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Technological Pedagogical Content Knowledge of Pre-service Teachers in Ghana

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Abstract:
Introduction: Technological Pedagogical Content Knowledge (TPACK) is a framework that integrates the domains of technology, pedagogy, and content knowledge to enhance teachers' understanding of how they can effectively incorporate technology into their instruction.
Methods: The study examines the technological pedagogical content knowledge of pre-service teachers in Ghana through a cross-sectional survey design. Six hundred and seventeen pre-service teachers responded to an online TPACK survey instrument. The study uses descriptive and inferential statistical tools to analyse the data.
Results: The study indicates that pre-service teachers in Ghana generally possess moderate to high competencies in TPACK. The study further reveals that male pre-service teachers reported higher levels of TPACK competence than their female counterparts. Lastly, the study shows that prior teaching experience had no significant impact on pre-service teachers' TPACK development in Ghana.
Discussion: This study examines the perceived levels of technological pedagogical content knowledge (TPACK) among pre-service teachers in Ghana.

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Specifically, the study investigated pre-service teachers' perceptions of technological pedagogical content knowledge and whether their TPACK competencies vary based on gender and prior teaching experiences.
Limitations: This study was restricted to pre-service teachers at a specific university in Ghana. Furthermore, although the TPACK instrument has been validated, its adaptation to the Ghanaian context may not fully reflect local educational practices or technological infrastructure.
Conclusions: It is recommended that teacher education service providers prioritise strengthening technology integration into their pre-service teacher education programmes.

Key words: content, knowledge, pedagogy, pre-service teachers, technology.

Introduction

Technological developments over the past decades have transformed various sectors of Ghanaian society, especially education. Numerous digital tools, resources, and platforms have been created through technological innovations deployed in the educational industry for teaching, learning, assessment, and academic management. Even though technology has potentially transformed education and its practices, it may also present certain limitations if not harnessed effectively and adequately. Technology and technological tools can potentially benefit education only when teachers leverage them appropriately and efficiently for instruction (Abedi et al., 2024; Schmid et al., 2020). Recent educational research indicated that teachers' knowledge of technology and how they can effectively integrate it into instruction contribute significantly to the adoption and integration of technology in education (Darkwa & Agyei, 2021; Schmid et al., 2020). A model, commonly referred to as Technology, Pedagogy, and Content Knowledge (TPACK), helps to explain and describe the types of knowledge that teachers need to have to leverage technology appropriately, efficiently, and effectively in the education industry.

1 Literature review and theoretical frameword

TPACK is a theoretical model rooted in Shulman's notions of pedagogical content knowledge (PCK). According to Schmid at al. (2020), TPACK is considered the most important model for explaining and describing a teacher's competencies for successful teaching with technology. Shulman (1986) developed the TPACK framework, where he considered the teacher not just an expert in pedagogy and content but also an expert in combining content and pedagogy to facilitate teaching and learning. He, therefore, labelled the framework as pedagogical content knowledge (PCK). Mishra and Kohler, in 2006, extended the pedagogical content knowledge of Shulman to include technological knowledge for effective delivery of instruction in the digital age

(Schmid et al., 2020). With this extension, PCK became a technological pedagogical content knowledge framework based on three principal components: Pedagogical Knowledge (PK), Content Knowledge (CK), and Technological Knowledge (TK). Mishra and Kohler (2006) proposed a framework with four hybrid components formed at the intersections of Shulman's (1986, 1987) framework. The four hybrid components with intersections are (1) Pedagogical Content Knowledge (PCK), (2) Technological Pedagogical Knowledge (TPK), (3) Technological Content Knowledge (TCK), and (4) Technological Pedagogical Content Knowledge (TPCK) (Koehler & Mishra, 2008).

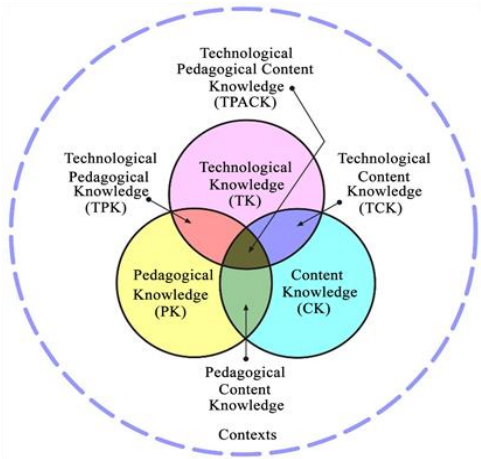

Figure 1. Mishra & Koehler's (2006) TPACK framework.

Schmid et al. (2020) found seven key components of the TPACK model. These components include technology knowledge, content knowledge, pedagogical knowledge, and pedagogical content knowledge, among others. Technology Knowledge (TK) means that teachers know how to use a variety of technology tools, from old-fashioned ones like paper and pencil to more advanced ones like the internet, educational software, digital video, and interactive whiteboards. Mishra and Koehler (2006) say that Content Knowledge (CK) is knowing the subject matter to be taught. This means that teachers must not only know the content well, but they also know how it might differ in different subject areas. Pedagogical Knowledge (PK) is knowing how to plan lessons, assess students, manage a classroom, and use different teaching methods. According to Shulman (1986), teachers' Pedagogical Content Knowledge (PCK) integrates both content and pedagogy to enhance instruction within a specific subject area. It also

underscores how particular content can be effectively taught, taking into account that teaching techniques vary by discipline. Technological Content Knowledge (TCK) involves an understanding of how technology can reshape and present subject matter in new ways. It emphasizes that educators should recognize how the use of specific technologies can influence how students engage with and understand concepts within a given subject area. Technological Pedagogical Knowledge (TPK) is the awareness that teachers have of how different technological tools can support their teaching practices, coupled with the understanding that integrating technology can transform their instructional practices and classroom interactions. Technological Pedagogical Content Knowledge (TPACK) implies the comprehensive knowledge teachers require to effectively integrate technology, pedagogy, and subject content to enhance students' learning. It enables them to meaningfully integrate digital tools into their instruction across various subject areas.

Teachers should understand the complex interplay between the three essential components of knowledge - Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK) by teaching content using appropriate pedagogical methods and technologies in any discipline. The TPACK framework posits that an effective integration of technology, pedagogy, and content knowledge is imperative for fostering a deep understanding of content and enhancing students' learning experience. It is also critically important because it enables teachers to develop meaningful and compelling learning experiences for students, and that requires that teachers have a deep understanding of what to teach (content knowledge), how to teach (pedagogical knowledge) and how to incorporate technology into teaching and learning for the acquisition of the 21st-century competencies (technological knowledge). Again, it helps policymakers to provide significant leadership in developing professional standards for teaching and learning with technology.

The composition of the TPACK framework in the education field has triggered attempts to assess it as an emergent teacher knowledge base for teaching and learning. Although the TPACK construct was initially developed for in-service teachers (Mishra & Koehler, 2006), it is also a vital component of pre-service teachers' preparation because it enhances the overall teaching effectiveness of pre-service teachers (Chai & Koh, 2017). Several studies have demonstrated the importance of structured TPACK training in developing essential skills for pre-service teachers (Diamah et al., 2022; Kim & Lee, 2018). The technological pedagogical content knowledge framework has become a critical component of pre-service teacher education as it provides a comprehensive model for integrating technology into teaching practices. It significantly improves pre-service teachers' competencies and enhances teaching effectiveness and student engagement (Keser et al., 2015). Additionally, pre-service teachers who engage

in TPACK-focused training programmes exhibit tremendous improvement in their TPACK competencies. It also aids in fostering pre-service teachers' understanding of programming as a technological tool to improve student engagement and learning (Kim & Lee, 2018). Baran and Uygun (2016) emphasised that pre-service teacher education programmes incorporate continuing professional development opportunities to enhance technology integration into their teaching practices. Syawallina and Suganda (2023) observed that TPACK facilitates a more learner-centred teaching and learning approach. They stressed that integrating technology with pedagogy and subject matter knowledge in initial pre-service education can foster a more engaging and effective learning environment to encourage and sustain learning. Integrating TPACK into teacher education programmes is essential in preparing teachers who can navigate the complexities of modern classrooms where technology plays a critical role in facilitating learning (Koehler & Mishra, 2008). Ajani (2024), noted that integrating TPACK into pre-service teacher education enables teachers to create personalised learning experiences that are essential for preparing students for success in an ever-increasing digital world and addressing challenges posed by the contemporary educational context, such as a shift to online learning at the peak of the COVID-19 pandemic.

Pre-service teacher preparation programmes in Ghana have been developed to equip the next generation of teachers with the essential knowledge and skills to fully discharge their teaching functions with zeal and efficiency as teachers in pre-tertiary institutions. This notwithstanding, no study has explored the pre-service teachers' level of TPACK in Ghana to shape teacher education policy and practice. Most pre-service teachers' level TPACT studies have been conducted in China (Huang et al., 2022), and Europe (Molgen et al., 2024; Schmid et al., 2020).

Investigations into the incorporation of the TPACK framework in pre-service teacher-related literature, especially in Ghana, are under-explored. Several developing nations, including Ghana, continue to experience challenges in preparing teachers in the TPACK framework. The TPACK framework provides a significant platform for teacher educators to re-evaluate and include preparation practices that would expose pre-service teachers to novel strategies that would enhance the effective integration of technology into their teaching in diverse contexts. The TPACK framework, therefore, is a multiple approach to pre-service professional training and development with 21st-century learning competencies to deliver quality education to help the nation achieve the United Nations' sustainable development goal 4 (quality education). However, technology adoption has been met with challenges, including ill-prepared teachers.

This paper delved into the Ghanaian situation by assessing the understanding of the Technological Pedagogical Content Knowledge of Pre-service Teachers in Ghana. More specifically, this study answered the following research questions: (1) How do pre-service teachers perceive their level of technological pedagogical content knowledge about teaching and learning? Moreover, (2) What differences exist in the TPACK development of pre-service teachers across gender, teaching experience, and subject discipline? There are limited studies in Ghana's context that have explored pre-service teachers' pedagogical content knowledge. Related studies such as Nyamekye et al. (2022) assessed Ghanaian language teachers' level of TPACK in Ghana. Mensah et al. (2021) also explored senior high school geography teachers' integration of technology into geography teaching. Buabeng-Andoh (2019), examined the factors that influence the pedagogical use of ICT in secondary schools in Ghana. In contrast, the study by Asare et al., (2023) explored ICT integration in teaching and learning in colleges of education in Ghana. The present study seeks to fill out the void left in the literature. Studying the technological pedagogical content knowledge of pre-service teachers in Ghana will help teacher education service providers assess, analyze, and improve upon the training of the next generation of Ghanaian teachers who can integrate pedagogy, content, and technology to deliver quality 21st-century education.

2 Methods

The study employs a cross-sectional survey design to examine pre-service teachers' technological pedagogical content knowledge in Ghana. A cross-sectional design was chosen as it enabled the researchers to collect data from a more comprehensive sample at one time to study the technological pedagogical content knowledge of the pre-service teachers in Ghana.

The sample was drawn from 3532 final-year-student teachers in a teacher education university in Ghana through convenient sampling. An online survey instrument was designed and posted to all departmental WhatsApp platforms of the final-year pre-service teachers. The respondents were assured of confidentiality and encouraged to answer the questionnaire only once. The online survey lasted for two months before it was closed. In all, 617 responded to the questionnaire, representing 17.5% of the total population of the final-year students.

2.1 Instrument

The TPACK survey instrument validated by Schmid et al. (2020) was adopted to examine pre-service teachers' technological pedagogical content knowledge. This instrument was deemed appropriate because it could be considered valid and reliable for assessing pre-service teachers' TPACK (Molgen et al., 2024;

Schmid et al., 2020). The instrument consisted of two parts, and part one elicited pre-service teachers' demographic profiles such as age, gender, programme of study and teaching experience. Part two consisted of 28 items underlying the seven components of TPACK, namely: 1. content knowledge (4 items), 2. technology knowledge (4 items), 3. pedagogical knowledge (4 items), 4. pedagogical content knowledge (4 items), 5. technological content knowledge (4 items), 6. technological pedagogical knowledge (4 items) and 7. technological pedagogical content knowledge (4 items). All items were rated on a 4-point Likert scale that ranges from: Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1). The psychometric properties of the subscale of the TPACK have been established by Schmid et al. (2020). The reliability coefficient of each subscale is as follows: 1. content knowledge (.77), 2. technology knowledge (.90), 3. pedagogical knowledge (.84), 4. pedagogical content knowledge (.79), 5. technological pedagogical knowledge (.81), 6. technological content knowledge (.91) and 7. technological pedagogical content knowledge (.87).

2.2 Data analysis

The study examined the technological pedagogical content knowledge of pre-service teachers in Ghana. The demographic details of the participants were analysed using descriptive statistics. Descriptive statistics (mean and standard deviation) were used to analyzed the perception of pre-service teachers' TPACK for each factor. The study employed independent sample t-tests to investigate whether gender and teaching experience, two categorical background factors, had an impact on their TPACK knowledge.

3 Results

Table 1

Demographics of the respondents

Demographics characteristics	*Frequency (N)*	*Percent (%)*
Gender	*608*	*100.0*
Male	369	60.7
Female	239	39.3
Age	*608*	*100.0*
20-25 years	264	43.4
26-30 years	178	29.3
31-35 years	122	20.1
36-40 years	35	5.8
41-45 years	9	1.5

Programme	*608*	*100.0*
BSc ITE	121	19.9
BA English Language	29	4.8
BSc Mathematics Education	79	13.0
BSc Catering and Hospitality Edu.	36	5.9
BA Social Studies with Economics	65	10.7
BSc Fashion Design and Textiles	82	13.5
BSc Management Education	152	25.0
BSc Accounting Education	44	7.2
Teach_Exp	*608*	*100.0*
No	393	64.6
Yes	215	35.4

Research Question One: How do pre-service teachers perceive their level of technological pedagogical content knowledge about teaching and learning?
TPCK is a framework that integrates the domains of technology, pedagogy, and content knowledge to better understand how teachers can effectively incorporate technology into their teaching practices. Research question one examines the perception of pre-service teachers of their TPCK development, focusing on various components including technological knowledge, pedagogical knowledge, content knowledge and the interactions between these domains. The data presented is based on pre-service teachers' self-assessed competence across various knowledge domains, with responses measured on a 4-point scale. Pre-service teachers' perception of their competence in these areas can provide insights into potential areas for improvement in teacher education programmes.

Table 2

Analysis of pre-service teachers' perception of their level of technological pedagogical content knowledge about teaching and learning

Factors	*Mean*	*Std. Dev.*
TK	3.08	0.62
CK	3.15	0.69
PK	3.32	0.71
PCK	3.26	0.66
TCK	3.05	0.65
TPK	3.19	0.68
TPCK	3.21	0.65

The analysis of pre-service teachers' perceptions of their technological pedagogical content knowledge reveals that they generally perceive themselves to have moderate to high competence across the different knowledge areas. Technological Knowledge (TK): The mean score for TK is 3.08, suggesting that most pre-service teachers agree (mean=3) that they possess adequate technological knowledge, though they are not fully confident (mean=4) in this

area. This result highlights that they feel somewhat comfortable using technology, but there may still be room for growth to strengthen their confidence and expertise in this area. For CK, the mean score is 3.15, indicating that pre-service teachers agree that they possess strong content knowledge related to their subject matter. This score being slightly above 3 suggests a moderate level of confidence in their ability to understand and deliver content knowledge, though there is still some space for improvement. The mean score of PK is 3.32, the highest among all categories. This shows that pre-service teachers tend to strongly agree (closer to 4) that they are competent in teaching strategies and managing classroom interactions. Their confidence in pedagogical skills appears to be robust. The mean score for PCK is 3.26, reflecting those pre-service teachers agree that they can effectively integrate pedagogical methods with their content knowledge. This indicates a solid understanding of how to teach specific content in a way that is accessible to students, although it is not at the level of "strongly agree."

The mean score for TCK is 3.05, indicating that pre-service teachers agree they are capable of using technology to deliver content knowledge. However, this is the lowest mean score among all categories, suggesting that while they are comfortable with technology, they do not yet feel fully confident in using it specifically for content instruction. Additional training or experience in this area may help increase their confidence. The mean score of TPK is 3.19, showing that pre-service teachers agree that they can integrate technology with pedagogy. This suggests moderate confidence in their ability to use technology to support their teaching methods, though further development could enhance their skills. The overall mean score for TPCK is 3.21, reflecting that pre-service teacher agree they can integrate technology, pedagogy, and content knowledge in their teaching practice. This moderately high score shows that while they are generally confident in combining these areas, there is still some room for improvement to reach a level of strong agreement (mean=4).

Research Question Two: What differences exist in the TPACK development of pre-service teachers across Gender?

In examining the development of Technological Pedagogical Content Knowledge (TPACK) among pre-service teachers, it is essential to consider whether gender plays a role in shaping their perceptions of their competence in integrating technology with pedagogy and content knowledge. Understanding any potential gender-based differences can help inform teacher training programmes and promote equitable learning experiences. To address this, an independent samples t-test was conducted to analyze the TPACK development of pre-service teachers across genders, assessing whether significant differences exist between male and female pre-service teachers in their self-reported levels

of TPACK. The following analysis presents the findings and interpretations based on the results of the t-test.

Table 3

Analysis Independent sample t-test in the TPACK development of pre-service teachers based on gender

Gender	*N*	*Mean*	*SD*	*t*	*df*	*Sig.*	*eta sqrt*
Male	369	3.244	0.558	3.542	608	0.001	0.020
Female	239	3.078	0.573				

Table 3 presents the results of an independent samples t-test conducted to examine the differences in Technological Pedagogical Content Knowledge (TPACK) development between male and female pre-service teachers. The mean TPACK score for male pre-service teachers is 3.244 (SD=0.558), while for female pre-service teachers, the mean score is 3.078 (SD=0.573). This indicates that male pre-service teachers generally perceive themselves as having a higher level of TPACK competence compared to their female counterparts. The t-value of 3.542, with 608 degrees of freedom, indicates a statistically significant difference between the two groups. A positive t-value shows that male pre-service teachers report higher mean TPACK scores than female pre-service teachers. The significance value (p-value) is 0.001, which is lower than the conventional alpha level of 0.05. This suggests that the difference in TPACK development between male and female pre-service teachers is statistically significant. Therefore, we can reject the null hypothesis, which states there is no significant difference between the genders in terms of TPACK development. The calculated eta squared (η^2) value is 0.020, indicating a small effect size. This suggests that while the difference between male and female pre-service teachers' TPACK scores is statistically significant, the practical significance of this difference is modest. In other words, although males perceive themselves as having slightly higher TPACK development than females, the actual difference in practical terms is relatively small.

What differences exist in the TPACK development of pre-service teachers based on teaching experience?

Teaching experience is often seen as a factor influencing teachers' confidence and competence in using Technological Pedagogical Content Knowledge (TPACK) in the classroom. Pre-service teachers with prior teaching experience may perceive themselves as having more developed skills in integrating technology with pedagogy and content than those without experience. This analysis explores whether teaching experience impacts the self-perceived

TPACK development of pre-service teachers. An independent samples t-test examined the differences in TPACK development between pre-service teachers with and without teaching experience.

Table 4

Analysis of Independent sample t-test in the TPACK development of pre-service teachers based on Teaching Experience (TE)

TE	*N*	*Mean*	*SD*	*t*	*df*	*Sig.*	*eta sqrt*
No	393	3.170	0.548	-.519	606	0.604	
Yes	215	3.195	0.607				

Table 4 presents the results of the independent samples t-test which compares the TPACK development of pre-service teachers with and without teaching experience. The mean TPACK score for pre-service teachers without teaching experience is 3.170 (SD=0.548), while for those with teaching experience, the mean score is 3.195 (SD=0.607). The means are quite close, indicating only a slight difference between the two groups in terms of their self-reported TPACK development. The t-value of -0.519 with 606 degrees of freedom suggests that the difference between the two groups is not substantial. A negative t-value indicates that pre-service teachers with no teaching experience have a slightly lower mean TPACK score than those with teaching experience, though the difference is minimal. The p-value (Sig.) of 0.604 is higher than the conventional alpha level of 0.05, indicating that the difference in TPACK development between pre-service teachers with and without teaching experience is not statistically significant. This suggests that teaching experience does not significantly influence pre-service teachers' perceptions of their TPACK development. Since the p-value is not significant, the eta squared (η^2) for effect size is not calculated. However, given the small t-value and the lack of significance, it is likely that the effect size would be very small, indicating that teaching experience has little practical impact on TPACK development in this sample.

4 Discussion

The study examined the perceived levels of technological pedagogical content knowledge of pre-service teachers in Ghana. More specifically, it sought to examine pre-service teachers' perceived level of technological pedagogical content knowledge about teaching and learning and to establish whether pre-service teachers' TPACK competencies differ across gender and teaching experiences. The findings of the study reveal that pre-service teachers in Ghana generally have moderate to high competencies across different dimensions of

TPACK, particularly Pedagogical Knowledge (M=3.32) and Pedagogical Content Knowledge (M=3.26). This suggests that while they perceive themselves as competent in integrating technology, pedagogy and content knowledge in their teaching and learning to deliver 21st-century education, their confidence in pedagogical skills appears more robust. The findings are consistent with recent studies that sought to suggest that pre-service teachers largely demonstrate positive attitudes toward the integration of technology in educational settings (Susanti 2023; Rafiq et al., 2022; Wang et al., 2020). Rafiq et al. (2022) found in a study that English as a Foreign Language pre-service teachers from a university in Indonesia demonstrated a high level of TPACK knowledge, particularly technological knowledge, which is an indication that they can competently incorporate technology into instruction. It is instructive to note that though pre-service teachers in Ghana and Indonesia have demonstrated high levels of TPACK competencies, the former is more competent in pedagogy, whereas the latter is competent in technology. It is evident from this study that teacher education programmes in Ghana are structured with more emphasis on content, pedagogy and pedagogical content knowledge than technology integration. Additionally, previous studies such as (Mare et al., 2019; Saricoban et al., 2019; Singh & Kasim, 2017) have all indicated that pre-service teachers seem to have adequate competencies of TPACK dimensions and are desirous to incorporate technology into their classroom teaching and learning exchanges. Moderate to high levels of competencies that Ghanaian pre-service teachers have demonstrated in TPACK dimensions, particularly in pedagogy and pedagogical content knowledge, can also be inferred that all the participants were final-year students who have gone through a structured teacher education programme. This view is supported by the assumption that the development of TPACK among pre-service teachers is mostly influenced by their years of study and as they advance in their studies, their TPACK scores tend to increase and broaden their competencies to integrate technology into pedagogy and content knowledge to promote 21st-century education (Ozdemir, 2016; Wang et al., 2020). The study has revealed that even though pre-service teachers possess adequate technological knowledge, they are not fully competent in integrating technology into their teaching, which calls for more training on how to integrate technology into everyday teaching and learning activities, given that today's children are digital migrants.

In assessing the development of technological pedagogical content knowledge of pre-service teachers in Ghana, the study examined whether gender influences their perceptions and competencies in integrating technology with pedagogy and content knowledge. It is established from the study that pre-service teachers' perceived level of technological pedagogical content knowledge about teaching and learning differs across genders. This study revealed that male pre-service

teachers perceived themselves as having higher levels of TPACK competence than their female counterparts. The findings of this study are consistent with previous studies that male pre-service teachers reported higher levels of TPACK competence compared to their female counterparts, especially in areas of technological knowledge, pedagogical knowledge and pedagogical content knowledge (Baker et al., 2020; Irwanto et al., 2022; Marange, 2024). The present findings are also inconsistent with a study by Sukarno, Riyadini and Alsamiri (2024) who reported no significant differences in the TPACK competence of male and female pre-service teachers in Indonesia. In a similar study, Syafi and Anam (2022), indicated gender did not influence TPACK mastery in Indonesia. In another study involving pre-service teachers in Turkey, Mailizar et al. (2021) found a significant gap in TPACK based on gender but indicated those gaps were not observed across educational settings globally. The mixed results for gender differences in TPACK competencies among pre-service teachers globally may be due to contextual factors like the educational environment and the specific characteristics of the teacher studied (Mailizar et al., 2021, Mao, 2023). The statistically significant difference between male and female pre-service regarding their TPACK mastery in Ghana can partly be because of the cultural context where societal norms and expectations often steer female pre-service toward specific roles that can potentially limit their exposure to technology and its usage in teaching and learning (Abubakar et al., 2020). Again, gender differences in technology use may influence male and female pre-service teachers' level of TPACK development as studies have shown that males are more confident in using technology than female pre-service teachers who mostly engage in more collaborative and communicative use of technology (Etmer & Ottenbreit-Leftwich, 2010). Finally, educational policies and precedents in Ghana (Owusu-Agyemang et al., 2021), self-efficacy and motivation (Mills & Tinelli, 2010), and pedagogical approaches and preferences of male and female pre-service teachers (Eisenberg & Johnson, 2021), may be influential factors in respect of the differences in their TPACK competencies.

Lastly, the study examined whether pre-service teachers with prior teaching experience perceive themselves as more competent in incorporating technology with pedagogy and content knowledge than their counterparts with no teaching experience. The study reported a slight difference between teachers with and without prior teaching experience regarding their perceptions of TPACK development. However, the differences did not appear to be statistically significant. This implies that teaching experience had no significant influence on pre-service teachers' TPACK development in Ghana. The present study's findings are consistent with those elsewhere that indicate that pre-service teachers with prior teaching experience often demonstrate different TPACK development compared to those without such experience (Tanucan et al., 2021;

Syafil & Anam, 2022). A study by Tanucan et al. (2021) observes that teachers who have had prior teaching experience often tend to have lower confidence in their TPACK development, irrespective of their previous experience in teaching. They attributed the situation to the tendency where pre-service teachers with prior experience to rely heavily on traditional pedagogical approaches that do not warrant the integration of new technology into teaching and learning. In a similar study, Jaeni (2024), also observed that pre-service teachers without prior teaching experience are more open to integrating technology into their teaching practices because they are less constrained by established routines.

5 Conclusions and implications for future research

The following major conclusions were derived from the findings of this study regarding the (TPACK) of pre-service teachers in Ghana:

Pre-service teachers in Ghana generally perceive themselves as having moderate to high competencies across different dimensions of TPACK, particularly in pedagogical knowledge (PK) and pedagogical content knowledge (PCK). This indicates a strong foundation in teaching strategies and integrating pedagogy with content knowledge; however, technological integration needs improvement. This requires effort from the pre-service teacher and the authorities in charge of providing teacher education. Also, the study showed significant gender differences in TPACK competence, with male pre-service teachers reporting higher levels of TPACK competence than their female counterparts. This suggests that gender-specific strategies are needed to address these disparities and ensure equitable TPACK development for all pre-service teachers.

On the other hand, prior teaching experience did not significantly influence pre-service teachers' TPACK development. Both experienced and inexperienced pre-service teachers reported similar levels of TPACK competence, signifying that teaching experience alone may not be a critical factor in developing TPACK skills. Finally, Ghanaian pre-service teachers possess adequate technological knowledge, they are not fully confident in integrating technology into instruction. This enjoins teacher education programmes to place greater emphasis on practical training that supports technology integration in education. Lastly, schools must be able to provide the technological resources that teachers need to use after acquiring the knowledge.

5.1 Implications for teacher education

The findings underscore the importance of structured TPACK training in teacher education programmes. Enhancing pre-service teachers' competencies in integrating technology with pedagogy and content knowledge is crucial for preparing them to deliver quality 21st-century education in Ghana and beyond.

This will ensure effective teacher delivery in the classroom. This will positively affect teaching and assessment of students.

5.2 Recommendations for future research

Further research involving mixed-methods approach is needed to explore the contextual factors influencing TPACK development, such as educational policies, cultural norms, and access to technological resources. Additionally, the study recommends a longitudinal study to offer deeper insights into how TPACK competencies evolve and their long-term impact on teacher education programmes in Ghana. By addressing these conclusions, teacher education service providers can better prepare Ghanaian pre-service teachers to use technology effectively and efficiently in their instruction to foster high-quality education in their Ghanaian classrooms.

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