledge. In order to address this research question Principal Component Analyses was done to examine the variance of the items and was conducted to examine the contribution among the six components to senior high school teachers TPACK. The results are presents in Table to 4.

Table 4: The knowledge type that influence teachers' Technological Pedagogical Content Knowledge

Component	Eigenvalue	% Variance Extracted	Cumulative %
1	23.6227	43.7457	43.7
2	7.2874	13.4952	57.2
3	3.0584	5.6637	62.9
4	1.8710	3.4649	66.4
5	1.7031	3.1539	69.5
6	1.3808	2.5571	72.1
7	1.0874	2.0136	74.1
8	.9308	1.7237	75.8
9	.8069	1.4942	77.3
10	.7458	1.3810	78.7

Source: Fieldwork (2024)

The seven components explained together 74.1% (see cumulative %) of the variance in senior high school teachers' TPACK. A recent recommendation pegs the total variance explained by the retained components in social science research at 60% (Hair, 2014). Therefore, by these thresholds, the seven components which explain 74.1% of THE teachers' TPACK are good determinants. The least variance of 2.01% in senior high school teachers' TPACK was explained by technological content knowledge. Technological knowledge component alone did not account for much of the variance (2.56%) in SHS teachers' TPACK just as content knowledge (3.46% accounted variance). It can clearly be seen that the integration of technological knowledge, pedagogical knowledge and content knowledge into technological pedagogical content knowledge explains the highest variance of 43.75% in SHS teachers' TPACK. This means that the technological pedagogical content knowledge component is the best contributor or influencer of SHS teachers' TPACK base.

The seven components explained together 74.1% (see cumulative %) of the variance in SHS teachers'

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TPACK. The findings showed that the seven components which explain 74.1% of SHS teachers' TPACK are good determinants teachers' TPACK. The least variance in SHS teachers' TPACK was explained by technological content knowledge. Technological knowledge component alone did not account for much of the variance in SHS teachers' TPACK just as content knowledge (3.46% accounted variance).

The finding of the study clearly showed that the integration of technological knowledge, pedagogical knowledge and content knowledge into technological pedagogical content knowledge explains the highest variance of 43.75% in SHS teachers' TPACK. This means that the technological pedagogical content knowledge component is the best contributor or influencer of SHS teachers' TPACK base. The TPACK framework describes how effective teaching with technology is possible by highlighting the connection and interplay among the technology, pedagogy and content.

Research Hypothesis One: There is no Statistically Significant Difference in Senior High School Teachers' Level of TPACK Based on Gender

This research hypothesis sought to determine whether there is significance difference between male and female SHS teachers with regard to their technological pedagogical content knowledge. In order to test this research hypothesis, an independent-samples t-test was used to determine whether there is a statistically significant difference between male and female SHS teachers with regard to the various components of TPACK. Since the TPACK consists of seven components, the T-test was conducted for each component by comparing the mean scores of male and female SHS teachers. The results are put together and presented in Table 5.

Table 5: T-Test Results for Differences in Senior High School Teachers' Level of Technological Pedagogical Content Knowledge based on Gender

Gender	Dimension	*M*	*SD*	*t*	*df*	*p*	η2
Male	TK	3.38	1.19	1.368	246	.001	.047
Female		2.87	1.18				
Male	CK	4.18	.79	-.007	246	.995	.000
Female		4.18	.65				
Male	PK	4.13	.81	-1.103	246	.271	.005
Female		4.24	.73				
Male	PCK	3.86	.99	-.583	246	.561	.001
Female		3.93	1.02				
Male	TPK	3.04	.99	-1.764	207	.079	.013
Female		3.28	1.10				
Male	TCK	3.10	1.22	2.048	246	.042	.017
Female		2.79	1.10				
Male	TPCK	3.42	1.12	.284	246	.777	.000
Female		3.38	1.11				

Source: Fieldwork (2024)

The preliminary Levene's test for equality of variances was conducted before the hypotheses were tested. This analysis helps in determining the degrees of freedom needed in determining statistical significance for

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the independent samples t-test. Equal variances were assumed for content knowledge, F = .894, *p* = .345; pedagogical knowledge, F = .013, *p* = .909; pedagogical content knowledge, F = .063, *p* = .802; technological content knowledge, F = 2.997, *p* = .085; and technological pedagogical content knowledge, F = .124, *p* = .725. However, equal variances were not assumed for technological pedagogical knowledge, F = 4.736, *p* = .030. Technological knowledge, F = 5.474, *p* = .020.

In Table 5, the independent samples t-test results show that no significant differences were observed in business teachers' level of content knowledge, *t*(246) = -.007, *p* = .995 (2-tailed), η2 = .000; pedagogical knowledge, *t*(246) = -1.103, *p* = .271 (2-tailed), η2 = .005; pedagogical content knowledge, *t*(246) = -.583, *p* = .561 (2-tailed), η2 = .001; technological pedagogical knowledge, *t*(207) = -1.764, *p* = .079 (2-tailed), η2 = .013; and technological pedagogical content knowledge, *t*(246) = .284, *p* = .777 (2-tailed), η2 = .000, based on their gender. For these variables, the eta squared (η2) shows that gender could not explain 6% of the variance. The highest variance explained by gender was 1.3% observed in technological pedagogical knowledge. This is regarded as small based on Cohen's (1988) guidelines for effect size. Therefore, the null hypotheses which examined differences in SHS teachers' technological knowledge, content knowledge, pedagogical knowledge, pedagogical content knowledge, technological pedagogical knowledge and technological pedagogical content knowledge based on gender were all not rejected.

However, significant differences were found in the SHS teachers' level of technological content knowledge based on gender, *t* (246) = 2.048, *p* = .042 (2-tailed), η2 = .017. Technological knowledge, *t*(246) = 3.491, *p* = .001 (2-tailed), η2 = .047. Hence, the null hypothesis was rejected. In Table 11, the male SHS teachers' (*M* = 3.10) appear to possess higher technological content knowledge than their female counterparts (*M* = 2.79). The difference observed is small (η2 = .017). Again, the male SHS teachers' (*M* = 3.38) appear to possess higher technological knowledge than their female counterparts (*M* = 2.87). Nevertheless, the difference observed is small (η2 = .047).

Research Hypothesis Two: There is no Statistically Significant Difference in Senior High School Teachers' Level of TPACK Based on working Experience

This research hypothesis was posed because some researchers found that teaching experience could influence teachers' level technological pedagogical content knowledge. In contrast, some researchers found that teaching experience did not influence teachers' level of TPACK. In order to answer this research hypothesis, one -way ANOVA was used to test whether teaching experience could teachers' level of TPACK: The results are displayed in Table 6.

Table 6: ANOVA Results for Differences in Senior High School Teachers' Level of Technological Pedagogical Content Knowledge based on Teaching Experience

	Dimension	Levene's Test		*F*	*Df*	*p*	η2
		F	*p*				
TE	TK	5.055	.001	6.634	4, 243	.000	.098
TE	CK	2.161	.074	1.901	4, 243	.111	.030
TE	PK	2.170	.073	1.151	4, 243	.333	.019
TE	PCK	4.310	.002	1.247	4, 243	.292	.020
TE	TPK	2.678	.032	2.394	4, 243	.051	.038
TE	TCK	3.298	.012	1.866	4, 243	.117	.030
TE	TPCK	23.575	<.001	7.386	4, 243	.000	.108

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Source: Fieldwork (2022)

The Levene's test of equality of variances was examined for the TPACK components based on teaching experience. Equal variances were assumed for content knowledge, F = 2.161, *p* = .074 and pedagogical knowledge, F = 2.107, *p* = .073. The rest of the TPACK component did not meet the homogeneity assumption. Thus, technological knowledge, F = 5.055, *p* = .001; pedagogical content knowledge, F = 4.310, *p* = .002; technological pedagogical knowledge, F = 2.678, *p* = .032; technological content knowledge, F = 3.298, *p* = .012; and technological pedagogical content knowledge, F = 23.575, *p* < .001 assumed unequal variances based on SHS teachers' teaching experiences.

Based on the ANOVA results, no significant difference was observed in SHS teachers' content knowledge, F(4, 243) = 1.901, *p* = .111 (2-tailed), η2 = .030; pedagogical knowledge, F(4, 243) = 1.151, *p* = .333 (2-tailed), η2 = .019; pedagogical content knowledge, F(4, 243) = 1.247, *p* = .292 (2-tailed), η2 = .020; technological pedagogical knowledge, F(4, 243) = 2.394, *p* = .051 (2-tailed), η2 = .038; and technological content knowledge, F(4, 243) = 1.866, *p* = .117 (2-tailed), η2 = .030, based on their teaching experiences. Therefore, the null hypotheses for the aforementioned TPACK components based on teaching experiences were not rejected.

The ANOVA test show significant differences in SHS teachers' technological knowledge, F(4, 243) = 6.634, *p* < .001 (2-tailed), η2 = .098 and technological pedagogical content knowledge, F(4, 243) = 7.386, *p* < .001 (2-tailed), η2 = .108, based on their teaching experiences. The magnitude of the differences observed was moderate for technological knowledge (η2 = .098) and technological pedagogical content knowledge (η2 = .108) based on Cohen's effect size guideline. Hence, a multiple post hoc test was conducted for both variables.

To quantify the differences and examine the margin of the differences, the eta square value was computed to examine the effect size or the differences. Table 7 presents the results for technological knowledge based on teaching experience.

Table 7: Games-Howell Multiple Comparisons for Technological Knowledge and Teaching Experience

(I) Number of years taught	(J) Number of years taught	Mean Difference (I-J)	Std. Error	Sig.
1-5 years	6-10 years	-0.4106	0.20112	0.25
	11-15 years	-.84384*	0.20343	0
	16-20 years	-.91893*	0.23096	0
	21 years and Above	-.99643*	0.29638	0.02
6-10 years	1-5 years	0.4106	0.20112	0.25
	11-15 years	-0.43325	0.19164	0.17
	16-20 years	-0.50833	0.22064	0.16
	21 years and Above	-0.58583	0.28841	0.28
11-15 years	1-5 years	.84384*	0.20343	0
	16-20 years	-0.07509	0.22275	1
	21 years and Above	-0.15259	0.29003	0.98
16-20 years	1-5 years	.91893*	0.23096	0
	21 years and Above	-0.0775	0.30996	1

Source: Fieldwork (2024)

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The multiple comparisons identified SHS teachers with 1-5 years teaching experience to possess lower technological knowledge than those with 11-15 years and 16-20 years of teaching experience. No differences in technological knowledge were found between SHS teachers with 1-5 years and 6-10 years of teaching experiences. Also, no significant differences were found in SHS teachers' technological knowledge among those with teaching experiences of 6-10 years, 11-15 years and 16-20 years. In conclusion, the SHS teachers with 1-5 years of teaching experiences appear to have the lowest technological knowledge. Table 8 presents the post hoc test for SHS teachers' technological pedagogical content knowledge and teaching experience.

Table 8: Games-Howell Multiple Comparisons for Technological Pedagogical Content Knowledge and Teaching Experience

(I) Number of years taught	(J) Number of years taught	Mean Difference (I-J)	Std. Error	Sig.
1-5 years	6-10 years	-.54340	.20678	.071
	11-15 years	-.95496*	.19178	.000
	16-20 years	-.59673	.22074	.062
	21 years and Above	-.90816*	.23248	.002
6-10 years	1-5 years	.54340	.20678	.071
	11-15 years	-.41156	.15825	.076
	16-20 years	-.05333	.19232	.999
	21 years and Above	-.36476	.20569	.402
11-15 years	1-5 years	.95496*	.19178	.000
	16-20 years	.35823	.17610	.266
	21 years and Above	.04680	.19061	.999
16-20 years	1-5 years	.59673	.22074	.062
	21 years and Above	-.31143	.21972	.620

Source: Fieldwork (2024)

In Table 8, significant differences in SHS teachers' technological pedagogical content knowledge were observed among those with 1-5 years teaching experience, 11-15 years teaching experience and those with teaching experience for 21 years and above. It can be seen that SHS teachers with 1-5 years teaching experiences possessed a lower technological pedagogical content knowledge than those with 11-15 years and those with 21 years and above teaching experiences. It seems to mean that the use of technology in teaching SHS content is within the ability of those SHS teachers with the highest years of teaching experiences. Such teachers might be older in the teaching profession. This argument is supported by the results in Table 8where the older SHS teachers seem to exhibit higher technological pedagogical content knowledge than their younger counterparts.

The finding suggested that less experience SHS teachers (less than 10 years of teaching experience) possessed higher technological knowledge than teacher with more 10 years teaching experience. The finding means that young in-service teachers who possessed have higher technological knowledge and have the capacities to apply technology but have lower content and pedagogical knowledge. The finding agreed with a study of Lee and Tsai (2010) who conducted a study on in-service teachers' perception of TPACK based on the Web based technology and found that teachers with less teaching experience possessed higher technological knowledge than teachers who possessed more teaching experience.

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Research Hypothesis Three: There is no Statistically Significant Difference in Senior High School Teachers' Level of Technological Pedagogical Content Knowledge Based on Educational Qualification.

This research hypothesis was equally significant because some reseachers (eg., Ozudogru & Ozudogru (2019) have found that teachers' qualification could influence teachers technological pedagogical content knowledge. On the contrary, other researchers did not find any significant difference. To answer this research hypothesis, one -way ANOVA was used to test whether there is any significant difference in SHS Teachers' Level of Technological Pedagogical Content Knowledge based on academic qualification. The results are presented in Table 9.

Table 9: ANOVA Results for Differences in Senior High School Teachers' Level of Technological Pedagogical Content Knowledge based on Highest Academic Qualification

	Dimension	Levene's Test		*F*	*Df*	*p*	η2
		F	*P*				
HAQ	TK	.543	.582	.393	2, 245	.675	.003
HAQ	CK	3.410	.035	1.208	2, 245	.301	.010
HAQ	PK	2.421	.091	.643	2, 245	.527	.005
HAQ	PCK	4.034	.091	1.955	2, 245	.144	.016
HAQ	TPK	3.082	.048	.189	2, 245	.828	.002
HAQ	TCK	1.103	.334	.137	2, 245	.872	.001
HAQ	TPCK	.141	.868	.494	2, 245	.611	.004

Source: Fieldwork (2024)

The preliminary test for Levene's equality of variances failed for content knowledge, F = 3.410, p = .035, and technological pedagogical knowledge, F = 3.082, p = .048. However, equal variances were assumed for technological knowledge, F = .543, p = .582; pedagogical knowledge, F = 2.421, p = .091; pedagogical content knowledge, F = 4.034, p = .091; technological content knowledge, F = 1.103, p = .334; and technological pedagogical content knowledge, F = .141, p = .868.

The ANOVA test also showed that there were no statistically significant differences in SHS teachers' technological pedagogical content knowledge based on their highest academic qualification. Specifically, SHS teachers' technological knowledge, F(2, 245) = .393, p = .675 (2-tailed), η2 = .003; content knowledge, F(2, 245) = 1.208, p = .301 (2-tailed), η2 = .010; pedagogical knowledge, F(2, 245) = .643, p = .527 (2-tailed), η2 = .005; pedagogical content knowledge, F(2, 245) = 1.955, p = .144 (2-tailed), η2 = .016; technological pedagogical knowledge, F(2, 245) = .189, p = .828 (2-tailed), η2 = .002; technological content knowledge, F(2, 245) = .137, p = .872 (2-tailed), η2 = .001; and technological pedagogical content knowledge, F(2, 245) = .494, p = .611 (2-tailed), η2 = .004 reported non-significant differences based on their highest academic qualification. Hence, the null hypothesis was not rejected.

DISCUSSIONS

With regards to Teachers' Level of Technological pedagogical content Knowledge found that some of the teachers did not have adequate technological pedagogical content knowledge. They did not know how to blend technology with the pedagogy and subject content for teaching. They indicated that they were still learning and would welcome any workshop for them in that regard. The finding that teachers' level of technological knowledge was moderate aligned with studies of several researchers (Chai, Koh & Tsai

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(2010), Luik, Taimalu and Suviste (2018), Oz (2015), Ozudogru and Ozudogru (2019), Akyuz (2018), Alqurashi, Gokbel and Carbonara (2017) who found in their studies that teachers' level of technological knowledge was moderate. The finding of the study further supports a study of Mailizar and Fan (2020) whose finding showed that teachers have moderate technological knowledge. The findings were also similar to Irmak and Yilmaz Tuzun (2019) whose finding showed that teachers possessed moderate level of technological knowledge. The finding of study support that of Bas and Senturk (2018) who's finding revealed that teacher level of technological knowledge was at a moderate level. Teachers who have technological are likely to incorporate technology into their teaching in order to become effective teacher. In modern teaching the use of technology plays a more progressive role, making teaching more interactive than before, and sustains students' interest in classroom learning and facilitating better understanding. Alhababi, (2017) found that technology is an effective tool for both teachers and students to improve teaching and learning using TPCK when is effectively used in teaching.

However, the findings contradict the previous studies of Bingimlas, (2018), Chai, Koh & Tsai (2010), Kazu and Erten (2014), Horzum (2013) Heitink, Voogt, Fisser, Verplanken, van Braak (2017), Luik, Taimalu and Suviste, (2018) whose findings showed that teachers' level of technological knowledge was high. The finding disagreed with a study of Archambault and Crippen (2009), whose findings showed that teachers have less technological knowledge but had high level of pedagogy, content, pedagogical content. The finding also contradicts the study of Giannakos, Doukakis, Pappas, Adamopoulos and Giannopoulou (2015) who conducted a study in Grece and found that teachers' level of technological knowledge was high. The finding also contradicted a study conducted by Cahyani, Azizah and Evan (2020) whose finding showed that teachers' level of technological knowledge was shown as the highest for both male and female teachers among all the seven knowledge components of TPACK level of Science teachers. This finding was explained by the availability of web-based technology training opportunity for both male and female teachers to equally upgrade their technological knowledge (Koehler, Mishra & Cain, 2013).

On teachers' knowledge components contribute much variance in the Senior High School Teachers' Technological Pedagogical Content Knowledge framework

The results mean that TK made statistically significant contribution to TPACK has statistically significant positive effect on TPACK. The results showed that TCK was the second component that made statistically significant contribution to TPACK. The results showed that PCK was the third component that made statistically significant contribution to TPACK. The results showed that PK was the fourth component that made statistically significant contribution to TPACK. This results were statistically significant. The results implied that TK, TCK, PCK and PK made statistically significant contribution to SHS teachers TPACK. However, the CK and TPK did not significant contributions to TPACK.

The finding support that of Chieng and Tan (2021) whose findings showed that among the independent variables (CK, TK, PK, PCK, TCK, TPK and TPACK that made the contributions to integration of ICT, the TPACK and TCK made the significant contributions to integration of ICT. These constructs accounted for over 40% of the variance in integration of ICT. The finding of this study is inconsistent with that of Horzum (2013), and Pamuk, Ergun, Cakir, Yilmaz and Ayas (2015) whose findings showed that TCK and TPK made significant contributions to TPACK and accounted for more than 74% of the variance in TPACK. The finding of the study contradicts that of Chai, Koh and Tsai (2010) whose finding showed that technological knowledge, pedagogical knowledge and content knowledge are all significant predictors of teachers' TPACK, with pedagogical knowledge having the largest influence. Cetin-Berber and Erdem (2015) found that CK and PK contributed significantly to teachers TPACK but TK was not a significant predictor of TPACK.

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There is no Statistically Significant Difference in Senior High School Teachers' Level of TPACK Based on Gender

The results showed that there was a statistically significant difference in SHS teachers' level of technological knowledge and technological content knowledge based on gender, at the five percent significance level. Some studies such as Ozudogru, and Ozudogru (2019), Argon et al. (2015); Khine et al., (2019), Simsek and Sarsar (2019), Tuncer and Bahadir, (2016) Kazu and Erten (2014), found gender to be significant predictor of TPACK level of teachers.

Ozudogru, and Ozudogru (2019) revealed that gender explains TPACK domains in favour of male teachers. Canbolat (2011) found TK, TCK, TPK and TPACK levels of male candidates higher than female candidates in a study conducted with elementary school mathematics teacher candidates. This can be attributed to the fact that male teachers tend to explore the use of technology and are more familiar with the technology than their female counterpart. Some studies showed that there are differences in teachers' TPACK and gender. for instance, the findings of such as Kazu and Erten (2013) whose finding showed that gender is a significant predictor of TPACK, and found that female to have higher TPACK level than their male counterpart. The study the findings support the study of Prasojo, Habibi, Mukminin and Yaakob (2020) whose results showed that the female teachers' level of TPACK were higher in all the seven components of TPACK compared to the male teachers. Seven factors, TK, CK, PK, PCK, and TPACK were detected to be statistically significant for the difference.

However, the finding of some studies contradicts the finding of current study. For instance, Şad, Akgül and Delican (2015) found that there was no significant difference in students' level of TPACK based on gender. Astuti, Paidi, Subali, Hapsari, Pradana and Antony (2019), examined the biology teachers' mastery of TPACK and gender and found that there was no significant difference in biology teachers' TPACK between male and female teachers with $p>0.5$. This implies that teachers' mastery of TPACK was not differentiated based on gender.

There is no Statistically Significant Difference in Senior High School Teachers' Level of TPACK Based on working Experience

The result of the study is consistent with a study by Liu, Zhang and Wang (2015) who found that in-service teachers' teaching experience played an important role in all variables of the TPACK. The study found that in-service teachers with 1-5 years of teaching experience have higher mean scores in technological knowledge than teachers with 11-20 years and above 20 years. The finding of the study is in agreement with that of Roig Mengual-Abdres and Quinto-Medrano (2015) who examined the teachers' level technological pedagogical content knowledge and found that teachers who had 0-7 years' experiences teaching had significantly higher TK than teachers who have 16-23 years teaching experience. This finding suggests that as the in-service teachers' years of teaching experience increases, their technological knowledge decreases. The reason being that teachers with teaching experience are more open to accepting technology in learning and tend to use technology for educational purposes. The results of the study are in line with previous studies (Cheng &Xie, 2018; Inan & Lowther, 2010; Liu, Zhang & Wang, 2015) found that teachers who had more than 15 years of teaching experience (experienced teachers) usually had lower level of technological knowledge to use technology in the classroom as compared to less experienced teachers.

The finding contradicts the finding of Jang and Tsai (2012) who found that teachers with more teaching experience possessed higher TPACK than teachers with less teaching experience. The found that the mean scores of pedagogical knowledge and content knowledge level of in-service teacher who have 6-10 years of teaching experience or more were significantly higher than those with 1 to 5 years. In the TPK, TCK, TPACK variable, in-service teachers with 6 to 10 years of teaching experience scored the highest. The

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finding supports a study by (Lee, Suharwoto, Niess and Sadri, 2006) whose finding showed that inexperienced teachers who were weaker in pedagogical knowledge were less able to connect pedagogy and content. The finding concurred with that of Pierson (2001) who found that teachers who possess less pedagogical knowledge were not able to integrate technology with pedagogy knowledge. Similarly, Lee and Tsai (2010) who found that inexperienced teachers cannot differentiate between PK and PCK.

There is no Statistically Significant Difference in Senior High School Teachers' Level of Technological Pedagogical Content Knowledge Based on Educational Qualification.

The findings showed that there were no statistically significant differences in SHS teachers' level of technological pedagogical content knowledge and their highest academic qualification. This finding suggests that educational qualification does not bring differences use of technology in teaching. The finding implied that higher qualification not a requirement for teaching in the Senior High School level.The findings aligned with that of Mai and Hamzah (2016) who found that there are no significant differences in Sciences level of TK, CK, TCK and TPACK based on their educational qualification. On the other hand, the findings contradict of Antony et al. (2019) who found that academic qualification has influence on teacher level of TPACK.

CONCLUSIONS

The study concluded that Technology permeates every facet of human endeavour and its role in facilitating teaching and enhancing students' knowledge acquisition cannot be disregarded in this contemporary times. Teachers' high content knowledge is not surprising since that has been the focus of judging their suitability to teach in schools. Hence, the teachers seem to have focused much on developing their content knowledge to the neglect of other vital contemporary skills such the use of technology. The implication is that they are likely to be glued to the old ways of acquiring and impacting knowledge to their students. Even though rich knowledge is likely to be transmitted to their students, this might not take place in a modern contemporary classroom that pays attention to the interest of learners and the dictate of time. The overall effect could be that some learners might be dawn away from the classroom in search for interesting endeavours rather than to stay in boring and outmoded classroom environment characterised by old ways of teaching. Further conclusions on teachers TPACK draws the attention of stakeholders on the need to develop teachers' technological knowledge. This need is noted by their moderate technological content knowledge found in the study despite their high content knowledge. It was obvious in the study that they possessed high content knowledge but the problem was their low technological knowledge relative to other distinct knowledge base in the TPACK framework. Hence, they were limited in how they could represent content using technology for the purposes of teaching. The implication is that variety in terms of content representation is likely to be hindered, and possibly impedes lessons that could be tailored to the specific needs of learners. The study found the need to motivate and develop female teachers' technological knowledge for effective classroom instruction. In terms of teaching experience and TPACK, the study concludes that higher teaching experience obtained in a technologically motivated school environment strengthens TPACK. This suggests that any training programme organised to update the TPACK of teachers with limited knowledge and capacity should focus on teachers with less teaching experience. Also, any policy to motivate teachers to use technology to teach must focus on the less experienced teachers. The study concludes that teachers' technological knowledge and educational qualification are separable entities. This implies that, teachers use of TPACK does not depend on the level of education or educational qualification. Hence, given the needed support, any teacher can learn how to use technology in teaching. Teachers' TPACK was influenced by their gender, where the male teachers displayed higher level TPACK. By implication, the male teachers appear better in amalgamating technology, pedagogy and content knowledge in instructing lessons than their female counterparts. Hence, the female teachers must be trained.

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RECOMMENDATIONS

The study recommends that the Ministry of Education and government should supply the Senior High Schools with computers, projectors, laptops and internet facilities. Again, regular refresher courses should be organised for the teachers to update their knowledge on emerging technologies because some of the teachers were trained at a time where the use of technology in teaching was not common. Organising regular refresher will assist the teachers to be abreast with the modern technology since technology keeps on changing. On teachers' higher content knowledge, the study recommends that the Ministry of Education through Ghana Education Service should give teachers incentives to motivate them to engage in effective teaching. The study recommends that Ministry of education through GES should organise refreshers courses on modern methods of teaching and motivate teachers to apply them. study recommends that GES should motivate female teachers to Learn the use of technology in teaching. This can be done through seminars and workshop focussing on the relevance of technology in teaching. The study recommends that heads of the Senior High Schools should organise regular in-service training for less experience to enhance their level of TPACK. This can be done by using more experienced teachers as resource persons.

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