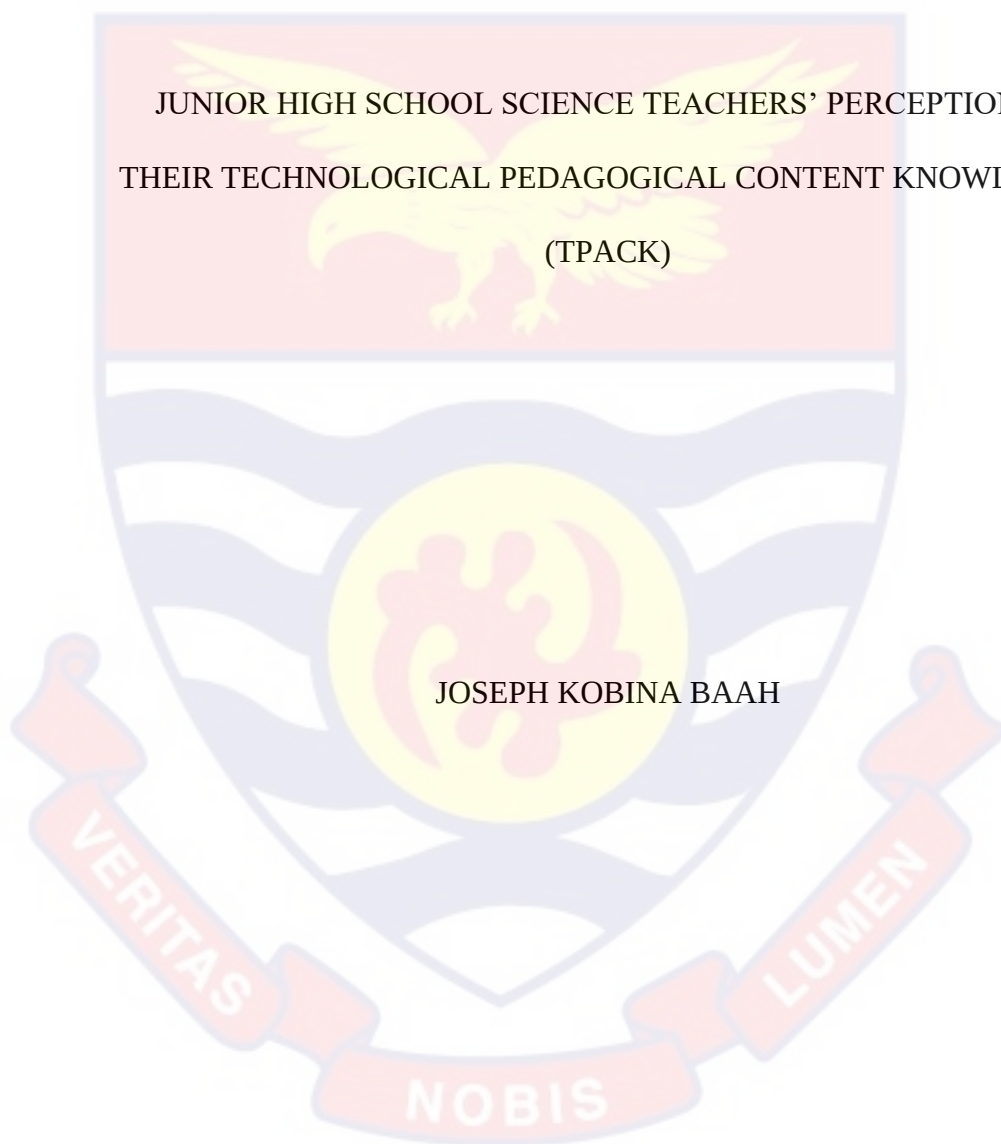


UNIVERSITY OF CAPE COAST

JUNIOR HIGH SCHOOL SCIENCE TEACHERS' PERCEPTION OF
THEIR TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE
(TPACK)

JOSEPH KOBINA BAAH



2024

UNIVERSITY OF CAPE COAST

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(TPACK)

BY

JOSEPH KOBINA BAAH

Thesis submitted to the Department of Science Education, Faculty of Science
and Technology Education of the College of Education Studies, University of
Cape Coast, in partial fulfillment of the requirements for the award of Master
of Philosophy degree in Science Education

SEPTEMBER 2024

DECLARATION

Candidate's Declaration

I hereby declare that the thesis is the result of my own original hard work and that no part of it has been presented for another degree in this institution or elsewhere.

Candidate's Signature Date:

Name: Joseph Kobina Baah

Supervisor's Declaration

I hereby declare that the preparation and presentation of the Thesis was supervised in accordance with the guidelines on supervision of project work laid down by the University of Cape Coast.

Signature of the supervisor Date:

Name: Dr. Kofi Acheaw Owusu

ABSTRACT

The purpose of this study was to examine science teachers' perception of their technological pedagogical content knowledge (TPACK) in Central region of Ghana. The specific objective of the study was to examine the perceived understanding of Junior High School (JHS) science teachers in the various constructs of TPACK framework. The study also looked at the extent to which content knowledge (CK), pedagogical knowledge (PK), technological knowledge (TK), pedagogical content knowledge (PCK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK) correlate with TPACK (also referred to as TPCK). The study finally identified the influence of gender and teaching experience of science teachers' TPACK. The study used cross sectional survey design. The study used questionnaire to gather primary data to address the research questions. The study used proportionate sampling to select a sample size of 155 JHS science teachers. Results were analysed using frequency, Mean and standard deviation and simple linear multiple regression. Based on the results of this study it was concluded that Komenda Edina Equafo Abream (KEEA) municipality and Cape Coast metropolis JHS teachers who teach integrated science have high-perceived understanding of TPACK constructs. TPCK has highly positive correlation with the other six constructs. From the results, it can be concluded that JHS integrated science teachers in these two municipalities have high-perceived understanding of TPACK framework constructs.

KEY WORDS

Content Knowledge

Educational Technology

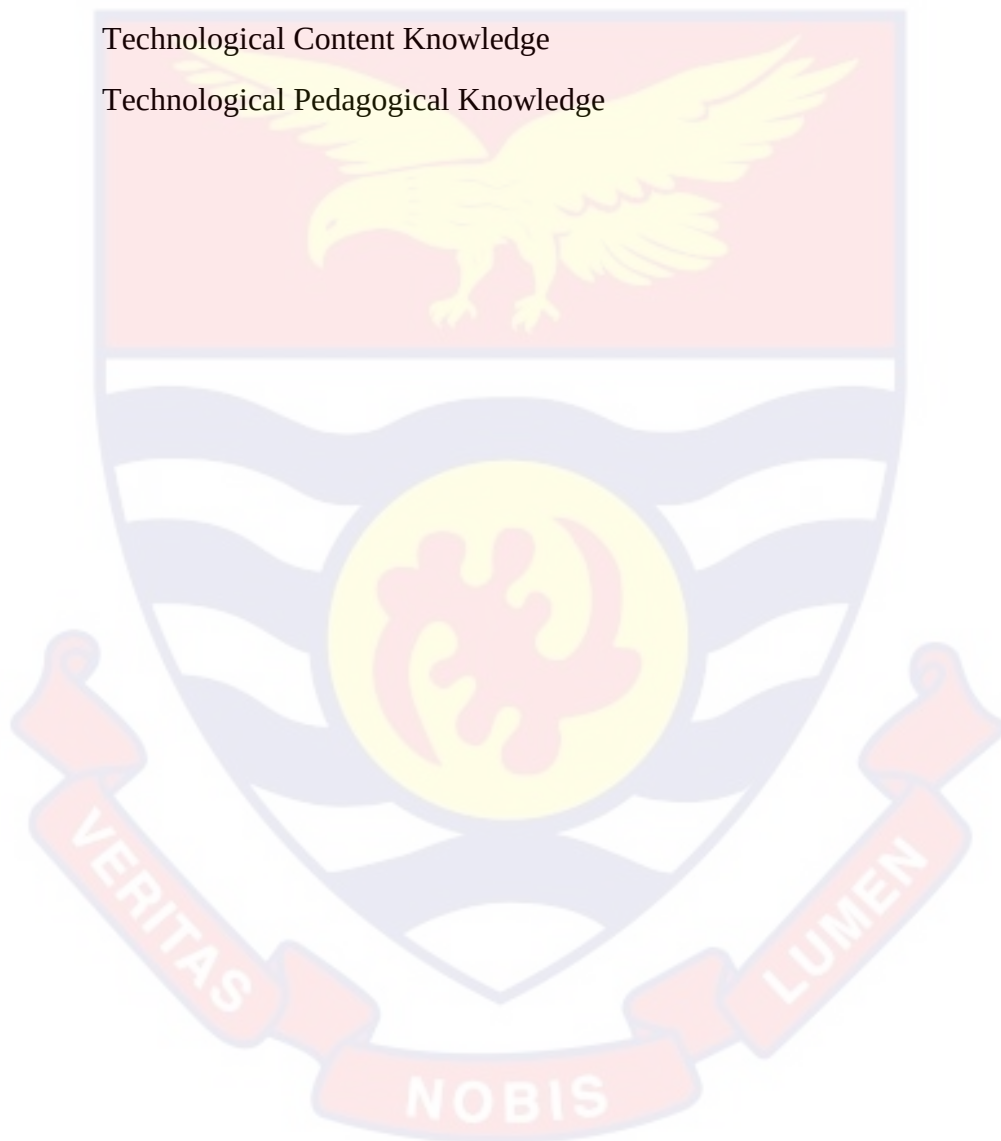
Pedagogical Knowledge

Technological Knowledge

Technological Integration

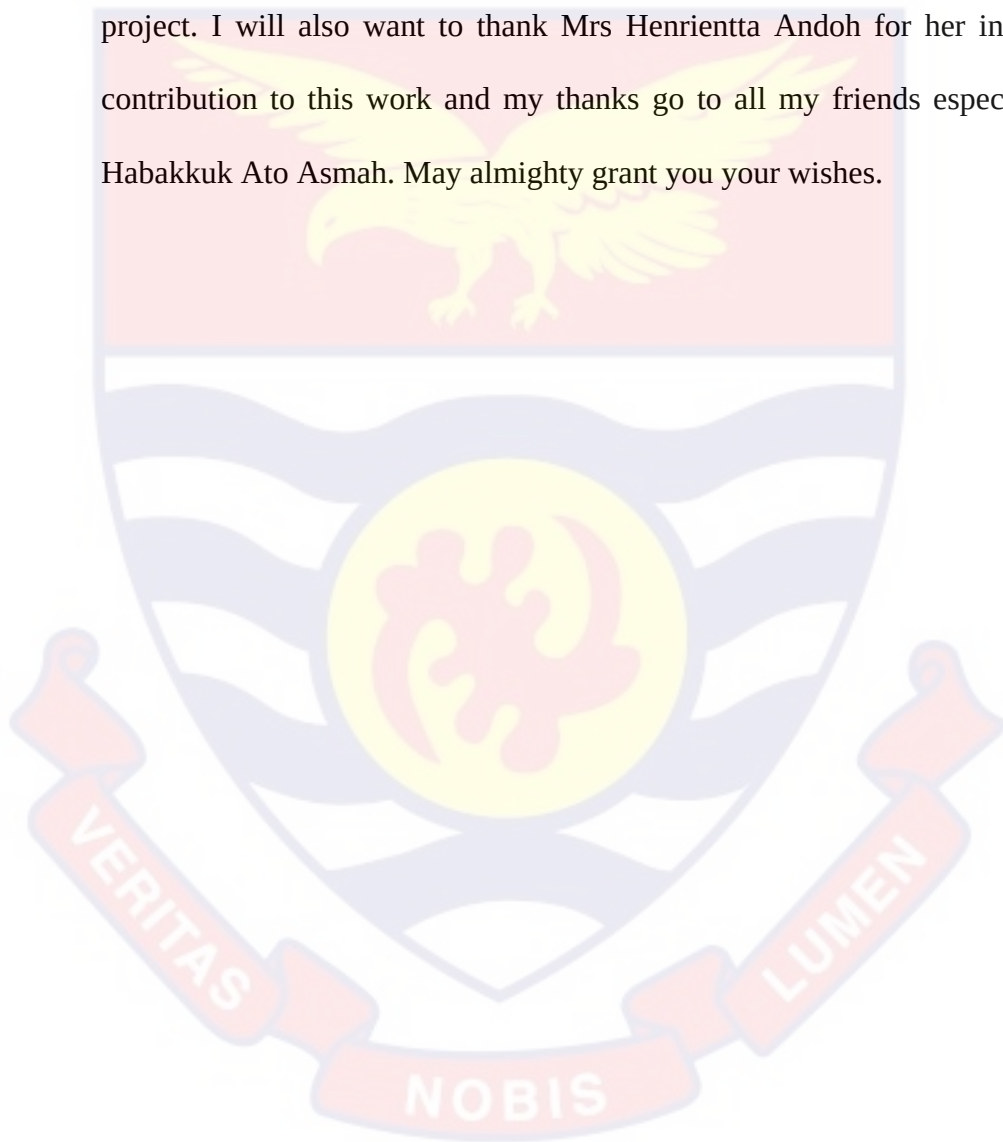
Technological Content Knowledge

Technological Pedagogical Knowledge



ACKNOWLEDGEMENTS

I would like to express my profound gratitude to my supervisor, Dr. Kofi Acheaw Owusu, for supervising this thesis and given me all the necessary assistance and support. I also extend my heartfelt appreciation to Dr. Andoh Nicholas and Dr. Abass Adams for their guidance and support in writing this project. I will also want to thank Mrs Henrientta Andoh for her invaluable contribution to this work and my thanks go to all my friends especially Mr Habakkuk Ato Asmah. May almighty grant you your wishes.



DEDICATION

To my lovely wife love Abena Kwaw, sons Fortune Kobina Baah, Divine

Kojo Baah and my only daughter Agape Efua Tawiah Baah.



TABLE OF CONTENTS

	Page
DECLARATION	ii
ABSTRACT	iii
KEY WORDS	iv
ACKNOWLEDGEMENTS	v
DEDICATION	vi
TABLE OF CONTENTS	vii
LIST OF FIGURES	xii
LIST OF ABBREVIATIONS	xiii
CHAPTER ONE: INTRODUCTION	
Background to the Study	1
Statement of the Problem	5
Purpose of the Study	9
Research Questions	9
Significance of the Study	9
Delimitation	10
Limitations	10
Definition of Terms	11
Organization of the Study	12
CHAPTER TWO: LITERATURE REVIEW	
Theoretical Review	14
Conceptual Framework	36
Research Gap	50
Chapter Summary	51

CHAPTER THREE: RESEARCH METHODS

Research Design	53
Study Area	55
Population	55
Sampling Procedure	56
Data Collection Instrument	57
Data Collection Procedures	61
Data Processing and Analysis	64
Chapter Summary	65

CHAPTER FOUR: RESULT AND DISCUSSION

Research Question One: What are the Science Teacher's Understanding of the Various Constructs of TPACK?	66
Discussion of Science Teachers' TPACK	77
Research Question Two: To What Extent do the Constructs of TPACK Correlate with Each Other?	79
Discussion on the Correlation among Science Teachers' TPACK Constructs	81
Research Question Three: Which of the TPACK Constructs has the Largest Prediction of TPCK?	82
Discussions of TPACK Constructs that has the Largest Prediction of TPCK	88
Research Question Four: What Influence does Gender had on TPACK Constructs?	90
Discussion on the Influence of Gender on TPACK Constructs	94
Research Question Five: What Influence does Teaching Experience had on TPACK Constructs?	95

Discussion on the Influence of Teaching Experience on TPACK	
Constructs	100
Chapter Summary	101
CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS	
Summary of the Findings	102
Key Findings	103
Conclusion	105
Recommendations	105
Implications of the Study on Education Practice	106
Contributions to Knowledge and Literature	107
Suggestions for Further Research	108
REFERENCES	109
APPENDICES	151
APPENDIX A: QUESTIONNAIRE FOR SCIENCE TEACHERS’ TECHNOLOGICAL PADEGOLOGICAL CONTENT KNOWLEDGE	151

LIST OF TABLES

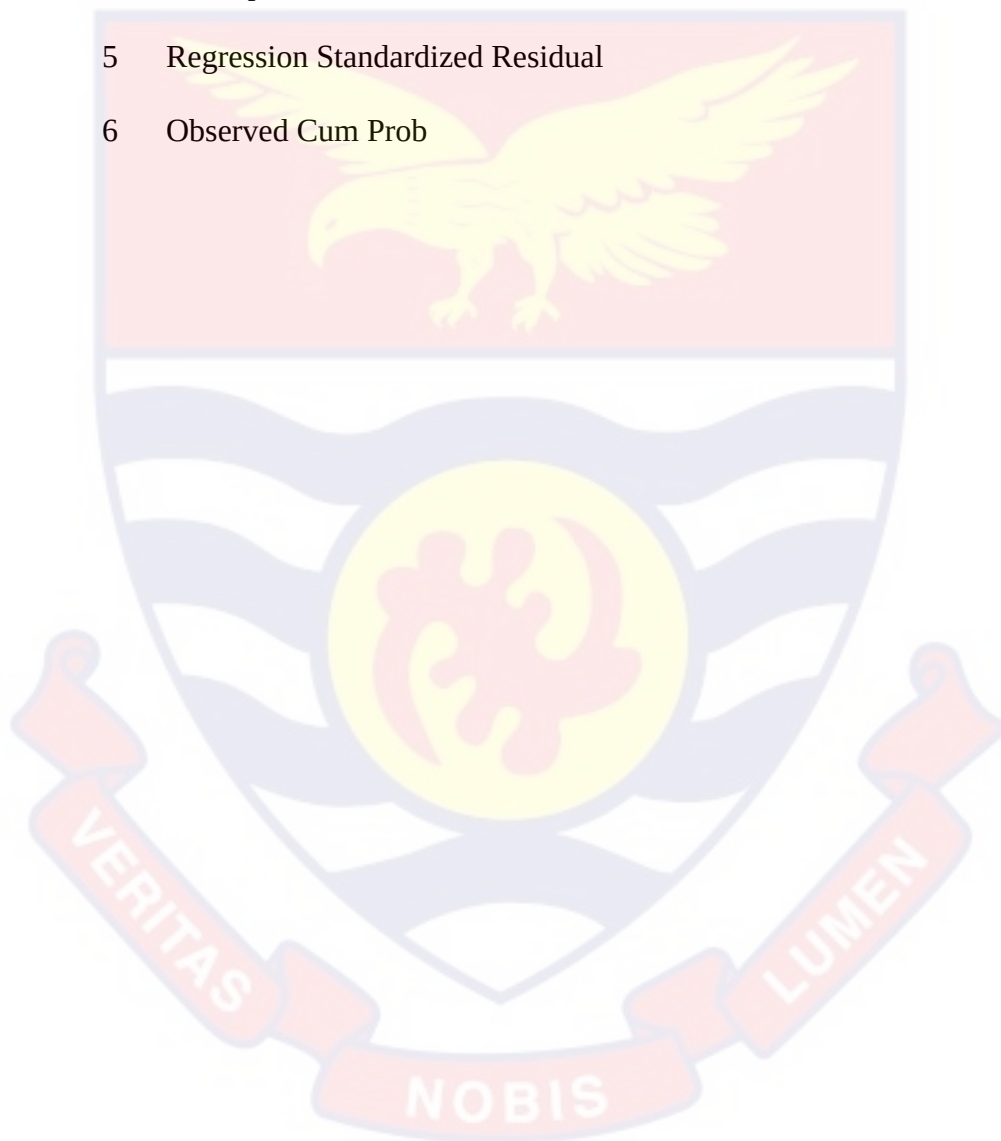
Table	Page
1 Science Teachers' Alpha on the Items of TPACK Constructs	60
2 Science Teachers' Mean Scores for TPACK Constructs	67
3 Science Teachers' Mean Scores for TK Items	68
4 Science Teachers' Mean Scores for Content Knowledge Items	69
5 Science Teachers' Mean Score for the Items Under PK	70
6 Mean Scores for the Items Under PCK	71
7 Teachers' Mean Scores for the Items Under TPK	73
8 Science Teachers' Mean Scores on the Items Under TCK	74
9 Science Teachers' Mean Scores on the Items Under TPACK Construct.	76
10 Correlation Result among TPACK Constructs	80
11 Multicollinearity Test	85
12 Mahalanobis Residuals Statistics ^a	85
13 Model Summary for the Multiple Regression	86
14 ANOVA ^a	87
15 Coefficient Table	87
16 Box's Test of Equality of Covariance Matrices ^a for Qender	90
17 Descriptive Statistics Male and Female Science Teachers' TPACK	91
18 Multivariate Tests ^a of TPACK Across Respondents Gender	92
19 Descriptive Statistics on Teacher Mean on Teaching Experience	95
20 Box's Test of Equality of Covariance Matrices for Teaching Experience	97

21	Multivariate Tests of TPACK across Respondents Teaching Experience	97
22	Bonferroni Multiple Comparison of TPACK Constructs Across Years of Experience.	99



LIST OF FIGURES

Figure	Page
1 Model of Teacher Knowledge (Shulman, 1986)	20
2 Model of Teacher Knowledge (Grossman, 1990)	21
3 TPACK Framework Adapted (Koehler & Mishra, 2009).	23
4 Conceptual Framework	37
5 Regression Standardized Residual	83
6 Observed Cum Prob	84



LIST OF ABBREVIATIONS

CK	Content Knowledge
ELF	English Language Foreign teachers
ICT	Information and Communication Technologies
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
TCK	Technological Content Knowledge
TK	Technological Knowledge
TPACK	Technological pedagogical content Knowledge framework
TPCK	Intersecting construct of Technological Pedagogical and Content Knowledge
TPK	Technological Pedagogical Knowledge

CHAPTER ONE

INTRODUCTION

Technology evolution has greatly impacted every sector of human lives and education is not an exception. From the past, technology has played very important part in the sustainability and development of our society and its infusion with education is therefore inevitable. Technology in education is not only for teachers' benefit but also provides students with access to numerous information and aids them in their learning process (Gillakjani, 2017). Many universities and other educational institutions are using technology within their instruction methods (Shehzadi, Nisar, Hussain, Basheer, Hameed & Chaudhry, 2020). This study therefore, sets out to examine Junior High School science teachers' technological pedagogical content knowledge (TPACK). This chapter serves as the introduction to the whole thesis. The chapter encompasses the background of the study, the statement of the problem, the purpose of the study, the objectives of the study, the research questions, and the significant of the study, the delimitation and limitations, the organization of the study and finally the summary of the chapter.

Background to the Study

The incorporation of technology into education has been a central topic for many countries' agenda all over the world for the past two decades (Chen & Jang, 2014; Chen, Zou, Cheng & Xie, 2020; Davis & Falba, 2002). The rapid technological development in today's world in human activities cannot be overemphasised due to the importance of technology in every field of human endeavour by providing support and solutions to the problems encountered in the field of teaching and learning (Fu, 2013). Sarkar (2012) noted that the use

of ICT has become an important component of educational reform and an integral part of the education delivery. This assertion was later supported by Mohamed, Tlemsni and Matthew (2021) that the world had reached a stage where it is almost impossible for a person without the necessary computer knowledge and skills to work appropriately in society. Technology portrays developmental thought, and enhancement of growth, while lack of it stirs sentiments in the direction of outdated human servitude resulting in incompetence and lack of dexterity (Dunmire, 2010).

Technology integration in teaching and learning has changed the conventional teaching methods and transformed instructional practices leading to new instructional methods, which are beneficial to students as well as teachers (Tezci, 2011; Reddy & Bubonia, 2020). For instance, technology integration in teaching can motivate learners and provide them with important skills to reinforce their learning (Bingimlas, 2009). Moreover, technology allows students to have access to sources of information and become independent learners (Azmi, 2017; Wikan & Molster, 2011). The use of technology in teaching and learning will enrich learning environment and allows learners to understand complex issues, encouraging flexible knowledge construction and enhance individual differences (Sang, Valcke, Braak, Tondeur & Zhu, 2011).

All over the world, information communication technology is what stakeholders are proposing as the reform agenda particularly in education (Tilya, 2008). This means that integrating ICT into the school system will enhance teaching and learning. Agyei and Voogt (2012) indicated that policy makers and governments have invested in teaching with technologies (e.g.,

computers, mobile devices, and interactive screens) to improve teaching. As accentuated by Tilya (2008), the ICT integration in education is highly advanced in developed countries, and hence the need for developing countries to utilise ICT in teaching. For instance, African countries such as Rwanda, South African, Seychelles and Tunisia have adopted the application of ICT in teaching and learning due to its importance in education (Ejemeyovwi, Osabuohien & Bowale, 2020; Okoli & Tewari, 2020; Oloruntoba, Ishola, & Ekanade, 2020).

Ghana made an effort in 2002 to use ICT in education when the “Ghana ICT for Accelerated Development” (Ghana ICT4AD Policy, 2002) was initiated. The policy framework led to ICT integration into Ghana’s educational reform (Awuku, 2018). The attending effect was the equipping of learners in pre-tertiary institutions in Ghana with the requisite literacy skills in ICT and helping them to use these knowledge and skills in their studies as well as in their everyday activities (CRDD, 2007). Teachers were therefore, expected to apply technology to enhance the activities in their classrooms. Such demands necessitate that teachers are properly equipped with ICT skills and competencies in order to incorporate ICT in the teaching enterprise.

As accentuated by Koehler, Mishra and Yahya, (2004) for effective integration of technology in teaching and learning teachers should possess blended knowledge of content, pedagogy and technology and not in isolation. Koehler, Mishra and Yahya’s assertion was later supported by Angeli and Valanides, (2009) and Otreel-Cass, Cowie and Khoo, (2010) that ICT usage in teaching often requires teachers to negotiate a balance of content, pedagogy and technology. Therefore, teachers planning technology integration into their

instruction should consider the requirements of curriculum, the constraints and affordances of the available technology and effective pedagogical practices (Harris & Hofer, 2009). Three constructs: Content, pedagogy, technology, and their interrelationship with each other are the fabric of effective teaching with technology (Mishra & Koehler, 2006).

To address these challenges of teachers' inability to integrate technology in teaching, Mishra and Koehler (2006) introduced technology pedagogical content knowledge (TPACK) model, which is an extension of pedagogical content knowledge proposed by Schulman (1986). Pedagogical content knowledge is the intertwine of both subject matter and methodologies with the sole aim to develop better understanding of teaching and learning practices (Voogt, Fisser, Pareja Roblin, Tondeur & van Braak, 2013). Mishra and Koehler (2006) argued that TPACK is a type of knowledge that teachers need to integrate technology into their teaching practices. According to Greene and Jones (2020), TPACK framework acknowledges that content domains are effectively influenced by the deep application of pedagogical uses of ICT.

Technological pedagogical content knowledge (TPACK) is knowledge of interactions among content, pedagogy, and technology (Wang, 2019). TPACK requires specialized technological knowledge and its interactions with pedagogy and content coherently to achieve effective teaching. Employing the technological and pedagogical knowledge to teach effectively for students to understand the content, makes the learning of the subject matter easier (Koehler & Mishra, 2009; Schmidt et al., 2009). Students' learning is highly promoted if teachers demonstrate a high level of TPACK application in their teaching profession according to the TPACK framework (Oktasari & Putri, 2020). The

TPACK framework has been confirmed to be reliable and valid in terms of measurement of teachers' ability to incorporate technology into the teaching and learning processes according to previous studies (Koh, Chai & Tsai, 2013; Schmid, Brianza & Petko, 2020; Meroño, Calderón & Arias-Estero, 2020). This means teachers need to be conversant with TPACK and its application. Thus, even as technology has become an integral part of the Ghanaian educational system, it is pertinent that a critical look is taken at teachers' understanding of constructs in the TPACK framework. The current study also sought to look at factors that might influence teachers' TPACK constructs.

Statement of the Problem

Countries want their citizens to be global citizens and function effectively in the rapid technological changes and economic development. Such aspirations require that technology is appropriately integrated into educational system. The government of Ghana acknowledged the advantages of technology integration in the classroom and introduced various policies to facilitate the deployment of technology in the educational system (Ministry of Education, 2008). For instance, a national policy on ICT in education was promulgated in 2008 with a focus of providing a platform for graduates from Ghanaian institutions to enhance their ICT usage in knowledge construction and initiate innovative technological inventions (Adarkwah, 2021). There has been provision of laptops to teachers and technological infrastructure such as computer laboratories and internet facilities to educational institutions at all levels (Adarkwah, 2021).

Given that teachers serve as the primary facilitators of curricular implementation, it is imperative that they possess a comprehensive

understanding of ICT. This knowledge is crucial in enabling them effectively utilize these technological tools in their pedagogical practices (Bingimlas, 2009; Lai & Pratt, 2008). It looks prudent that the government has provided technological tools to assist them inculcate into their learners the core competencies of ICT, which includes the use of technology to retrieve information; communicate effectively using technology, use of technology for collaboration and using technology to do critical thinking (Gastelu, Kiss & Dominguez, 2015). In addition, the new curriculum of the common core science programme also demands that science teachers develop the spirit of curiosity, creativity, innovation and critical thinking skills, to enable them communicate scientific ideas effectively with the aid of modern technological tools (CCPC, 2020).

However, the mere introduction of ICT tools is not enough (Fischer, Lundin & Lindberg, 2020) since technology is not educational by default, but a tool that should be carefully integrated into the classroom activities by teachers to suit learners' needs (Kereluik et.al., 2011). For successful technology integration, Koehler and Mishra (2009) posited that the knowledge the teachers need to effectively integrate technology into teaching and learning is technological pedagogical content knowledge (TPACK). Technological pedagogical content knowledge is a specialized knowledge that combines technology, pedagogy and content in a blended fashion and is a very important concept since effectiveness of technology integration in teaching and learning hinges on teachers' pedagogical orientations (Waseela, 2022, Webb, 2005). Thus, even as Ghanaian science teachers are expected to integrate technology

in the classroom, it is necessary that their practice of technology integration is gouged.

Despite the introduction and the benefits of technology in teaching and learning in basic schools some empirical studies by (Arkorful, & Aboagye, 2021; Ayebi-Arthur, et.al., 2023; Natia & Al-hassan, 2015 suggests that technology integration has not been effective in teaching and learning in Ghanaian schools. 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). Other studies (Afari-Kumah & Tanye, 2009; Chidiebere, 2020; Ohiwerei, 2008; Ugwuogo, 2013) also claimed that teachers' underutilisation of technologies is due to inadequate knowledge and skills of teachers on how to operate them. The ineffective use of technology in teaching will make lessons abstract for students to understand, boring instead of pleasure, passive for students' participation, and deprive students' access to key information.

A significant body of research has been conducted on TPACK in developed countries. Notably, researchers such as Bulut (2012), Erdogan and Sahin (2010), Jang and Tsai (2013), and Luik, Taimalu and Suviste (2018) have found a statistically significant difference between male and female teachers in terms of their knowledge level with respect to TPACK constructs. Furthermore, several studies (Jang, Tsai & Chen, 2013; Jordan, 2013; Lee & Tsai, 2010; Mutluoglu, 2012) have discovered that veteran teachers generally possess less TK construct, but exhibit high levels in the remaining TPACK constructs.

However, it is crucial to note that while these studies offer valuable insights, they are largely confined to their specific geographical and cultural

contexts. There is an urgent need for more comparative studies that can shed light on the interplay between TPACK and subject-specific factors, and demographic variables across diverse subject areas. Such research could potentially unveil unique principles as well as cultural variations, thereby augmenting our comprehension of TPACK and its practical implications for teachers in specific subject areas.

In Ghana, numerous scholars have also contributed to this field of study. For instance, Appiah and Mfum-Appiah (2019) investigated the TPACK of JHS teachers in Religious and Moral Education, while Agyei and Voogt (2012) explored the TPACK of Senior High School (SHS) mathematics teachers. Gyaase, Gyamfi and Kuranchie (2019) studied the TPACK of pre-tertiary teachers in colleges of education; Yalley (2017) examined the TPACK of SHS social studies teachers. None of these studies explores the influence of demographic factors on TPACK.

Despite these contributions, a review of the literature reveals a noticeable gap in research focusing on the TPACK of JHS science teachers. This study aims to address this gap and contribute to the understanding of JHS science teachers' TPACK. Furthermore, it seeks to examine the influence of gender and teaching experience on TPACK constructs an area that has been largely overlooked in the Ghanaian context. The findings of this study could potentially inform the development of teacher training programs and contribute to the broader discourse on TPACK in education.

Purpose of the Study

The purpose of this study was to examine JHS science teachers' perceived understanding of TPACK Constructs.

The objectives that guided the study were:

1. To examine the perceived understanding of science teachers in the various constructs of TPACK.
2. To examine the extent to which TPACK correlates with its constructs (CK, PK, TK, PCK, TCK and TPK).
3. To examine the TPACK construct with largest prediction of TPACK.
4. To identify the influence of gender on science teachers' TPACK.
5. To identify the influence of teaching experience on science teachers' TPACK.

Research Questions

The research questions formulated to guide the Study were:

1. What are the perceptions of JHS science teachers' understanding of the constructs of the TPACK framework?
2. What extent does TPACK correlates with its constructs (CK, PK, TK, PCK, TCK and TPK)?
3. Which of the TPACK constructs had the largest prediction of TPACK
4. What influence does gender had on TPACK constructs?
5. What influence does teaching experience has on TPACK constructs?

Significance of the Study

This research presented evidence that adds to the body of literature in the area of ICT integration in education delivery and expansion of TPACK framework discussion.

Delimitation

The study was delimited to only Junior High school teachers in KEEA and Cape Coast metropolis because it is believed that KEEA and Cape Coast have enough science teachers due to their proximity to University of Cape Coast (UCC). The study also focused on public schools' science teachers in KEEA and Cape Coast metropolis and excluded private schools because it is believed that private schools do not have professional science teachers. In a survey study, a number of research instruments can be used to collect the data, however, this study used only questionnaire as data collection instrument.

Limitations

The study had its own limitation just since no human endeavour is free from setbacks. There are certain imposed limitations that are inherent in any research activity, but must be handled. Due to the study's quantitative nature, structured questionnaires were adapted which exposed the study to some limitations. For instance, some of the questionnaires administered were never answered nor returned which affected the total data used for analysis. To overcome such challenges follow up were done to minimize the non-responds rate, which might impact on the findings of the study. Structured (closed-ended) questionnaires were administered to the respondents which limited them from making personal suggestions which could have improved the study's quality. The study overcame these limitations by developing a comprehensive questionnaire which covered all the study's variables and in turn improved the quality of the research. Out of 16 regions only central region teachers were sampled for the study and this could affect the generalization of the findings to Ghana as whole.

Definition of Terms

Educational Technology (ET): refers to the study and ethical practice of facilitating teaching and learning in order to improve performance by creating, using and managing appropriate technological process and resources.

Content Knowledge (CK): refers to the knowledge the teacher possesses about the actual subject matter that is to be learned or taught. This knowledge help teachers to be aware and know what content and nature of knowledge in each content areas to teach.

Technological Knowledge (TK): refers to teachers' knowledge about technology. It is a knowledge needed by the teacher to use technology and his/her ability to solve problems using technology.

Pedagogical Knowledge (PK): refers to the methodological knowledge that teachers need to apply appropriate for effective teaching specific content to learners. PK is about deep processes and practical application of methods of teaching and learning and how it encompasses among other things in teaching and learning enterprise to achieve overall students learning output.

Technological Content Knowledge (TCK): refers to knowledge one needs in order to know how to relate technology and content to influence, and constrain each other to achieve a specific purpose in teaching. TCK also refers to knowledge that provides new ways of teaching content by employing technology. It is about flexibility use of appropriate technologies for educational purposes, thus using technology to represent content in various ways.

Pedagogical Content Knowledge (PCK): refers to methodological knowledge that is applicable and appropriate for teaching specific content. This knowledge includes the understanding of different teaching methods and various theories in subject matter for different subjects. PCK comprises adapting, organizing and presenting different student interest and skills through the blending of content and pedagogy within the presentation for understanding in order to handle problems students face in their education process.

Technological Pedagogical Knowledge (TPK): refers to the knowledge teachers need for the application of the various technologies. This includes constraints and affordances that influence methodological applications and strategies in a teaching and learning setting. TPK is knowing and adopting different technologies to enhance teaching methods.

Technological Pedagogical Content Knowledge (TPACK): refers to the knowledge of interaction among content, pedagogical, and technology. This is a specialized knowledge needed for interweaving technology with pedagogy and content to achieve a coherent technology integration in teaching and learning process.

Organization of the Study

The thesis consisted of five chapters. The introduction was captured in the first chapter, which covers the study background, the problem statement, the objectives of the research and questions for the research, study's significance, delimitation and limitations of the research. Relevant literature review was captured in Chapter two of the study. It discussed the theoretical framework on which the study was based and related conceptual issues. In particular, the concept of PCK and its relationship to the present work was exhaustively

explain. Empirical studies related to the study was also reviewed. Chapter three described the research methods that was used in the study and highlighted the research design, population, the sample and sampling procedure, data collection procedures, validity and reliability of the instruments, and data analysis procedures. The Fourth chapter dealt with discussion and results. The fifth chapter presented the summary of results, the study conclusions and recommendations.



CHAPTER TWO

LITERATURE REVIEW

The chapter discussed the study's comprehensive literature review. The theoretical review, the history of the TPACK framework. The TPACK framework and its various constructs. The demographic variables of teachers (gender and teaching experience) and the use of technology in teaching by science teachers. The review of science teachers' TPACK framework and its reflection on the research questions and hypothesis. Review of research gap and more importantly a summary of the literature reviewed.

Theoretical Review

A theory is a set of interrelated constructs, that present a systematic view of phenomena by specifying relations among variables, with the purpose of examining and predicting phenomena (Camp, 2010). A lot of Models for ICT integration for instructions are currently available to aid teacher-designers plan their ICT integration into the curriculum. Some of which are Technology Acceptance Model (TAM) (Davis, 1989), ICARE (Introduction; Connect; Activity; Reflect; Extend) model (Hoffma & Ritchie, 1998), ASSURE (Analyse learners; State the objective; Select method, media and materials; Require learning participation; Evaluate and revise) model (Heinich, Molenda, Russell & Smaldino, 2001), Innovation diffusion Theory (Rogers, 2003), Pierson's Technology Integration Model (Woodbridge, 2004), Technology Integration Planning Model for teachers (Roblyer, 2006), Social Model (Wang, 2008), SAMR (Substitution Augmentation Modification Redefinition) model (Puentadura, 2012) and many more. These models show how teachers can incorporate various resources and tools into teaching and learning to achieve

technology integration in education. This study employs two theories: Innovation diffusion theory and TPACK framework.

Innovation theory of diffusion

French sociologist Gabriel Tarde first used the theory of diffusion, also known as the innovation diffusion theory in 1903 (Toews, 2003). The diffusion theory is all about the spread of innovation, ideas and technology through a culture or cultures. According to Rogers, (1995) diffusion is act of communicating innovation through various channels over time among people of a social system. Sociologists, psychologists and anthropologist have extensively studied diffusion theory (Al-Rahmi, Yahaya, Alamri, Alyousseef & Kamin, 2019; Claude, Hansson & Ben, 2019; Cirus & Simonova, 2020; Gu, Khan, & Khan, 2019; Pinho, Franco & Mendes, ,2021; Sasaki, 2018; Isa & Hashim, 2018; Scott & McGuire, 2017; Shiau, Huang, Yang & Juang, 2018).

According to diffusion, theory people have many different qualities that cause them to accept or reject an innovation and there are many corresponding different qualities of innovations, which can cause an individual to accept innovation readily or resist them. If a product or service is useless or fruitless, it becomes difficult to find its way through the final users (Almad & Wajid, 2018). One can say that technology is a fruitful product and service in education and finding its way to the final users in education delivery is very important. From the innovation theory lens, teachers' use of ICT can be seen through (Goh & Sigala, 2020; Jwaifell & Gasaymeh, 2013; Scott & McGuire, 2017; Selim, Eid & Agag, 2020). One of the theoretical models which has been accepted and proven useful for explaining and predicting people's behaviour when it comes with information technology is innovation diffusion theory (Yuen, Cai, Qi

&Wang, 2020; Yuen, Wong, Ma & Wang, 2020). The innovation diffusion theory suggests and clarifies those factors like intention; attitude and belief in a particular technological system affect teaching and learning. It also argues that individual's attitude and behavioural intentions affects the influence of the actual use of technology directly or indirectly. Thus, the effectiveness usage of technology by teachers to maximize their teaching and learning process will be affected by intention, belief and attitude they have.

There are five stages to the process of adopting an innovation according to diffusion theory (Vecchio, Agnusdei, Miglietta & Capitanio, 2020). An individual becomes aware of an innovation but has no information about it, is the first stage. Persuasion is the next, which the individual becomes actively interested in seeking knowledge about the innovation. Decision is the third stage, the individual weighs the advantages and disadvantages of the innovation and decides whether to or not to adopt it. Implementation stage is when an individual actually does adopt and use the innovation. The final stage is confirmation –where an individual acknowledges and adopt the innovation. After adopting the innovation, the individual makes a final decision about whether or not to continue using it based on his/her own personal experience with it. These same stages apply, to varying degrees, to groups of people in addition to individuals.

Many factors determine how likely individuals will adopt or reject innovation. It has been acknowledged that, if an innovation is better, it will eventually be adopted and adapted (Hilmersson, Johanson, Lundberg & Papaionnou, 2021). However, if moral values of the people contrary to the innovation, people adopt less to it. Thus, peoples are likelihood to adapt to

innovation whose roles and aspiration are in conformity to the moral values of the community people found themselves in. Many people will also refuse to use the innovation when they find it difficult to use it. Thus simplicity is also influences the rate of adoption of an innovation (Mallinson, 2020). This means that developers must endeavour to make the technology user friendly. Teachers should also be conversant with technology they use and make is so simple for students to appreciate it. People will find it difficult to resist the temptation to adopt innovation when they see that the innovation is beneficial to them and their neighbours. Many people are likely to follow suit if highly respected members in community adopt an innovation. Therefore, head teachers and departmental heads should lead the innovation drive. Consensus building by stakeholders in education to encourage teachers to incorporate technology effectively in their teaching is the way to go. Hence, in this study, Innovation Diffusion Theory was chosen to be the basic model to further examine the ICT integration, because of its relevance to the study. The theory addresses the issue of how users adopt and adapt to use a technology integration, the relationship among users' beliefs about technology usage, attitudes and intentions to use technology in the process of teaching and learning.

Pedagogical content knowledge (PCK) framework

All over the world, various professions have body of knowledge which spell out the skills those who practice that profession are supposed to exhibit to qualify them as competent practitioners. However, the teaching profession, which is one of the oldest profession through which all other professions were born, lack that. There is no consensus about the standard knowledge teachers should possess to qualify them as professionals (Fernandez, 2014). As a result,

most teachers think they do not need any special knowledge beyond the specific content to be a teacher. Because of this teaching profession has become a temporary one and people join anytime and leave anytime they want. This has created an impression that teaching is not a profession and society do not regard it as such. Specific content (such as Physics, Chemistry, Geography, Biology etc.) is the primary knowledge to be a teacher, however, in the 21st century, the specific skills for teaching is very important and one cannot overlook (kind, 2009). Montero (as cited in Fernandez, 2014) teaching encompasses a number of things and goes far beyond what happens in classroom, it includes less visible and less socially recognized activities such as planning and assessment performed by teachers. Therefore, teacher educators must take into consideration these activities during the preparation and analysis of knowledge of teachers.

The difference that exist between the knowledge about the teaching and learning of a topic and knowing about that topic is huge (Bucat, 2005). These differences are being catered for by the introduction of the PCK. The concept that has come to represent the knowledge teachers need in teaching and learning process is PCK (kind, 2009). One of the concepts that has attracted concerns of researchers and has been widely used in the literature and proving to be a fruitful model about teachers' knowledge for specific professional development is PCK constructs. Research has proving that PCK makes one a good teacher (Abell, 2008; Fernandez, 2014). The central knowledge one needs to have in order to teach effectively is skills to know how to teach. In 1980s education researchers became aware that teachers need not only base knowledge but also skills to teach effectively (Shulman, 1986). Accordingly, series of models were

proposed by various authors (Elbaz,1983; Freire,1985; Gauthier,1998; Pepper,2008; Wilson, Shulman & Richert,1987; Shulman, 1986,1987; Tardif, 2002) in an attempt to describe and delineate a body of knowledge base, teachers need to teach effectively. Personal knowledge, Knowledge from initial and continuous training knowledge of curriculum and knowledge of professional practice were different sources of knowledge teaching profession required to effect the changing dynamics.

In the quest for empowering teachers to overcome the knowledge deficiency in teaching profession Shulman (1986) introduced the model PCK as a component of what he called a knowledge base for teaching (Fernandez, 2014). According to Fernandez (2014) the knowledge of instructional strategies and representation of the specific content on the one hand, and students' conceptions of specific content and understanding of learning difficulties on the other are the key elements in the Shulmans' conception for PCK. In the university of Texas in 1983, Shulman presented a paper titled "the missing paradigm in the research about teaching". At this conference, Shulman introduced the expression PCK, see Figure 1. The first time to show a specific type of knowledge teacher needs, a knowledge that make distinction between a teacher in a given discipline from an expert of that discipline (Fernandez, 2014). The selection of teachers was focused on content and pedagogy and Shulman found out whether it is always imperative to have a separation between content and pedagogy on the path of becoming a teacher (Shulman, 1986).

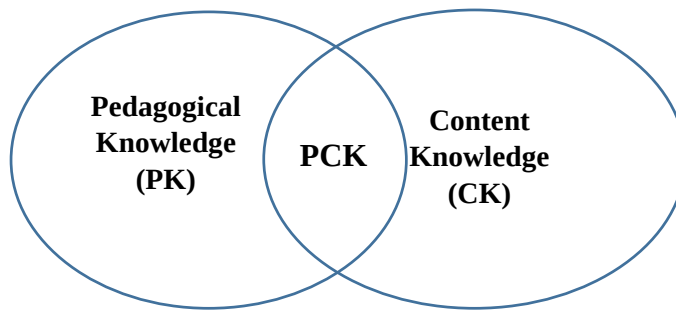


Figure 1: Model of Teacher Knowledge (Shulman, 1986)

Source: Researchgate.net

Since then PCK has been widely used by various researchers in educational field the moment the term was coined. After the introduction of PCK by Shulman, Grossman (1990) was the first person to add onto the PCK model. From him there are four interacting elements that teachers need as basis for effective teaching. These are 1. General pedagogical knowledge; 2. Subject matter knowledge; 3. The pedagogical content knowledge 4. Knowledge of context. In his model, PCK is seen as the transformation of PK, content and context specific and it occupies the central position (Figure 2). Grossman gave a hierarchical representation of knowledge that teachers need to teach effectively after Grossman re-examines the Shulman's idea of knowledge base for teachers and included the knowledge of the curriculum into PCK.

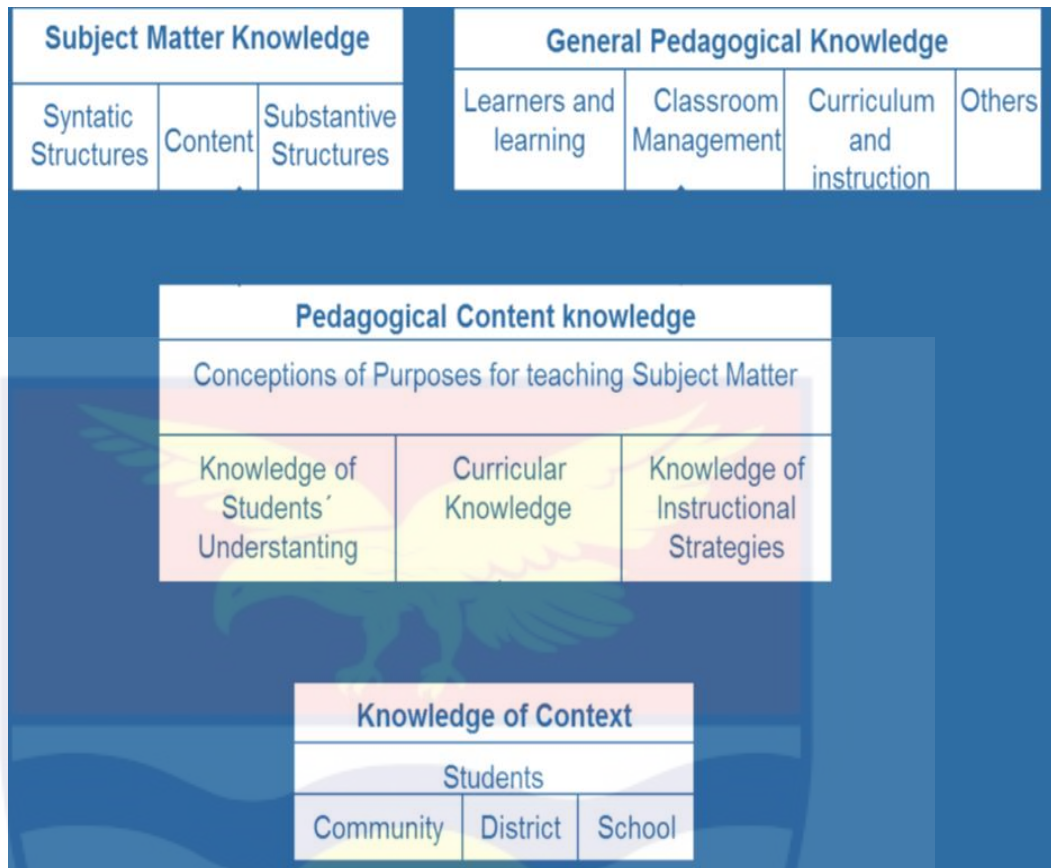


Figure 2: Model of Teacher Knowledge (Grossman, 1990)

Source: Grossman, (1990, p.5)

The PCK model was modified continuously by different authors until 2001 when Pierson initially clarified the idea and introduced the Technological component into the model and was followed by other scholars such as (Angeli & Valanides, 2005; Koehler & Mishra, 2005; Niess, 2005) all proposed a similar concept - a more specific approach to incorporate technology into PCK effectively. These efforts by the above researchers resulted in the TPACK model. However, the widespread popularity of the term TPACK began when Mishra and Kohler's primary work defined the model and described both central constructs of the TPACK in 2006.

Technological pedagogical content knowledge (TPACK)

Technological pedagogical content knowledge (TPACK) is an instrument for measuring technology integration in education (Fabian, Lachner & Backfisch, 2020). Teachers need TPACK in order to know how to integrate technology in the curriculum efficiently (Assadi & Hibi, 2020). Initially, TPACK was called "TPCK" until 2008, when some scholars in the research community suggested a more easy-to-speak term - TPACK according to Jang (2010). Explicitly incorporating technological knowledge into the Schulman (1986, 1987) conceptual model for PCK, the TPACK framework was constructed (Cain, Koehler & Mishra, 2013).

Figure 3 depicts pictorial representation of a diagram using three overlapping circles, each depicting a distinct form of landmark knowledge representing TPACK various constructs (see Fig.3). The three distinct categories of knowledge are TK, PK and CK. From the pictorial representation of TPACK, the combination of three distinct basic constructs of knowledge produces four additional types of knowledge: TPK, PCK, TCK and TPCK. In a nutshell, the intersection of these three knowledge types is an innate understanding of teaching content with appropriate pedagogical methods and technologies. In all, seven components are found on the TPACK model.

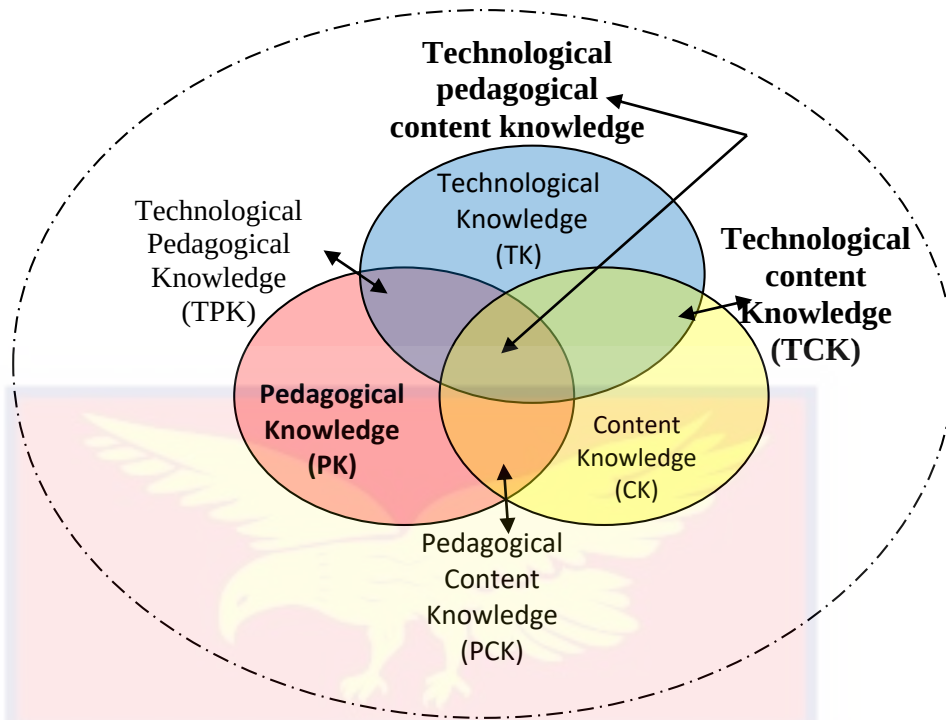


Figure 3: TPACK Framework Adapted (Koehler & Mishra, 2009).

Source: Koehler and Mishra (2009, p.63)

The combination of CK, PK, TK, PCK, TCK, TPK and TPACK enables teachers to know and understand what knowledge is needed to integrate technology in classroom teaching and how they can develop it in themselves (Sintawati & Abdurrahman, 2020). This means TPACK is very essential in technology integration in education. Mishra and Koehler (2006) applied the framework to both preservice and in-service teachers. This study is employing Mishra and Koehler (2006) TPACK framework which was used as the Knowledge teachers need to teach effectively in the 21st century (Rets, Rienties & Lewis, 2020).

Technological knowledge (TK)

Technological Knowledge is a teachers' knowledge about technology. In a broad perspective, it is a knowledge needed by the teacher to use technology and his/her ability to solve problems using technology (Purwaningsih et al.,

2020; Voogt et al., 2013). TK includes both older technologies such as books, chalk and blackboard and newer digital technologies such as the internet, digital video, and the different form of providing information (Li, Sun & Jee, 2019; Polly, Mims, Shepherd & Inan, 2010). Chai et al. (2011) penned that TK includes teachers' ability to use technologies such as whiteboard, smartboard, tablets and web 2.0 tools such as (Wiki Blog, Facebook etc.).

From the studies, (e.g., Koehler, Mishra & Yahya, 2007; König, Bremerich-Vos, Buchholtz, Fladung, & Glutsch, 2020; Moore, 2013; Windschitl & Sahl, 2002) it has been established that when teachers integrate technology into lessons, instruction is demystified and learners become more interested in the subject. Besides, when teaching and learning are supported by technology, it encourages the teacher and learner interactions and lesson delivery is much interesting (Keller, Neumann & Fischer, 2017). This assertion was supported by Hebebcı, Bertiz and Alan, (2020) that teachers' TK is not only the instrumental knowledge but also its affordance and constraints of a given technology. This helps the individuals to accomplish a variety of different task using ICT to develop various ways of accomplishing a given task (Rocha, 2020). Recommendation from (Hulburt, Colaianne, & Roeser, 2020; Koehler & Mishra, 2008) is that educators should not only concentrate the development of technological skills in teacher education studies but also throughout their professional career since teachers' interests and awareness of different technologies and its usage contribute significantly to their professional competency.

Lack of TK of Pre-service teachers will impact negatively in the future classroom teachers' activities according to (Ozgun-Koca, Meagher & Edwards,

2010; Şahal & Ozdemir, 2020). Integration of technology into the courses through observation and participation has a positive impact on pre-service teachers' TK (Polly, Mims, Shepherd & Inan, 2010; Oakley, 2020).

Content knowledge (CK)

CK is the knowledge the teacher possesses about the actual subject matter that is to be learned or taught. According to Koehler and Mishra (2009), teachers' knowledge about the subject matter he/she teaches is the CK. Teachers should be aware and need to know what content and nature of knowledge in each content areas to teach (Kuennen, & Beam, 2020). The content areas differ in different subject matter (Anders & Guzzetti, 2020; Mishra & Koehler, 2006). The CK recognizes the knowledge and its organization in the minds of the teachers. Teachers should, therefore, be able to organize, connect ideas, concept and theories accordingly (Fries, Son, Givvin, & Stigler, 2020; Kubsch, Nordine, Neumann, Fortus & Krajcik, 2019).

According to Koehler and Mishra (2009), teachers lack of understanding of CK can misrepresent those subjects to their students. This assertion was supported by Putri, Hidayat and Purwianingsih (2020) that teachers without CK are likely to have misconceptions or misleading facts regarding the Subject. Therefore, for teachers to be effective they must to have a broad and comprehensive knowledge based upon the subject they teach and present the content logically and systematically (Jang & Tsai, 2013; Ramaligela, 2020).

Pedagogical knowledge (PK)

Methodological knowledge that teachers need to apply appropriate for effective teaching specific content is PK. PK also refers to teachers' knowledge of teaching and learning (Surayya & Asrobi, 2020). PK is about deep processes

and practical application of methods of teaching and learning and how it encompasses among other things in teaching and learning enterprise to achieve overall students learning output (Gou, Liu & Wang, 2020). PK is the knowledge teacher needs in teaching and learning to commence and sustain the teaching processes from the beginning to the end of the activity (Sahin, 2011). Student's assessment, classroom management and lesson plan are all parts of this activity. It also includes various classroom management knowledge such as students' evaluation strategies for them to understand and development concepts and theories of learning and how they can apply to their daily activities (Chai et al., 2011; Kaplon-Schilis & Lyublinskaya, 2020). PK is teaching strategies which are employed by instructors to satisfy individual learning needs in the presentation of the subject matter (Gou, Liu & Wang, 2020). This means PK is needed for practice, procedures, strategies and methods necessary for achieving teaching and learning.

Pedagogical content knowledge (PCK)

Pedagogical content knowledge is a methodological knowledge that is applicable and appropriate for teaching specific content. It includes the understanding of different teaching methods and various theories in subject matter for different subjects (Tufail, & Mahmood, 2020). PCK comprises adapting, organizing and presenting different student interest and skills through the blending of content and pedagogy within the presentation for understanding in order to handle problems students face in their education process (Park & Oliver, 2008). Cain, Koehler and Mishra, (2013). PCK helps teachers to combine content and pedagogy into a logical representation and adaptation of

the specific issues, problems or ideas to meet the individual differences among students during the instruction process.

From Miheso and Mavhunga (2020), PCK is the pivot that teaching and learning revolves. Teachers need PCK to transfer content knowledge and help their students to develop a deep understanding of specific subject matter (Chan & Hume, 2019). This assertion was confirmed by Mazibe, Coetzee and Gaigher (2020) that pedagogical knowledge, context knowledge and content knowledge is specific subject knowledge needed for teacher and learners' interaction during lesson delivery. Teachers elaborate on components and key ideas of the subject content knowledge using various presentations (e.g., analogies illustrations, examples, demonstration, explanations etc.) of the concept, curriculum and activities for instruction during transformation process.

Mikeska, Brockway, Ciofalo, Jin & Ritterm (2020) opined that knowing students' prior knowledge and context-specific theories and what makes concepts difficult or easy to learn, in the educational enterprise is the primary concern of PCK. This means that, teachers need to know that in the teaching enterprise the sole aim is to transform the content in the various subject matter in a way that is easy and understandable for learners to comprehend the material, so teachers must adapt and use teaching materials, depending on the needs of the students to support the links among curriculum, assessment and education as a whole.

Technological content knowledge (TCK)

TCK is how one relates technology and content to influence, and constrain each other to achieve a specific purpose in teaching. TCK also refers to knowledge that provides new ways of teaching content by employing

technology (Gou, Liu, & Wang, 2020). TCK is presenting subject matter using technology. It is about flexibility use of appropriate technologies for educational purposes (Alrwaished, Alkandari & Alhashem, 2020). TCK is using technology to represent content in various ways such as how to use internet games to display operation on fractions (Chai et al., (2011). Having TCK means one can create new representations of specific content. It implies teachers should know and understand that with a particular technology, they can change the way students practice and understand concepts in a particular content area.

Koehler and Mishra (2009) opined that with TCK teachers can visualize a situation where technology can be integrated into teaching effectively. This assertion was supported by Novais, Maqueira, Ortiz and Bruque, (2019) that computer simulations in the field of physics and mathematics are examples of important development in technology integration of education delivery. This means that technology and content influences and supports each other in education delivery. Therefore, teachers should have a good repertoire of content areas as well as technical competencies to enhance students learning. Teachers need to know not only the subject matter but also the application of technology to the subject matter because technology can make it easier for learners to understand theories and concepts better (Malik, Rohendi & Widiaty, 2019).

Technological pedagogical knowledge (TPK)

Technological pedagogical knowledge is about the knowledge teachers need for the application of the various technologies. It includes constraints and affordances that influence methodological applications and strategies in a teaching and learning setting. TPK is knowing and adopting different technologies to enhance teaching methods (Mishra & Koehler, 2009; Harris &

Hoffer, 2009). TPK is having the necessary technological capabilities and how to use it in teaching and learning settings and conversely, being aware of changes this particular technology might bring in teaching and learning settings. It includes the range of existing available tools and the ability to choose the right tools taking into consideration its fitness, affordance and knowledge of methodologies and capacity to use technologies to effect successful teaching and learning (Shao, Zhang, Chen & Zhang, 2020). This includes all other management activities such as knowledge of tools maintenance, class records, attendance, grading and generic knowledge of technology.

According to Chai et al., (2011) TPK is using different methodologies and technologies to achieve proper teaching approaches. TPK can effectively utilize only when the teacher has a general understanding of educational strategies and apply technology to it (Nurhadi et al., 2019). It requires an understanding of how teaching and learning are changing by the use of specific techniques. It comprises appropriate educational designs and strategies integrating technological tools and equipment to realize their strengths and limitations. The educational purpose was not the reason why most popular computer programs were designed. Instead, it was produced for business, entertainment, communication and social interactions (Koehler & Mishra, 2009). Therefore, it is imperative on part of teachers to go beyond the general uses of technologies and integrate them into teaching.

Technological pedagogical content knowledge (TPACK)

Technological pedagogical content knowledge is knowledge of interaction among content, pedagogical, and technology (Wang, 2019). TPACK is a specialized knowledge needed for interweaving technology with c

pedagogy and content to achieve a coherent technology integration in teaching and learning process. Employing the knowledge of technology and pedagogy to effectively deploy the content to the student making the learning of the subject easier is what TPACK is all about (Koehler & Mishra, 2009; Schmidt et al., 2009). Effective teaching with technology which afford instructors an understanding in terms of how to apply pedagogical techniques to achieve technology integration in order to present content indirectly to students (Oner, 2020). It includes the knowledge of the concepts which make learning easier and how technology will be helpful for learning, knowledge of how to use technology to build new information onto existing knowledge. This includes also the development of new epistemologies or strengthening the old ones (Harris et al., 2009, Holt, 2019).

TPACK model requires that teachers develop a comprehensive and flexible knowledge of all the components and appropriate technology in the teaching and learning process. TPACK is a special type of knowledge which every teacher needs in today's digital world to deliver his/her lessons. TPACK is utilizing the various technologies and methodologies to deliver lessons with easy, more convenient to make learners understand the lesson friendly and interesting (Nazari, Nafissi & Estaji, 2020). From research, it is clear that teachers in 21st century need to reconsider their teaching enterprise by employing available technologies to transform traditional ways of teaching by incorporating modern and emerging technologies to demystify difficult lessons (Jang & Tsai, 2013).

Precise definition of TPACK constructs

In the field of research, precise definitions in the building of theory is very important. In theoretical model precise definitions of constructs help in shaping and building research theory in order to reach consensus among researchers. When researchers work from vague and fuzzy terms and definitions, a large bulk finding may be likely to be generated and this may result in different ideas, inaccurate explanations and meaningless outcomes (Burkhardt & Schoenfeld, 2003). According to Angeli and Valanides (2009) readers find it difficult to understand the precise definitions of TPACK constructs because the data from literature support the fact that definitions are “fuzzy” and lack sufficient clarity. Evidence from the various studies suggest that researchers have different definitions of TPACK constructs, these differences were major and therefore, had major implication for comprehending and measuring the TPACK constructs. For instance, the comprehensive conceptual analysis review of TPACK from Cox (2008), showed 10 distinct definitions for TPK, 13 for TCK and 89 different definitions for TPACK. This attest to the fact that the definition of TPACK constructs are unclear and ambiguous likely to generate different ideas leading to inaccurate definition and explanation and casting wrong impressions on the model (Owusu, 2014).

Many researches have been conducted with few studies contributing significantly to the TPACK theoretical framework development because of imprecision definition of the TPACK constructs (Graham, 2011). The term TPACK could be substituted with the phrase technology integration in many published papers without any significant change in meaning (Graham, 2011). Many researchers find it difficult to distinguish between TCK and TPK and

concluded that PK is included in TCK by many researchers. From the TPACK framework the definition of TK lacks clarity. It was added as a third domain of knowledge to the PCK framework even though; it does not show the scope of TPACK and designate its meaningful addition to the PCK framework (Graham, 2011).

According to Koehler and Mishra (2008), no distinction between the types of technology encompassed within TK. (Technologies like the pencil, chalkboard and whiteboard were considered older and newer digital technologies like power points, electronic board were included by them). Owusu (2014) concluded that if there are no older and new technologies then every teacher is using TPACK since every teacher is using either chalk, markers, whiteboard or book in his or her teaching activities. (Smaldino, Russell, Heinich & Molenda, 2005), opined that from the broad conception of instructional technologists the term technology is not only physical devices but also processes applied to solve problems. According to Jonassen, (2004) there are two types of technologies “hard technologies” (e.g. tools, devices hardware etc.) and “soft technologies” (e.g. methods, processes etc.)

Due to lack of explicit definition of the term technological knowledge some authors have made an attempt to define the technology scope by identifying a particular “flavour” of TPACK with the aim of helping their readers comprehend the intension behind their message they want to carry across. For instance, the term ICT- TPACK was used by (Angeli & Valanides, 2009) as information and communication technologies (ICT) usage in their studies; the Acronym TPACK- W was propounded and used by Lee and Tsai (2010) to represent World Wide Web in their studies with the aim to finding out

how teachers used the web-based instructions in their teaching practice and in an attempt to help teachers to use TPACK to teach geography. (Doering & Veletsiano, 2008) propounded the term geospatial technologies (G-TPACK) to communicate to their readers with intension that for teachers to excel in the teaching of geography, they must successfully be exposed to G-TPACK. It is known that the rationale for the introduction of TK into PCK framework was to emphasize the technological aspect of the teaching, therefore, the definition of technology in the framework is very crucial, and authors must define it precisely to avoid ambiguity in the mind of their readers.

Cox and Graham (2009) made distinction between the emerging/digital technologies and transparent technologies). According to them, the transparent technologies have become obsolete and there are no more considered as technologies. They believed that TK in TPACK model should focus on emerging technologies and not transparent technologies. They further added that if the TK in TPACK framework focuses on emerging technologies it means teachers employing the framework should have the requisite abilities to use these emerging technologies and not the obsolete ones (transparent technologies). The distinction will go a long way to erase the confusion in the minds of readers as numerous articles of TPACK fail to give precise definition about technological knowledge domain of the TPACK framework (Owusu, 2014). This study is employing the Cox and Graham (2009) view of technology. Thus, emerging technologies is the precise definition for the “technology” in this current study.

Digital or emerging technologies

We are in technological age and therefore, technology is indispensable in life of any developing society. The rate at which technology is evolving is alarming and it is affecting all spheres of human life. Teaching and learning is not an exception to this effect technology has brought on society and consequently the overall educational system. The use and integration of technology in educational delivery has become inevitable. Hence, the responsibilities and duties teachers supposed to perform have also change drastically in today's digital age. Teachers' responsibilities and duties are not only to use technology but more seriously effective integration of technologies in their classroom activities (Cure & Ozdener, 2008). Therefore, certain level of ICT awareness is very essential for both students and teachers to be inclined technological in this context (Ozturk, 2013). (Gunuc & Babacan, 2017) supported this assertion that integration of technology can have serious impact on teaching and learning. Therefore, teachers are expected to equip themselves with these emerging technologies to be abreast with digital age students.

Tablets and iPads help students feel more confident in their learning after participating in technology-driven activities by promoting active learning. Teachers could engage students in online discussion by linking all computers. The students can then take part in the discussion by writing on the screen. Teachers are supposed to integrate technologies into their instructional practices. Technology integration has afforded special educator the opportunity to offer individualized and differentiation instructions, which were not possibly available for children with special needs in the past (Akpan & Beard, 2014). Greater independence and higher achievement for students as a result of

technology integration in education delivery is the hallmark. These technological tools have categorized into Transparent Technologies and New or Emerging Technologies (Cox & Graham, 2011).

Digital or Emerging Technologies are most tools for teaching and learning through online modes such as Zoom, Google classroom, Google Hangouts, Skype meet up, YouTube, LMS, Microsoft WebEx etc. These tools have come to stay and teachers have no option than to adopt and adapt to it. Through these technological tools for teaching and learning will be affected the education delivery at large. For instance, Learning Management System (LMS) is used by many educational institutions to offer a virtual e-learning platform especial during the Covid 19 pandemic. This platform allows management of virtual classroom, registration process, learning tracking, student monitoring, study materials and lecture delivery and testing (Rao et al.,2020). Video conferencing, communicative space etc. offer students the capacity to interact with and use online resources to enhance their confidence. For example, students can scan, exchange and guarantee collective learning when using Web 2 to benefit more than the traditional way of learning (Biag, 2011).

Again social media site like Telegram, WhatsApp, Google classroom offer students an opportunity to work together, collaborate with each other, contribute their ideas about a concept or topic and communicate with themselves. This build self-confidence among learners and increase tolerance among students. Students outside classroom get access to what their counterpart learnt at their absence through these tools. Some of these platforms have become part of educational delivery in Ghana. WhatsApp, YouTube, Google classroom and Facebook messenger are platform being used by universities and college of

education as tools for online line especially during Covid 19 pandemic season. These platforms reduce paper work and encourage fast and efficient way of education delivery. The goal of these platforms such as Google classroom is to improve communication, increase resources sharing, reduce paper work and improve tolerance among students (Jakkaew & Hemrungrote, 2017) and finally high number of students which cannot be possible in normal classrooms to be effectively managed conveniently (Heggart et al., 2018).

Google Classroom platform is more convenient, provides a network community with a slight resemblance of Facebook user interface, accessible, a free mobile app and easy and reliable to use (Jordan & Duckett, 2018). What a teacher has to know is that in today's digital world one cannot do away with these technologies and as such a modern teacher has to raise up to task ahead of him/her to embrace the challenges these emerging technologies will hurl against him/her to be competitive in today's global economy.

Conceptual Framework

A Conceptual framework serves as an intellectual tool in research to delineate potential strategies or to propose a favoured methodology to an idea or concept. This conceptual framework elucidates the relationship among the independent and dependent variables of the study. To have a roadmap for the research, this conceptual framework has been formulated and showcased, grounded on the TPACK framework by Koehler and Mishra (2009). In this suggested conceptual framework, the influence of the teachers' demographic factors (specifically, gender and years of teaching experience) are represented as mediating variables within the framework influencing the relationship between the independent variable and the dependent variable (see Figure 4).

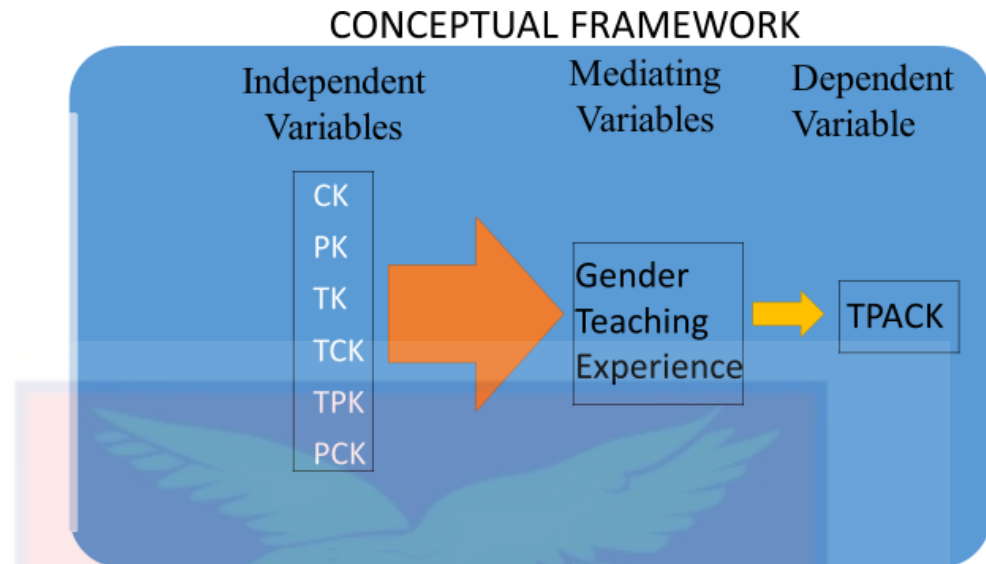


Figure 4: Conceptual Framework

Source: Baah (2023)

The conceptual framework explicates the relationship between the demographic factors (gender and teaching experience) and their potential influence on the TK, PK, CK, TCK, PCK, TPK constructs of TPACK. These TK, PK, CK, TCK, PCK, TPK components are the independent variables that could potentially affect the teachers' perceived understanding of TPACK, which is the dependent variable.

Measuring TPACK variables

All over the world, researchers have used various ways to measuring TPACK constructs. Some of which are open-ended questionnaires, interviews, performance assessments and self-report rating scales (Chai, Koh & Tsai, 2016; Su & Foulger, 2019; Willermark, 2018). One of the frequently used instrument to measure TPACK was open-ended questionnaire. Many researchers had used open-ended questionnaire to measure TPACK constructs (e.g. Archambault & Crippen, 2009; Chai, Koh & Tsai, 2011). Nevertheless, there are contradicting findings from these reports.

In Ghana, Appiah (2016) conducted study on RME teachers' level of perception on TPACK constructs in the Aowin District of the western Region. The teachers rated their understanding of TPACK perception high for Content Knowledge (CK) and Pedagogical Knowledge (PK) but low for TK. Yalley (2016) looked at social studies teachers' TPACK perception level and concluded that teachers possessed high TK, CK, PK, PCK and TCK.

Mtebe and Raphael (2018) conducted a study in Tanzania to examine in-service teachers' TPACK. The study used a sample size of 152 teachers to complete a survey. Means and standard deviations were used to assess teachers perceived understanding level on their TPACK. The result showed that teachers' level of CK, PK and PCK constructs were high and that of TK, TCK TPK and TPCK were moderate. In another study in Greek, Roussinoa and Jimoyiannis (2019) looked at primary school teachers' TPACK perception. With survey, the data revealed that teachers had high CK, PK, PCK and TK but teachers scored low in TCK, TPK and TPCK. The study conducted by Aniq and Draji (2019) and Wulansari, Adlim and Syukri (2020) to assess TPACK level of teachers also concluded that teachers scored high in their PK, CK and PCK constructs than TK, TCK TPK and TPCK constructs. Again, in Taiwan, Huang Chen and Jang (2020) looked at TPACK level of In-service teachers. The study sampled 415 teachers and employed survey using five-point Likert scale to gather data. The findings revealed that teachers' CK and PK construct are higher than TK.

Pamuk, Ergun, Cakir, Yilmaz and Ayas, (2015), examined carefully how the components of TPACK correlate. The study aimed at understanding the TPACK framework and its dynamics that aid the effective TPACK

development. The study result revealed significant correlations among all the TPACK constructs. TPK and TCK constructs had the largest statistical contributors to explain TPCK variance in the structure equation modelling analysis. Again, second –level knowledge basis (TPK, TCK, PCK) predict TPACK development stronger than core knowledge basis (TK, PK, CK). TCK in the structural model stands out as the mediator knowledge base. Mai and Hamzah (2016) explored the Primary Science Teachers' Perceptions of TPACK in Malaysia. The purpose of the study was to determine the primary science teachers' perceptions of TPACK, addressing teachers' perception of the affordance of technology application in teaching. The study employed quantitative research method and sampled 133 science teachers. The findings of the data suggested that teachers had more knowledge in TPACK model areas, that science teachers rated themselves around four on a five-point scale for all of the subscales, indicating a high level of confidence for these TPACK areas. The construct with the highest level of perception are TK ($M=4$; $SD=.503$) and TPK ($M=4.064$; $SD=.554$), but moderate for TCK ($M=3.975$; $SD=0.496$). The study also run a Pearson's linear correlation r coefficient to analyze the relationship that exist among the different TPACK model constructs. The result revealed that there was strong positive correlation that exist between the variable PCK and PK ($r=.783$, $n=133$, $p=.001$), between TK and TCK ($r=.666$, $n=133$, $p=.001$), between TCK and TPCK ($r=.652$, $n=133$, $p=.001$), between TPK and TPCK ($r=.638$, $n=133$, $p=.001$) and between PCK and TPCK ($r=.637$, $n=133$, $p=.001$). However, TK and CK present a positive though weak correlation with TPCK (between TCK and PK: $r=.211$, $n=133$, $p=.015$; between TCK and PCK: $r=.239$, $n=133$, $p=.006$; and between TK and PK: $r=.334$, $n=133$,

$p=,000$). Online survey conducted by Archambault and Crippen (2009) on teachers' TPACK level concluded that teachers had increased knowledge levels in the various constructs. Correlation analysis also revealed that there was large correlation among the constructs, (.690) for PC, (.743) for TC and TP, (.787) for TPC and TP, and (.733) for TC. The authors concluded that there is intersection and interconnectedness of the TPACK constructs therefore, the constructs should not be isolated.

Acikgul and Aslaner, (2019) carried out a study to investigate relationship between the TPACK levels and self-efficacy perception levels of pre-service mathematics teachers in Anatolia. The purpose of the study was to determine relationship between mathematics teachers' TPACK level and self-efficacy perception levels. The study used correlational research approach and employed 88 participants (female =72, male = 16). The findings of the study revealed that there is no statistically significant correlation between CK scores obtained from achievement test. No statistically significant correlation was obtained between PCK and TCK. The scores obtained from PCK, TCK and TPCK scores from lesson plan-participant report and PCK, TCK and TPCK self-efficacy perception scores from TPACK constructs were all not statistically significant. The study found out that there is medium level relationship between PCK and TPCK scores obtained from lesson plan-participant reports.

Basaran (2020) investigated mathematics and science teacher candidates' perception on TPACK-21 based on 21-century skills. The purpose of the research was to find out the relationships of TPACK constructs and which contribute to the TPACK-21 scale. The study used quantitative approach specifically relation survey model and sampled 254 pre-service teachers from

the departments of science and mathematics at a state university in Turkey. The study used the scale developed by Valtonen et al. (2017) to determine prospective teachers' 21st century skills. The result revealed that there was direct and positive effect of TCK, TPK-21, and PCK-21 from external variables consisting of binary knowledge fields of the research seen on TPACK-21. These variables account for 74% changes in TPACK-21 with TCK having highest effect on the TPACK-21. Again, TCK and PCK-21 are directly and positively affected by CK and this effect is greater than that of TK and PK-21. The study concluded that when proper evaluation is taken, a gradual model including CK and PCK-21 can be proposed instead of a direct technology –based approach to professional development programs in order to increase 21st century competencies of teachers' TPACK-21s.

Teachers' TPACK in science teaching

Enhancing the teachers' TPACK development is very important for various research populations, and science teacher education is not an exception. Integration of ICT for instruction has been the recommendation of many authors because it is believed it will improve science teaching and learning. Many studies have been conducted on the implementation of TPACK framework in science education, these studies examined different variables. For instances, Lee and Tsai (2008) looked at teachers' beliefs about self-efficacy and found out that correlation between teacher beliefs and TPACJK constructs. (Guzey & Roehrig; Jang,2010) looked at skills of integrating technology into teaching and concluded that TPACK has influence on teaching and learning; (Lin et al.,2012; Jang & Tsai) teachers' gender and TPACK found out that gender has influence on TPACK. Helppolainen and Aksela (2015) looked at chemistry teachers' ICT

integration and found that the ICT usage of chemistry teachers were in line with other science teachers. (Allan et al., 2010; Guzey & Roehrig, 2009; Hechter, 2012; Jang, 2010; Jang & Chen, 2016; Kazu & Erten, 2014; Khan, 2011; Lin et al., 2013; Trautmann & MaKinster, 2010) conducted studies on TPACK development in science classroom teachers. Most of these studies concluded that science teachers' TPACK correlate positively with the other six TPACK constructs.

Some researchers, (e.g., Brantley-Dias & Ertmer, 2013; Jimonyiannis, 2010) acknowledged the need to adapt TPACK to measure specific subject. Jimonyinnis (2010) developed the concept of Technological Pedagogical Science Knowledge (TPASK). TPASK model is composed of three knowledge domains: PCK, TPK and TCK but focus more on science education. Equally important, TPACK in science education is the work of Yet et al. (2014), a practical TPACK framework with eight knowledge dimensions in which science teacher practice teaching with technology should know according to them. These are use of ICT to understand students, ICT usage to understand subject content, planning ICT infused curriculum, usage of ICT representations, integrating ICT in teaching strategies, ICT instructional management application, incorporate ICT in teaching context, and assess students using ICT. This framework was introduced to help enhance ICT integration in science teaching.

One must to understand that in order to provide our students with technological teaching the internet alone is not sufficient to provide the need support for adequate teachers' preparation. Therefore, Lee introduced Technological Pedagogical Content Knowledge -Web (TPACK-W) and Tsai

(2008) because they believed internet alone could be a means to an end and not end in itself. Wang, Tsai and Wei (2015) employed TPACK-W to examine a potential mediator contributing to the relationship between teaching and learning conception in science and its self-efficacy by science teacher. The result revealed a positive relationship between knowledge and attitudes towards internet-based instruction and constructivist conceptions of teaching and learning.

Since science concepts are more relatively abstract to students, one expect science teachers to adopt and adapt technology to help resolve students' difficulties in learning (Wu, 2013). However, regardless of rampant, and quantity of technological framework in our society to help demystify teaching and learning, science teachers appear to have not been integrating the technology effectively into their lesson delivery to boost students' understanding.

Relationship between teachers demographic variables and TPACK

Demographic variables such as gender, age, teaching experience etc. are variables that are used frequently in terms of educational studies. In general, many differences exist among these demographic variables. For instance, attitude of technology users differs according to gender, age and occupational experiences. Most people think that males have more interest in Technology than female; therefore, they perceived the use of ICT as a male-related activity (North & Noyes, 2002). According to Sainz and Saez, (2010) the perception that technology is highly technical and are for males leads to development of negative attitudes in female towards information technological tools. Similarly,

society also deems that younger persons have what it takes to operate information technological tools more competently than older persons do.

In 21st century, technology is the key to every profession and teaching profession is not an exception. Utilization of information technological tools is an important skill for teachers, in today's digital world, and skills persons possessed is mostly influenced by their demographic variables. It is believed that teachers' demographic variables may have an effect on their TPACK competencies. Beside, many studies have empirically indicated that there is no significant difference between gender and TPACK levels (Acikgul & Aslaner, 2015, Koh & Sing 2011). On the other hand, several studies have also said otherwise, some of these studies have shown that there were significant differences among the TPACK constructs and demographic variables such as gender and teaching experience (e.g., Erdogan & Sahin 2010; Jang & Tsai, 2013). Hence, this study wants to see that of KEEA and Cape Coast municipality science teachers' demographics and TPACK.

Relationship between gender and TPACK

Bulut (2012) conducted a study in Central Anatolia - Turkey to investigate mathematics teachers' perception of TPACK regarding geometry. The study aimed at examine the relationship among the TPACK constructs and gender of mathematics teachers. The study used correlational research method, specifically, causal-comparative research method. The study used 780 mathematics teachers as participants (male =239 (30.7%), female = 540 (69%). A two-way MANOVA was carried out to examine the relationships between the demographic variables of mathematics teachers and their TPACK understanding. The result showed that no statistical significant interaction effect

between class and gender, $F(7, 769) = .94, p = .48$). There was a statistically significant differences in mean with respect to male and female participant in terms of overall TPACK variables, $F(7, 769) = 12.35, p = .000$; Wilks' Lambda = .90 with medium effect size (partial eta squared = .101).

Jang and Tsai (2013) explored the TPACK of Taiwanese secondary school science teachers using a new contextualized TPACK model. The study looked at association between in-service teachers' TPACK and other factors. The purpose of the study was to examine the TPACK of in-service secondary school science teachers by employing a TPACK questionnaires developed by Jang and Tsai (2012). The study employed quantitative research method and used simple random sample technique to sampled 1292 secondary school science teachers as participants from 123 secondary schools. The instrument used to collect data was questionnaires. When t-test was performed on two groups (i.e. gender) to be compared for TPACK. The results showed that according to gender, science teachers' TPACK was statistically significant. Male science teachers scored their knowledge of technology substantially higher than female teachers did, taking into account other TPACK sub-components did. The study concluded that gender is an important factor for the TPACK development of secondary school science teachers.

Altun (2013) examined student teachers' TPACK levels based on some variables in Turkey. The purpose of the study was to examine the final year students' TPACK level in general and investigate its relationship with different variables (gender, subject specialization, having a personal computer and Internet connection). The study employed quantitative approach and used survey method. The study used simple random sample technique to sampled

609 final year students to participate in the research. This consists female N=400 (65.7%) and male N=209 (34.3%). As the data collection tool, an adapted Turkish version of the TPACK scale was used. The findings revealed that general TPACK levels of students obtained a mean score of ($M=3.46$; $SD=.50$). The independent t-test result about participant's gender and its relationship with sub-components indicated that there was a meaningful difference between gender of the participants and some of the sub-components of TPACK scale.

Karaca (2015) conducted survey research to analyze the TPACK of teachers in Turkey. The study's purpose was to determine teachers' TPACK level and also to determine how teachers' TPACK scores differ based on the characteristics of gender, grade level. The study used 142 teachers and employed survey research approach. There was a significant difference in the scores for male ($M = 125.4$, $SD = 17.4$) and females ($M = 132.5$, $SD = 15.1$

Oz (2015) assessed English as a Foreign Language Teachers' TPACK in Turkey. The study employed mixed method search design and used 76 participants composed of 55 (72.5%) female and 21 (27.5%) male. The result of quantitative analysis showed that teachers had highly developed knowledge of TPACK. The PK ($M=29.14$, $SD=3.47$) and TK ($M= 25.80$, $SD= 3.98$) with the highest mean scores, whilst the lowest mean scores were TCK ($M= 11.73$, $SD= 1.60$) and PCK ($M= 12.21$, $SD= 1.84$). The result of independent sample t test revealed that there is statistical significant difference between male and female teachers in TK, $t(74) = -2.62$, $p < .05$, and PK, $t(74) = 2.279$, $p < .05$, dimensions with female participants scoring higher than male participants in PK and vice versa in TK. Statistically, based on the 'Eta Square' value (η^2) 'effect size'

indicated a moderate significant difference between groups in both of the significant dimension ($n^2 < 0.14$) (Cohen, 1988).

Ergen, Yelken and Kanadli (2019) researched on TPACK by Gender in Turkey. The aim of the study was to use meta-analysis method to examine whether there is a significant difference in the effect size of the TPACK according to gender. The study used meta-analysis with intention of calculating the overall effect size of the studies on TPACK in terms of gender. Researchers accessed 482 previous studies conducted on TPACK. The overall sample size of the previous studies that informed this study is 9562 people, consisting of 154 instructors, 2705 teachers and 4797 teacher candidates. This comprises of 5320 females and 4242 males. The result of the study showed that there is a significant difference between the knowledge types about TPACK by gender, and in the sub-group analysis, TK, TPK and TPACK have a significant effect size ($p < 0.05$) in favour of male; however, CK, PCK, TCK and PK were found to have no significant effect size in favour of male. The study further run a heterogeneity test about gender to determine whether there is heterogeneity among the studies included in the meta-analysis, and if any, its size. The result was found significant ($p < .05$). Q value is 168.940 with 28 degree of freedom. The critical value in the chi-square table, with 28 degrees of freedom and at .05 level, was about 41,337. Since the Q value was greater than the critical value, it was concluded that the variance between the studies was due to the other characteristics of the study rather than sample error. Moreover, the I² index proves with a value of 84% that the heterogeneity between studies was very high.

Relationship between teaching experience and TPACK

Koh, Hai and Tsai (2014) looked at Demographic Factors, TPACK Constructs, and Teachers' Perceptions of Constructivist-Oriented TPACK. The purpose of the study was to examine the TPACK for Meaningful Learning Survey and to analyze the perceptions of constructivist-oriented technological pedagogical content knowledge (C-TPACK) of teachers. The study was quantitative in nature and survey was used. The study used 354 participants consisting of 231 females (65.25%) and 123 males (34.75%). The result showed that teaching experience is not strongly related to TPACK constructs. C-TK, C-TPK, TCK, and C-TPACK have small negative significant correlation with teaching experience. The result of regression model showed that the predictive power of teaching experience was less than that of TPACK constructs among themselves.

Jang and Chang (2016), explored the TPACK of Taiwanese university physics instructors. The purpose of the study was to examine the TPACK differences between university students' perception and instructors' perceptions and assess differences in university physics instructors' TPACK according to teaching experience. The study adopted quantitative approach and sampled 182 participants using simple random sampling techniques. Participants were grouped according to number of years they have taught as follows: 1-5 years teaching experience 26 (17.9%); 6–15 years' experience of teaching 74(51.0%); 16–25 years of experience 34 (23.4%), and 26 years and above experience of teaching 11(7.6%). The result of the study revealed that, there was statistical significance in overall TPACK according to teaching experience.

In another study conducted in Saudi Arabia by Bingimlas (2018), the researcher investigated the level of teachers' TPACK. The purpose of the study was to analyze teachers' TPACK and to examine the way in which it differs based on gender, teaching subject and teaching experience. The researcher employed quantitative research design for the study. The study sampled 243 participants composed of 111(45.7%) males and 132 (54.3%) females. 32% of these participants about 70% had teaching experience between 10-20 years and about 27% had teaching experience between 5-10 years. The study used mean and standard deviation to find out the level of teachers' knowledge of technology, pedagogy and content (TPC) and sup-TPACK. The result was ranked as follows: PK (M=4.13, SD=0.76), PCK (M=4.03, SD=.088), CK (M=3.75, SD=0.79), TCK (M=3.73, SD=0.97), TPK (M= 3.68, 0.97), TPACK (M=3.16, SD= 1.02), and TK (M=3.15, SD= 1.04). Meaning teachers' thought about general confidence level of their TPACK (M=3.65, SD =0.76). The one way AVOVA was used to determine the differences between teachers' TPACK and their teaching experiences. The result showed that teachers' TK was statistically significantly different among teachers, with various levels of teaching experiences at p-value of <0.01. Again, PK and TPACK were statistically significantly different according to teaching experience at level of p-value of <0.05. In a nutshell, there was a statistical significant difference between TPACK and teaching experience.

Roussinos and Jimoyiannis (2019) conducted a study to examine the Primary Education Teachers' Perceptions of TPACK and the Related Educational Context Factors in Greece. The purpose of the study was to examine TPACK framework and how it can guide the development of teachers'

knowledge and skills regarding integration of ICT classroom practices. Quantitative research design was used for the study. Three hundred and ninety nine participants were sampled composed of 83(23.1%) male and 277(76.9%) female teachers. The result of overall TPACK constructs in relation to teaching experience show no statistical significant correlation. Kruskal-Wallis statistical test was run and novice teachers rated their TK significantly higher than the veteran teachers ($X^2(6) = 16.809, p < 0.01$). The result also showed that teachers with more teaching experience had higher PCK level ($X^2(6) = 14.933, p < 0.20$).

Research Gap

Literature suggest that several studies have been conducted on TPACK framework globally. Volumes of these studies were conducted in developed countries and few were in developing countries. Literature revealed that most of these studies were done in Europe (e.g. Angeli & Valanides, 2009; Bostancioglu & Handley, 2018; Chai, Koh, & Tsai, 2010; Graziano, Herring, Carpenter, Smaldino & Finsness, 2017; Martin, 2018; Miguel-Revilla, Martinez-Ferreira & Sanchez-Agusti, 2020; Niess, 2005; Petko, 2020; Rets, Rienties & Lewis, 2020; Rets, Rienties & Lewis, 2020; Santika, Indriayu & Sangka, 2021 Tseng, Chai, Tan & Park, 2020). In Asia (e.g. Castera, Marre, Yok, Sherab, Impedovo, Sarapuu & Armand, 2020; Greene & Jones, 2020; Jeong & Kim, 2009; Koh, Chai & Tsai, 2010; Lee, Chai & Hong, 2019; Liang, Chai, Koh, Yang & Tsai, 2013). Few have been done in African (e.g. Glazer, 2020; Khosa & Molotsi, 2020; Oda, Herman & Hasan, 2020; Tunjera & Chigona, 2020). In Ghana, (Agyei, Voogt, 2015, Apau, 2017; Appiah & Mfum-Appiah, 2019; Gyaase, Gyamfi & Kuranchie, 2019; Yalley, 2016) were the studies conducted. These studies provide empirical evidence that TPACK has a

significant influence on teaching and learning (see Adamu & Hajara, 2015; Facchini & Melki, 2013; Jalles, 2019; Kumar et al., 2012; Magazzino et al., 2015; Obeng & Sakyi, 2017; Sagdic, Sasmaz, & Tuncer, 2019).

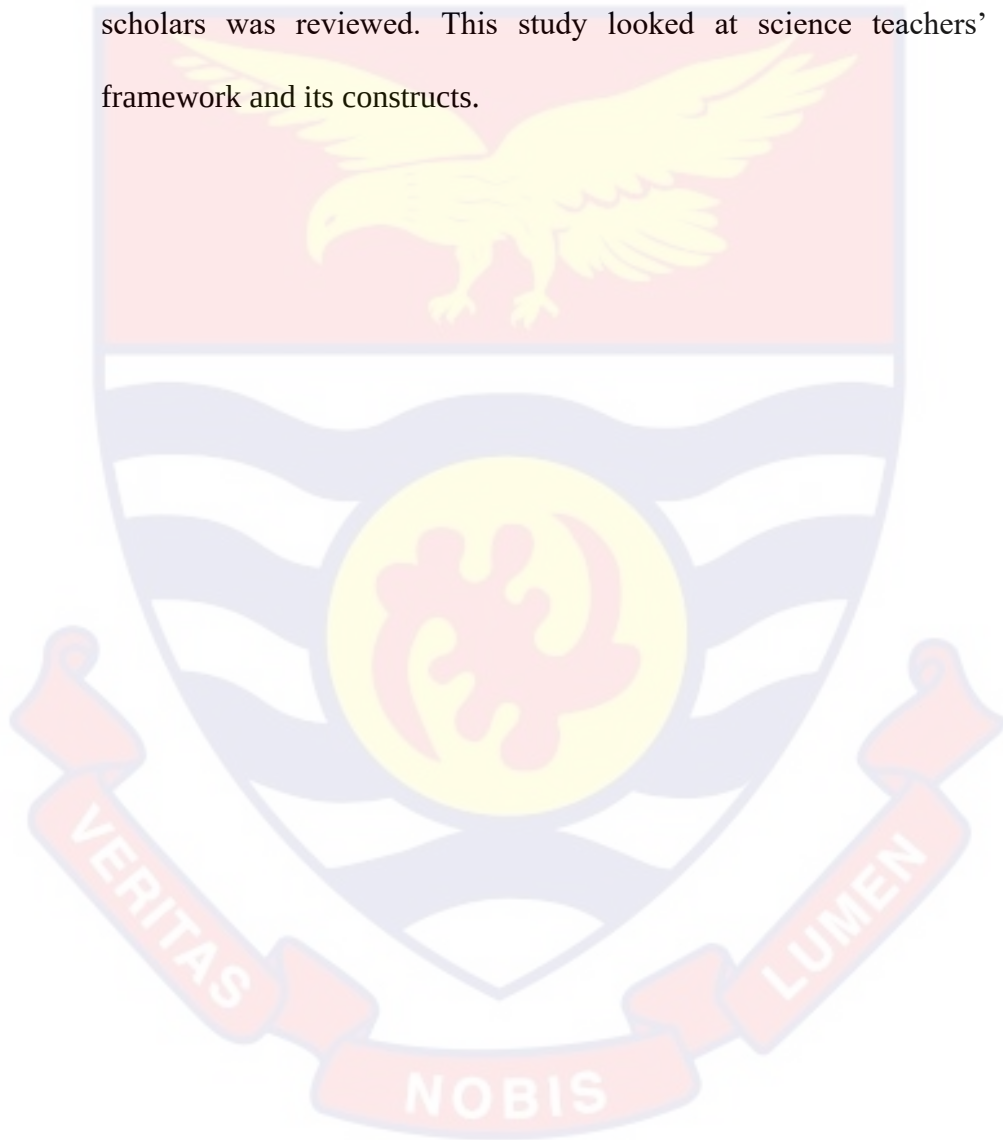
Some of the studies focused on various variables: demographic variables and their relationship between TPACK levels of teachers (Lee & Tsai 2008; Niederhausemr & Perkman 2010). The correlation between TPACK and TPACK sub-construct (e.g. Owusu, Conner & Astall, 2014). Some of these studies also show that TPACK scales have been developed or adapted to various groups of participants, including pre-service teachers (Agyei & Voogt, 2012; Baran & Uygun, 2016; Canbazoglu Bilici et al., 2013; Dikkartin Ovez & Akyuz, 2013; Erdogan & Sahin, 2010; Kaya & Dag, 2013; Koehler & Mishra, 2009; Pamuk, 2012) and in-service teachers (Altun, 2013; Lee & Tsai, 2010; Owusu, Conner & Astall, 2014) to investigate preservice and in-service teachers' ability to integrate technology into their teaching.

Apau (2017), studied student-teacher preparedness of TPACK. Agyei and Voogt (2011) paid attention to mathematics teachers, Appiah and Mfum-Appiah (2019), looked at Religious and Moral Education teachers; Gyaase, Gyamfi and Kuranchie (2019), examined e-readiness for the incorporation of ICT in pre-tertiary education and Yalley, (2016) looked at social studies teachers in senior high school. It appears few studies have been done on JHS science teachers' TPACK in Ghana, therefore, the current study looked at JHS science teachers TPACK.

Chapter Summary

The chapter gives the account of theoretical review, historical development of the TPACK framework, constructs of the TPACK framework,

the relationship among various constructs of the science teachers' TPACK, teacher's demographic variables (gender and teaching experience) and teachers' TPACK and science teaching. The chapter also provides the literature review and indicates its implication for the current study. The TPACK framework by Mishra and Koehler (2006) which has been widely discussed and used by most scholars was reviewed. This study looked at science teachers' TPACK framework and its constructs.



CHAPTER THREE

RESEARCH METHODS

The chapter described the research methods employed to collect the relevant data for the thesis. The chapter described the epistemological orientation of the study, the research approach, research design, and the population, sample and sampling procedures. The chapter covered the instrument used to collect the data, data validity and reliability and how the instrument was administered, data collection procedures, data processing and analysis and ethical consideration.

Research Design

The study used cross sectional survey research design where the researcher administered questionnaire to the population to depict the perceived understanding of JHS science teachers' TPACK constructs (Creswell, 2012). The study considered cross sectional survey design as appropriate because it allowed the researcher to gather large amount of data from the respondents and findings to generalize the results. This research design has advantages of producing good responses from the wide range of respondents. The data gathered provides meaningful explanations and paints picture of respondents' opinion and behaviour at a particular point in time. The survey also provides statistical test result, which can be related to past research studies (Ozudogru & Ozudogru, 2019).

Moreover, the researcher can rely on the data with greater confidence to answer a particular question of special interest. The survey can be analysed quickly. It is less time-consuming, and responses can be analysed and tabulated within a short timeframe. Data can be analysed quantitatively using descriptive

and inferential statistics (De Leeuw, 2005; Mugenda & Mugenda 2003). The researcher has control over the research process and can generate the findings that are representative of the entire population at an affordable cost than collecting data for the whole population (Edmondson & McManus, 2007; Ghauri, Grønhaug & Strange, 2020).

However, survey has its own weakness some of which are that data fails to provide a respondent's experiences and descriptions in full details. Thus, it lacks ability to ask probing questions to seek clarification concerning the issue at hand. Another weakness of the survey is that a large sample size will be required for the data analyses; hence, lack of resources will make the study difficult to conduct. Although, there are weaknesses associated with survey, this study still employed survey because, the strengths outweighed the weaknesses, hence, the researcher used survey design to examine the perceived understanding of JHS science teachers' TPACK and its various constructs.

This is because the survey design helps the researcher to provide detailed explanation to the problem. The design helped the researcher to investigate the cause and effect relationship among study variables (Creswell & Creswell, 2017). In addition, the design assisted the researcher to employ the inferential statistics such as Pearson's Product Moment Correlation to answer research question two, Standard Multiple Regression to answer research question three and Multivariate Analysis of Variance (MANOVA) to answer research questions four and five based on the data collected from the respondents.

Study Area

The study area comprises Cape Coast and Komenda Edina Eguafo Abirem (KEEA). Cape Coast lies to the south along the Gulf of Guinea, while the Komenda/Edina/Eguafo/Abirem Municipality forms the western border with the Cape Coast Metropolis. To the east, we find the Abura/Asebu/Kwamankese District, and to the north, the Twifo/Heman/Lower Denkyira District. This region spans approximately 238,535 km², encompassing diverse biomes ranging from coastal savannahs to tropical rainforests.

The Komenda-Edina-Eguafo-Abirem (KEEA) Municipality was established in 1988, carved out from the Cape Coast Metropolis through the enactment of LI 1857. It shares its southern border with the Atlantic Ocean (Gulf of Guinea), while its eastern boundary adjoins the Cape Coast Metropolis. To the north and west, it shares boundaries with the Twifo-Hemang-Lower Denkyira District and the Mpohor-Wassa East District, respectively. The study used KEEA municipality and Cape Coast metropolis because the researcher randomly selected these two districts from the 22 districts in the central region of Ghana.

Population

The target population was the JHS teachers in KEEA municipality and Cape Coast Metropolis of the central region. The researcher conducted the study in the public JHS in the KEEA municipality and Cape Coast metropolis of the central region. This is because the researcher randomly selected KEEA municipality and Cape Coast metropolis from them 22 districts, municipalities and metropolises in the central region of Ghana. In addition, it is believed that they are the municipality and the metropolis with more graduate teachers in the basic schools due to their closeness to university of Cape Coast.

Sampling Procedure

The study sampled a reasonable number of the population to represent the large number of the target population size. Krejcie and Morgan (1970) sampling determination table was used. The Krejcie and Morgan sampling determination table provides a scientific rationale for selecting the sample size. From the Krejcie and Morgan sampling determination table 144 respondents was supposed to sample from a target population of 230. The study added 11 respondents to 144 to make it 155 respondents. This is larger than what the table suggest however, the study went ahead because the study wanted to cater for non-responses rate. The study used computer-based random number generator programme to randomly select the respondents for the study.

The computer-generated simple random sampling method was chosen to select the respondents for the study. The researcher used simple random sampling because of following advantages if applied appropriately. Compared to any other sampling method, simple random technique helps to reduce any bias involved (Codling, Plank & Benhamou, 2008; McKay, Beckman & Conover, 2000). The data from simple random sampling is of high quality (Cohen, Manion, Morrison & Wyse, 2010). The simple random sampling technique is relatively easy to use, offers fairness in selecting members, according to Groves et al. (2011), and is the most straightforward probability sampling technique. The goal of the research, which involves generalisation of results over the entire population (JHS science teacher in KEEA and Cape Coast metropolis and Ghana in general), also prompted this decision. Finally, since the population size is vast, simple random sampling method was deemed appropriate, because there is no restriction on the sample size the researcher

needs to create. It is usually easy to pick a smaller sample size from the existing larger population (Salganik & Heckathorn, 2004).

Data Collection Instrument

The study administered questionnaire to solicit for information from the respondents. According to Collis and Hussey (2013), a questionnaire is an instrument used to collect data in which a selected group of respondents are made to complete a written set of questions to find out their views on a given issue. The study used a questionnaire in order to answer the research questions. The data instrument was adapted from Owusu, Conner and Astall (2018) who had used the instrument in a similar study. For complex and multidimensional variables, using existing instrument is more appropriate if one exist. The items of the survey covered the seven constructs of TPACK framework (Astall, Conner & Owusu, 2018). The questionnaire for this study consisted of different sections with each of the section focusing on one research objective. In all, the questionnaire had fifty-five items. Section “A” of the questionnaire captured the demographic information of the respondents with respect to participants’ gender, age and teaching experience. This aspect is useful in understanding the background information of the respondents. Section “B” of the questionnaire captured information on science teachers’ Technological Knowledge (TK) with seven items. Section “C” of the questionnaire covered information on science teachers’ CK with eight items. Section “D” of the questionnaire captured eight items on science teachers’ PK, Section “E” of the questionnaire captured eight items of PCK, Section F of the questionnaire captured six items of TPK, Section “G” covers seven items of TCK, and Section “H” eight items of Knowledge of TPACK. Five-point Likert scale was used for all the items in the survey. This

is because it believed that 5-point Likert scale is comparatively simple for respondents to reliable responses (Lam & Kolic, 2008).

The study also used questionnaire in order to ensure that items on the instrument are standardized such that each respondent gets the same question and in the same format. Questionnaire also enabled the researcher to gather the original data from the sample of the population within a short time and at low cost for purposes of describing the entire population. The questionnaire also provides the clarifications sought by the respondents on the spot, which assist the respondents in filling the questionnaire. Again, the questionnaire is economical in terms of time and money and can be administered to a large number of respondents. It also ensures anonymity; hence, respondents can respond genuinely without fear of identification.

Validity of the research instruments

The instrument validity measures the particular concept it supposed to measure (Murphy et al., 2019). As stated in both Keraro (2014) and Isoe (2014), face validity is the degree to which an instrument is judged to be relevant in obtaining accurate and meaningful data on the variables of interest. Further, Borg and Gall (1989) explain that content validity as the degree to which the sample test or instrument items represent the content that the instrument was designed for while face validity is the degree to which an instrument appears to measure what it is supposed to measure. The items in the questionnaires should measure the exact questions the questionnaires were sought to measure. The author pooled the questions from surveys of the (Owusu, Conner & Astall, 2018). The authors conducted the validity and reliability test and the results were above the threshold (0.7). Pallant and Manual (2010) argue that the value

should be above 0.7. However, since the items were supposed to use in different context and sitting it was deemed necessary to ensure the reliability and validity. Therefore, the investigator gave the survey to the supervisor who is seasoned educational technologist and expert in technological pedagogical content knowledge to assess whether the instruments is truly measuring TPACK constructs. The supervisor and his team of experts reviewed the items to ensure that the items in the questionnaires fell within the TPACK framework constructs.

The instrument was also given to science teachers who often use technology to teach and were used to review the questionnaires as suggested by Punch (2009) the instrument should be finalized after going through sample of target population. The instrument was finally piloted, using fifty-five respondents from different district, which is not part of where the actual study was conducted before it was administered to KEEA municipality and Cape Coast metropolis JHS science teachers.

Reliability of the instrument

Reliability of an instrument is its consistency and an instrument should be high reliability if it can be trusted to give an accurate and consistent measurement of an unchanging value (Vitiello, Whittaker, Mulcahy, Kinzie & Helferstay, 2019; Gerlach, Arslan, Schultze, Reinhard & Penke, 2019). The study used Cronbach's Alpha to determine the internal consistency or average correlation of items in a survey instrument to gauge its reliability. All the constructs are highly reliable in the sense that all were greater than the minimum criteria of 0.7 recommended (Creswell & Clark, 2017; Creswell & Creswell, 2017). The TK items were seven and had the coefficient alpha of 0.748, PK

0.894 items eight, CK 0.794 eight items, PCK 0.777 eight items, TCK 0.358 seven items, TPK 0.313 six items and TPACK 0.873 eight items. The constructs were above 0.7, except two and sample was very large as far as pilot test is concerned. The items under these two constructs were dropped one by one to determine the items, which were not appropriate. After dropping item number 1 under the TPK construct (TPK1) and item number 3 under the TCK construct (TCK3) the coefficient went to .831 and .887 respectively. Even though, two of the items did not meet the threshold for Cronbach alpha the investigator retains them because investigator saw these items very important under their constructs. The Table 1 below shows the Cronbach alpha for the various constructs of TPACK.

Table 1: Science Teachers' Alpha on the Items of TPACK Constructs

Constructs	Cronbach's alpha	Number of items
TK	0.835	7
CK	0.854	8
PK	0.890	8
PCK	0.842	8
TPK	0.838	6
TCK	0.885	7
TPCK	0.899	8

Source: Field Survey, (2022)

Piloting of the survey

The researcher conducted a pilot test to determine the validity, reliability, and internal consistency of the instrument (Tannor, 2014). The pilot testing of the instrument will also help to ascertain whether there are problems in relation to the wording, format, instructions to skip questions, and to ensure that the respondents understood the items and provided useful answers (Tannor, 2014). The questionnaire was finally administered in different district from the municipality and metropolis where the study was actually conducted. The investigator took letter of approval from the department of science education in the University of Cape Coast (UCC) by the help of the supervisor which assisted him to administer the questionnaire. The researcher and a friend went to schools in the Abura Aseabu Komenkesse District (AAK) to administer the questionnaire to JHS science teachers in the district. The sample size of 56 questionnaires were administered and all were collected because the investigator and friend waited for the teachers to finish and collect at the same day. It took two days for the investigator to complete the piloted survey. Even though, 56 questionnaires were administered, 55 were used for the analysis because one of the respondents did not complete his/her questionnaire and that questionnaire was rejected. The reliability of the instrument was checked by the collated responses from the respondents before instrument was sent out for the actual study.

Data Collection Procedures

The study targeted every JHS science teacher in KEEA and Cape Coast metropolis as a potential respondent for the survey. Two research assistants were trained on how to explain the objective to the respondents, identify the

respondents and data management to make it easier for them to assist in the process of data collection. Two research assistants and investigator personally administered the questionnaire in the schools. Before administering the instrument, the researcher asked for permission to distribute the questionnaire personally with the two research assistants. Respondents were assured of confidentiality of any information given by them on the questionnaire. A covering letter explaining the objectives of the study, assuring the respondents' confidentiality, and asking them to participate in the study accompany the distribution of the questionnaires. The questionnaires were administered to respondents on the second week of December 2021 and ended in third week of December 2021.

A total of 155 questionnaires were sent out to the field for JHS science teachers to respond to, one hundred and forty-eight (148) were filled and received. However, 145 questionnaires were used for the analysis. This is because, three respondents did not complete their questionnaires therefore, those questionnaires were rejected. These 145 questionnaires representing 94% response' rate. The response' rate of 94% for this study was considered as good because according to Kothari (2011), the rate of response between 60% to 70% is adequate anything above 70% is considered excellent. This assertion was supported by Mugenda and Mugenda (2012) that 50% response rate is satisfactory, 60% is good and above 70% is excellent. Out of 145 teachers responded to the survey, 84 (58%) were males and 61(42%) were females. Majority of respondents 38 (26%) were aged above 40 years whereas 18 (12%) were in the age group of 26-30. A total of 42 (29%) had taught for 1-5 years,

only 2 (1.4%) had taught for more than 26 years. The rest of the respondents 101 representing 70% had taught between six to twenty-five years

Ethical Considerations

The issue of ethics is important in research that involved human being. The study upheld the ethical standards in collecting data from the respondents.

Ethical consideration in research is the norms or standards required to differentiate between rights and wrong (Connelly, 2014). As such, every research requires that researchers meet common ethical considerations in a bid to progress the reliability and acceptance of its outcomes, conclusions and recommendations. Common ethical issues considered in the study included honesty, right to privacy, voluntary participation, anonymity, confidentiality and addressing plagiarism issues (Connelly, 2014; Richard, Devinney, Yip & Johnson, 2009).

The researcher respected the participants' right to privacy, the identity or any identifying particulars of the participants remained anonymous throughout the study. All respondents were made aware of the research aims and the researcher ensured that the respondents understood the research aims. Respondents signed a letter of informed consent that allowed the researcher to use the information gathered for the research purposes. Ethical responsibilities entail protecting the rights of respondents and reporting results fairly and accurately. Ethics are standards imposed by professional members to safeguard themselves, their profession and pride. Ethical considerations include informed consent, confidentiality, deception and debriefing, de-hoaxing, non-maleficence, beneficence, as well as justice and fairness (Barnsley, 2020; Alderson & Morrow, 2020; Milton, 2019).

Barnsley (2020), and Srivastava, Heidari and Krause (2019) say that descriptive ethics are used in research and give the researcher guidelines on how to conduct research. Bernstein (2011), Markwei and Tetteh (2020) and Cao, Fang, Hou, Han, Xu, Dong and Zheng (2020) point out that psychologists take very serious ethical considerations to minimise any immediate discomfort or risk for research participants, as well as the need to protect participants from long term harm. Descriptive ethics emphasise on rules that are rational, objective, universal and impartial. Permission letter was sent to the understudy schools to allow the researcher to carry out the research. They allowed the researcher to distribute the questionnaire to the respondents in each school.

Data Processing and Analysis

After the collection of the questionnaires, the researcher coded and fed into the SPSS (version 22.0). The editing, coding, classification and tabulation of data was done. The editing was done to ensure that data is accurate and complete. The screening of data was done first by the researcher. Research question one: What are KEEA and Cape Coast metropolis JHS teachers' understanding of the TPACK constructs? Mean and standard deviation were used to analyse the data gathered to measure the central tendencies and dispersion respectively. Research question two: What extent do other TPACK constructs correlate with TPACK? To examine the relationship among the variables, Pearson's Product Moment Correlation was used to analyse the data gathered for the study. Research question three: Which of the TPACK constructs has the largest prediction of TPACK? In order to answer this research question, a standard multiple regression was performed.

The fourth research question, which sought to examine how gender of respondents influence their level of TPACK constructs, a MANOVA was used. The fifth research question: What influence does teaching experience has on TPACK constructs? The MANOVA was also used to analyse the data gathered to address the research question.

Chapter Summary

The chapter described the procedures adopted for data collection. The procedures involved were research design, sampling and technique employed for the sampling, instrument employed for the data collection, sources of data and analysis of data, which was, subsumed under general heading research methods. The quantitative research method was employed and cross sectional survey approach, was used to collect data from respondents. The descriptive statistics such as means and standard deviations, Correlation, regression and MANOVA were done. All the analyses were done with the help of SPSS version 22.

CHAPTER FOUR

RESULT AND DISCUSSION

The chapter presents the results emanated from the data gathered from JHS science teachers from the KEEA municipality and Cape Coast metropolis regarding their perceived understanding of TPACK constructs. To achieve the research objectives, the study used quantitative approach where a cross-sectional survey was utilized. Data was gathered using a five –point Likert scale questionnaire. Mean and standard deviation, correlation and multiple regression and multivariate analysis of variance (MANOVA) were used to analyse the data for the research questions. The results and the associated discussions have been presented according to the research questions.

Research Question One: What are the Science Teacher's Understanding of the Various Constructs of TPACK?

Research question one sought to examine teachers' understanding of TPACK. In ascertaining JHS science teachers' TPACK framework constructs, Five-point Likert scale (strongly disagree – strongly agree) indicating their TPACK constructs was used. The respondents were asked to choose from the set Five-point Likert scale (strongly disagree – strongly agree) as Strongly Agree = 5, Agree = 4, Neutral =3 and Disagree = 2 and Strongly Disagree =1for positive statements. The 3 was used as midpoint to determine whether the respondents had good knowledge of TPACK or not. Thus, $(5+4+3+2+1=15, 15 \div 5 = 3)$, therefore, the mean of means that falls above 3 is interpreted as high knowledge while if it falls below 3, it is interpreted as low knowledge. Mean and standard deviation were run for the teachers' level of various TPACK constructs. The results are presented in Table 2.

Table 2: Science Teachers' Mean Scores for TPACK Constructs

TPACK Constructs	M	SD
PK	4.44	0.72
CK	4.24	0.56
PCK	4.19	0.54
TPK	4.12	0.99
TPCK	4.05	0.59
TCK	3.97	0.80
TK	3.51	0.84

(N=145)

Source: Field survey (2023)

The mean scores for the teachers' understanding of all the various TPACK constructs were high and the least was TK construct (3.51) as shown by Table 2. PK construct is the one with highest means ($M = 4.44$, $SD = 0.72$). The results show that science teachers felt they have relatively high knowledge in TPACK. The constructs TK and TCK were the two constructs with mean scores less than four. Although TK and TCK mean scores were less than four, the values can be interpreted as agreed and high since it was more than midpoint 3.

Since the TPACK framework is multidimensional in nature, the constructs have specific items that helped to elicit teachers' perception of the construct. Thus, it was found to be prudent to analyse how science teachers responded to specific items of the various constructs. This was done to unearth specific items that may need special attention to inform teacher professional development programmes if the need arises. Therefore, scores of teachers' mean for each item under various constructs were computed. The responses of teachers' mean for TK items are presented in Table 3.

Table 3: Science Teachers' Mean Scores for TK Items

<i>TK Items</i>	<i>M</i>	<i>SD</i>
I abreast myself with modern technologies	3.83	1.01
I am aware of a lot of different technologies	3.74	1.03
I can install on my device new programs that I want to use	3.52	1.30
I possess Technological knowledge on how to use modern technology.	3.51	1.20
I know how to overcome challenges associated with the use of technology.	3.49	1.13
On my own, I can learn new software with ease.	3.43	1.27
I have used different technologies to work severally	3.05	1.30
Composite mean / std. deviation	3.51	1.18

(N=145)

Source: Field survey (2023)

From Table 3 it is in only two items of the TK construct that science teachers scored a mean above 3.5. The two items teachers scored a mean above 3.5 were “I keep up with important new technologies” (M=3.83, SD=1.01) and “I know about a lot of different technologies” (M= 3.74, SD = 1.03). This could be interpreted that science teachers were not confident with the TK construct, hence, they could not score high means for the TK items. The responses of science teachers' concerning items on Content knowledge (CK) construct revealed that teacher felt they have high perception of their CK. For CK items, teachers had a mean score of 4.0 and above for all of them as can be seen in Table 4.

Table 4: Science Teachers' Mean Scores for Content Knowledge Items

<i>CK items</i>	<i>M</i>	<i>SD</i>
The science I teach I have adequate knowledge about it.	4.39	0.77
I have varied methods of improving upon my understanding of the subject I teach	4.31	0.93
In my class, the concepts that need to be taught I can plan the scope and sequence	4.30	0.78
The lessons I taught I know how to relate them to real world situations.	4.25	0.77
I can reason scientifically.	4.25	0.70
I understand the nature of science better	4.20	0.83
I am abreast with developmental updates of my subject area	4.14	0.77
I am good about the subject matter of the subject I teach	4.08	0.82
Composite mean and std. deviation	4.24	0.80

(N= 145)

Source: Field survey (2023)

The confident and comfortability of teachers for the ways and strategies for developing their own understanding of the subject they teach, the score was high ($M = 4.39$, $SD = 0.77$). The low standard deviation suggests that teachers' responses were homogeneous in nature meaning they were in agreement in their responses. Teachers also positively affirmed that their understanding of the subject matter of what they teach are deep and wide ($M = 4.3$, $SD = 0.77$). The item on this construct (CK) which the teachers rated themselves low comparatively was 'I can use scientific way of thinking'. The mean score of this item was ($M = 4.08$, $SD = 0.82$).

Teachers' ability to select and use appropriate teaching methods and strategies to teach the content in order to aid students' better understanding of the lessons depends on their pedagogical knowledge (PK). To gather data on science teachers' level of PK, eight items were used. Teachers demonstrated high levels of knowledge in these items. For PK items teachers scored high means 4.0 and above for all of them as depicted in Table 5.

Table 5: Science Teachers' Mean Score for the Items Under PK

PK items	M	SD
I am good at students' performance assessment	4.60	.606
I take into account the current understanding of my student when teaching	4.54	.717
I tried as much as possible to deal with individual differences when teaching.	4.47	.590
In my classroom setting I use different teaching approaches	4.40	.606
I am able to better assessment techniques in my classroom.	4.35	.682
I can better manage and control my classroom.	4.32	.674
I can apply suitable strategy for my lesson delivery	4.29	.645
I can prepare lesson plan for the various topics I teach.	4.28	.752
Composite mean/ standard deviation	4.40	0.66

(N= 145)

Source: Field survey (2023)

The teachers indicated that they could select appropriate methods suitable for their lesson delivery. Again, they are highly confident when it comes to assessment tools and techniques, classroom management and catering for individual learner needs. Hence, the overall mean score for PK construct was

($M = 4.40$, $SD = 0.66$). From the standard deviation, there was homogeneity in respondents' responses.

With the pedagogical content knowledge (PCK) items, science teachers scored themselves high on all of them. With eight items under PCK construct teachers scored a mean of 4.0 and above for all the items. Table 6 depicts the PCK items mean scores.

Table 6: Mean Scores for the Items Under PCK

<i>PCK</i>	<i>M</i>	<i>SD</i>
I can help learners to think and learn in my subject area through effective teaching methods.	4.39	0.68
I know how to prepare lesson plans to encourage learners to understand the topics in subject matter.	4.25	0.65
Am able to forecast possible misconceptions in a particular topic.	4.22	0.89
Helping students to link the various concept in my subject is not a problem for me	4.21	0.69
Distinguishing right and wrong problem solving by students is not a problem for me.	4.21	0.79
Am able to deal with students' common misconceptions and understanding in my subject matter.	4.21	0.77
I achieve the stated objectives in my lesson plans	4.03	0.97
When am teaching I can set clear target for my learners	4.01	0.80
Composite mean/standard deviation	4.19	0.78

(N=145)

Source: Field survey (2023)

Science teachers asserted that they have ability to deliver lesson plans that capture better understanding of the topic in the subject they teach ($M = 4.39$, $SD = 0.68$). The overall mean for the items under PCK construct was 4.19. These means science teachers agreed to PCK construct items. The item with least mean score for PCK was “When am teaching I can set clear target for my learners” which had a mean score of 4.01. Nonetheless, the mean still represented agreed on the scale used which is very good since the item sought teachers’ ability to predict students’ entering behaviour and teach to erase any misconception students may bring to class.

Six items were used to determine teachers’ responses on technological pedagogical knowledge (TPK) construct. Science teachers seemed to agree to all the items under the TPK construct this is because all the items were scored 4.0 and above except the item ‘I am able to manage effectively a technological-rich classroom’ which had a mean of 3.96. This means teachers were not confidently sure they can effectively manage a technological-rich classroom. Table 7 depicts the mean scores for the items under the TPK construct.

Table 7: Teachers' Mean Scores for the Items Under TPK

<i>TPK Items</i>	<i>M</i>	<i>SD</i>
Am able to choose technologies that influence teaching approaches for lesson delivery.	4.14	0.86
Improving students' learning through the appropriate technologies is not a problem for me.	4.10	0.82
Am able to choose best technologies to fit my teaching	4.08	0.95
Am able to cater for individual teaching activity with different technologies	4.06	0.91
I can effectively assess students' learning using technology	4.04	0.87
Am able to manage a technology-rich classroom effectively	3.96	0.87
Composite mean/ standard deviation	4.06	0.88

(N= 145)

Source: Field survey (2023)

The overall mean shows that teachers rated their level of TPK construct as high ($M = 4.06$, $SD = 0.88$). This is an indication that science teachers have positive awareness of technologies that they need to teach effectively in their subject areas. The highest score for respondents for the items under this construct was 4.14 which indicated that teachers can help learners to use technology to assess learning. The standard deviation also suggested that respondents' responses were homogeneous in nature.

Another important construct under the TPACK framework which teachers need to be conversant with is technological content knowledge (TCK). This is because with TCK, teachers will be in position to identify appropriate technology to be applied for specific content to achieve effective technology integration in classrooms. Therefore, data was gathered using seven items to

ascertain science teachers' level of TCK. For TCK items teachers scored 4.0 and above for only two. The remaining five items had a mean of less than 4.0. The item with the highest mean score (4.10) was "I can use technological representation to demonstrate specific concepts in my subject matter". The standard deviation 0.86 for the teachers' responses for this item also indicated that teachers were homogeneous in their responses. Table 8 gives a summary of the score means of the items under TCK construct.

Table 8: Science Teachers' Mean Scores on the Items Under TCK

TCK Items	M	SD
I know about technologies that I can use for teaching specific concepts in my subject matter	4.10	0.86
I know how technology can be used to present my subject matter	4.02	0.75
Am able to enhance students' understanding of specific concepts through the use of technologies in my subject matter	3.99	0.77
Am able to demonstrate specific concepts by the use of technological representation.	3.98	0.83
Am able to deliver my content in my subject area with different technologies.	3.95	0.89
Am able to make students observe phenomenon in my subject matter through the use of technology easily.	3.90	0.88
Am able to create and manipulate scientific models through the use of technology (e.g. animations, modelling, etc)	3.61	1.01
Composite mean/standard deviation	3.94	0.86

(N= 145)

Source: Field survey (2023)

The item under TCK construct with lowest mean score (3.61) “was creating and manipulating models of scientific phenomenon such as animations”. The spread of teachers’ responses as can be seen from the standard deviation for this item was very wide compared to other items under the TCK construct. This means the responses for the teachers were in heterogeneous in nature. In a nutshell, science teachers find it difficult to use animations and modelling to help students understand scientific concepts that in real life situation will be difficult or impossible to observe.

Creating effective teaching and learning in the knowledge economy is feasible only by the blending of content, pedagogy and technology. The construct that depicts this blending of technology, content and pedagogy is called technological pedagogical content knowledge (TPCK). Teachers’ efficient selection and appropriate use of technology to effect technology integration in teaching and learning enterprise to enhance students understanding is all what TPCK is about. In order to ascertain teachers’ level of TPCK, eight items were used. The data gathered showed that science teachers understand the items of this construct, therefore scored high means. The mean scores for the science instructors were above 4.0 for the items under TPCK construct except two. These two items were teachers’ ability to apply technology to enhance scientific inquiry in the teaching environment and effective representation of content that depart from textbook approaches. The mean scores for these items were 3.94 and 3.99 respectively. The results for the responses to the items under the construct are displayed in Table 9.

Table 9: Science Teachers' Mean Scores on the Items Under TPCK Construct.

TPCK Items	<i>M</i>	<i>SD</i>
I am able to employ subject matter, technologies and teaching methods to deliver my lessons.	4.12	0.80
I am able to apply technologies to enhance what I teach, how I teach and what students learn.	4.12	0.77
I am able to combine content, teaching approaches and technologies in my classroom.	4.10	0.74
I am able to help my counterpart science teachers to apply technology, content and teaching methods at my school	4.06	0.69
I am able to choose better technologies for the understanding of my learner.	4.03	0.76
I can find and use online resources for effective demonstration of specific scientific concept.	4.01	0.74
I can apply ICT to enhance science classroom activities.	3.94	0.82
I can manipulate ICT to achieve effective content representation that may be very different from textbook approaches.	3.99	0.83
Composite mean and std. deviation	4.05	0.77

(N= 145)

Source: Field survey (2023)

Science teachers were highly confident that during teaching and learning processes students' learning is highly influenced by the selection of technology. Teachers also agreed that online materials could effectively demonstrate specific scientific concepts for students' better understanding. Again, teachers

demonstrated understanding that to help students comprehend content for a lesson, the choice of appropriate technologies are paramount.

The analysis indicates that Junior High School (JHS) science teachers believe they have a high understanding of the TPACK constructs. They scored highest in the PK construct ($M=4.44$) and demonstrated high levels of CK, with all items scoring a mean of 4.0 and above. However, they showed less confidence in the TK and TCK constructs, which had mean scores less than four. Despite these challenges, the overall understanding of the TPACK construct was high, suggesting that teachers perceive themselves as capable of effectively integrating technology in teaching and learning.

Discussion of Science Teachers' TPACK

From the results science teachers who participated in the study rated their understanding in the TPACK constructs very high except TK and TCK as shown in Table 2. The lowest means was TCK which fell below the “agreed” point, though, still higher than the midpoint. This could be attributed to the fact that most of the respondents received their initial teacher education-training program at a time when ICT was not a principal course of study in teacher education programmes since most respondents have taught for more than 10 years (Edumadze, 2015). Again, most educational institutions are not equipped with ICT tools to allow teachers to use them in their teaching (Buabeng-Andoh, 2012). Even though, teachers scored low for TK, all the other technology related constructs thus TPK, TPCK and TCK, they rated their understanding high (4.12, 4.05 and 3.97) respectively (see Table 2).

The findings of this study is in congruent with that of Luik, Taimalu and Laane, (2019) and Qui, He, Chen and Xiong (2022) who found that teachers

rated themselves very high in all the TPACK constructs except TK. The result from the study show that teachers indicated that they have in-depth knowledge in PK, CK and PCK. These means science teachers were more familiar and well versed with CK, PK and PCK constructs which are associated with old methods of teaching before introduction of emerging technologies in teaching enterprise.

The outcome of the study is in line with that of Mtebe and Raphael (2018) who conducted a study in Tanzania to examine In-service teachers' TPACK and found that teachers' level of CK, PK and PCK constructs were high than that of their TK, TCK TPK and TPCK. The trend of teachers having perceiving their CK, PK and PCK to be high is not related to only science teachers. For instance, Appiah (2016) and Asare-Danso (2017) found similar traits in Ghanaian Religious and Moral Education teachers and Archambault and Crippen (2009) in US.

Teachers' assessment of themselves as having high CK and PK could be attributed to the fact that the initial teacher education programmes which ushered them into their teaching profession has prepared them well by focusing on equipping the teachers with appropriate content and repertoire of pedagogical skills. This assertion supported by the fact that most of the teachers in the current study had their initial teacher education training which is highly concentrated on CK and PK that prepares them for their teaching profession. However, the finding from the current research is contrary to that of Graham et al., (2009), Luik, Taimalu and Suviste, (2018), and Mai and Hamzah, (2016) who found out that science teachers who scored high TPCK also scored high level on TK as well. The teachers in the current study rated their TPCK high, though, their TK was low (see Table 2).

The study found that science teachers rated their understanding of TPACK constructs highly, except for TK and TCK. This is attributed to the fact that most teachers received their initial education at a time when Information and Communication Technology (ICT) was not a principal course of study. Despite low scores for TK, teachers rated their understanding of other technology-related constructs highly. Teachers indicated in-depth knowledge in PK, CK, and PCK, which are associated with traditional teaching methods. This high self-assessment could be due to initial teacher education programs focusing on equipping teachers with appropriate content and pedagogical skills. However, despite high ratings for TPACK, their TK was low.

Research Question Two: To What Extent do the Constructs of TPACK Correlate with Each Other?

To answer the second research question which, sought to examine the relationship among the variables (TPACK framework constructs) the Person's Product Moment Correlation was used to analyse the data gathered for the study. This statistical tool was employed after the normality test has been conducted (see figure 4 and 5). The result of the Product Moment Correlation is depicted in Table 10.

Table 10: Correlation Result among TPACK Constructs

	TK	CK	PK	PCK	TPK	TCK	TPCK
TK	-	.359**	.101	.142	.376**	.347**	.525**
CK		-	.427**	.539**	.264**	.272**	.443**
PK			-	.410**	.288**	.233**	.336**
PCK				-	.381**	.340**	.412**
TPK					-	.371**	.445**
TCK						-	.599**
TPCK							-

Source: Field survey (2023)

The table 10 presents the correlation coefficients between the seven constructs of TPACK: TK, CK, PK, PCK, TPK, TCK, and TPCK. The results indicate significant positive correlations between most of the constructs. The highest correlation is observed between TCK and TPCK ($r = .599$, $p < .01$), suggesting a strong relationship between these two constructs. This implies that teachers who have a high understanding of the technology related to their specific content area also tend to have a high understanding of how to integrate technology, pedagogy, and content in their teaching.

TK shows a significant positive correlation with TPK ($r = .376$, $p < .01$), TCK ($r = .347$, $p < .01$), and TPCK ($r = .525$, $p < .01$). This suggests that teachers with a high level of TK are more likely to understand how to integrate technology with pedagogy, content, and both. CK shows a significant positive correlation with PK ($r = .427$, $p < .01$) and PCK ($r = .539$, $p < .01$), indicating

that teachers who have a high understanding of their content area also tend to have a high understanding of the pedagogical strategies needed to teach that content, and how to integrate those strategies with the content.

The TPACK framework analysis reveals significant positive correlations between most constructs. The strongest correlation is between TCK and TPCK, indicating that teachers proficient in technology related to their content area are likely to effectively integrate technology, pedagogy, and content in teaching. TK correlates positively with TPK, TCK, and TPCK, suggesting that teachers with high TK can integrate technology with pedagogy and content. CK shows a significant positive correlation with PK and PCK, implying that teachers with a deep understanding of their content area are likely to effectively integrate pedagogical strategies with the content.

Discussion on the Correlation among Science Teachers' TPACK

Constructs

From the correlation analysis, it is evident that TPCK, which is the intersection of TK, PK, and CK, is central to the TPACK framework. This is because anyone with TPCK should first have these cardinal constructs. This finding aligns with several studies (Archambault & Crippen, 2009; Ekrem & Recep, 2014; Lin, Tsai, Chai & Lee, 2012; Owusu, Conner & Astall, 2015). The study found a strong correlation between TCK and TPCK (0.599), indicating that an improved TCK is associated with an improved TPCK. This suggests that understanding how technology can be used to represent and teach particular content is crucial for effective teaching.

On the other hand, the weak correlation between TK and CK (0.359) is understandable, as the knowledge of the subject matter may not be strongly

linked to technological knowledge. This implies that being proficient in a subject area does not necessarily mean one is also proficient in using technology to teach that subject. Interestingly, there is no significant correlation between TK and PK, and between TK and PCK. This suggests that one may not need TK to develop his/her PK or PCK, and vice versa. This could be because pedagogical strategies and understanding how to represent and teach particular content do not necessarily require technological knowledge.

In conclusion, the TPACK framework emphasizes the interconnectedness of technology, pedagogy, and content knowledge. While TPCK is central to this framework, the correlations between the different constructs vary, highlighting the complexity of effectively integrating technology in teaching and learning. It underscores the need for teachers to develop a balanced understanding of all these constructs to enhance their teaching effectiveness.

Research Question Three: Which of the TPACK Constructs has the Largest Prediction of TPCK?

Since there were significant correlations among some of the constructs of TPACK, the third research question wanted to know which of the constructs of TPACK framework predicts TPCK. In an attempt to answer research question three, a standard multiple regression was performed. The TPCK was used as the dependent variable and TK, PK, CK, PCK, TPK and TCK were the independent variables. This was done to help educators to know which construct to pay more attention to when organizing professional training programmes that are related to technology integration in teaching for teachers. SPSS version 22 was used for the analysis and the classical regression assumptions was checked.

The correlation between dependent variable and independent variables were acceptable for the regression analysis since they were above 0.3 (Pallant, 2005; Tabachnick & Fidell, 2007). The correlations were not very high ($r > 0.9$) between the independent variables (Field, 2009). Other assumptions such as normality test, multicollinearity, autocorrelation test were all checked to ensure that the assumptions are not violated. The normality of the data set was checked using histogram as shown in Figure 4. The histogram showed that the data was normal and does not violate the regression analysis assumption (see Figure 5) below.

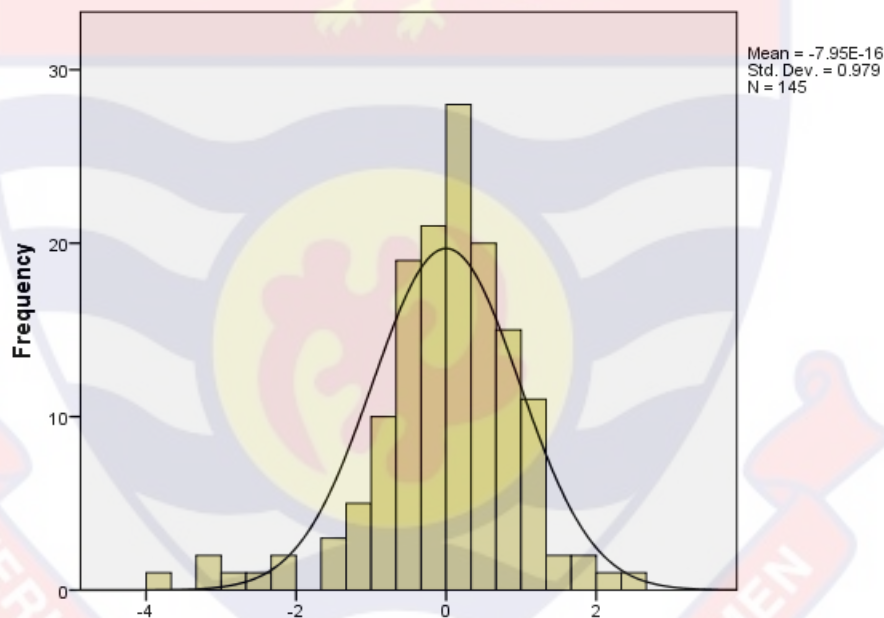


Figure 5: Regression Standardized Residual

Source: Field survey, 2023.

The study also used the normal probability plot to check the normality of the data and results are shown in Figure 6 below.

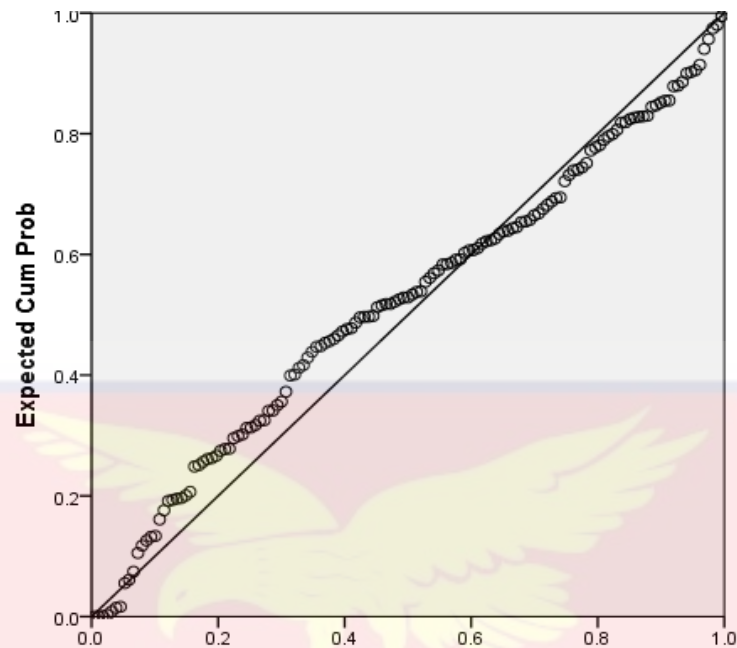


Figure 6: Observed Cum Prob

Source: Field survey (2023)

The results of the normal probability plot showed that the data is normally distributed. The graph revealed that the points spread around the diagonal line and follows the direction of the diagonal line and the points do not move away from the diagonal line therefore, the data is normal.

Multicollinearity Test

The variance inflation factor (VIF) was used to measure the multicollinearity among the variables in a regression model. The results showed that tolerance are greater than 0.1 and Variance inflation factors (VIF) figures were less than 10 suggesting that there was no problem of multicollinearity (Field, 2009; Pallant, 2005). Table 11 shows the result of the Multicollinearity Test.

Table 11: Multicollinearity Test

Variables	Tolerance	VIF
TK	.712	1.405
CK	.577	1.732
PK	.744	1.344
PCK	.589	1.697
TPK	.704	1.420
TCK	.761	1.314

Source: Field Survey (2023).

Outliers

Mahalanobis distances were used to examine the data to determine if there were outliers. The distances for 9 cases were higher than the critical value; however, the Cook's distance of these cases were lower than 1. Therefore, the cases were remained in the analysis since the outliers can be accepted with reasonable size data file (Pallant, 2007). Table 12 depicts the result of Mahalanobis residual statistics.

Table 12: Mahalanobis Residuals Statistics^a

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	26.8842	45.3786	32.1448	2.39294	145
Std. Predicted Value	-2.198	5.530	.000	1.000	145
Standard Error of Predicted Value	.398	3.293	.807	.394	145
Adjusted Predicted Value	25.5245	50.2003	32.1458	2.64024	145
Residual	-10.71002	14.11455	.00000	4.00121	145
Std. Residual	-2.620	3.453	.000	.979	145

Table 12 continued

	-2.672	3.731	.000	1.017	145
Deleted Residual	-12.20034	16.47546	-.00098	4.34390	145
Stud. Deleted Residual	-2.734	3.920	.000	1.030	145
Mahal. Distance	.376	92.486	5.959	10.446	145
Cook's Distance	.000	.503	.013	.052	145
Cantered Leverage Value	.003	.642	.041	.073	145

Source: Field Survey (2023)

Durbin watson test

The statistical tool used to check and test whether there is autocorrelation problem was Durbin-Watson. The Durbin-Watson for all variables was 1.842 that shows that there was no autocorrelation problem. The Durbin-Watson value of 1.5 to 2.5 is considered good and devoid of autocorrelation problem (Alseed, 2005). Since no assumption was violated multiple regression was conducted to determine which of the TPACK constructs contribute significantly to the development of overall TPACK construct. Six independents predictors (CK, PK, TK, PCK, TCK, and TPK) were run to see which one is the major predictor of TPCK (dependent variable). The result of the multiple regression is presented in Table 13.

Table 13: Model Summary for the Multiple Regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
	.739 ^a	.547	.527	3.23630	1.842

Source: Field survey (2023)

The R-Value of ($R = .739$) means there is strong positive correlation between the dependent variable (TPCK) and the independent variables (CK, PK, TK, PCK, TCK and TPK). The R-Square of the model shows the coefficient of determination ($R\text{-Square} = 0.547$). The Adjusted R Square of the model was

= 0.527. This shows that the multiple regression explains 52.7% of variation in science teachers' TPACK; hence, the regression model is useful for making predictions in TPACK framework. The other factors not captured in the model account for 47.3% of the variation in science teachers' TPACK framework development

Table 14: ANOVA^a

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1742.772	6	290.462	27.733	.000 ^b
	Residual	1445.366	138	10.474		
	Total	3188.138	144			

Source: Field survey (2023)

Table 14 tests the overall fitness of the regression model and it shows that the fitted regression model is significant as *P*-value of *F* statistics is 0.000 and this is less than significant level of 0.05. The Coefficient table was ran to help in determination of the regression equation. The results of the coefficient table were presented in Table 15.

Table 15: Coefficient Table

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	5.224	2.534		2.061	.041
TK	.236	.055	.294	4.325	.000
CK	.116	.079	.111	1.471	.143
PK	.082	.054	.100	1.512	.133
PCK	.116	.082	.106	1.417	.159
TPK	.078	.054	.098	1.440	.152
TCK	.313	.055	.371	5.645	.000

a. Dependent Variable: Technological Pedagogical Content Knowledge

Source: Field survey (2023)

The Unstandardized Coefficients column and its sub column ‘B’ gives the regression coefficients. The first value is constant which is also known as y intercept and the second one is the regression coefficient of dependant variable (TPCK) on independent variables (CK, PK, TK, PCK, TPK, TCK). Hence, the regression equation for the above model is $y = 5.224 + 0.236x_1 + 0.313x_2$

Where, $x_1 = \text{TK}$, $x_2 = \text{TCK}$.

From the coefficient table it can be seen that TK and TCK were the only construct of TPACK that made significant contributions to TPCK among the study participants. Thus, one from the primary constructs (TK) and one from the secondary constructs (TCK) of TPACK framework statistically significantly predict the TPCK at the five percent significance level. In terms of the magnitudes of the effects, the standardised coefficient results suggested that TCK contributes 31% to the dependent variable (TPACK) followed by TK (24%). Thus, the results revealed that, TK positively influences TPACK. CK also has a positive effect, but it is not statistically significant. PK, like CK, has a positive effect but lacks statistical significance. PCK positively influences TPACK. TPK significantly affects TPACK. TCK has the strongest impact on TPACK. These findings align with previous studies by Chai et al 2011; Horzum 2013; Pamuk et al. 2013, Owusu, Conner & Astall, 2015). Overall, integrating technology effectively while considering content-specific knowledge and pedagogy is crucial for teachers’ technological pedagogical content knowledge.

Discussions of TPACK Constructs that has the Largest Prediction of TPCK

The results of the study indicate that TCK predicts more to the TPACK framework than all other constructs of TPACK framework. The findings of the

current study are somewhat consistent with what past studies (Chai et al 2011; Horzum 2013; Pamuk et al. 2013, Owusu, Conner & Astall, 2015) have found. Horzum (2013) and Pamuk et al. (2013) found that TCK and TPK had the strongest effect on TPCK. Pamuk et al. 2013 indicted that TCK has the largest contributor on the TPCK. Horzum (2013) did not indicate which of the two constructs (TCK and TPK) made the largest contribution on TPCK. The structure equation analysis of Chai et al. (2011) revealed that TPK has the largest influence on TPACK framework. Chai et al. (2011) were not able to incorporate TCK into their structural equation model because of construction validation issues. The study of Owusu, Conner and Astall (2015) in New Zealand found no primary construct of the TPACK as significant predictor of TPCK but secondary constructs TPK and (TCK making unique contribution to TPCK. The study of Owusu, Conner and Astall (2015) found TCK to be contributor of TPCK after the stepwise regression analysis. The current study confirmed the significance of secondary construct (TCK) as a major contributor to TPCK but could not sustain that of TPK.

In other studies, conducted by Rukmana and Handayani (2021) and Liu, Zhang and Wang (2015) also revealed that the secondary constructs (TPK, TCK, PCK) predict TPACK development stronger than core knowledge basis (TK, PK, CK). All the above studies are in somewhat in line with the current study, which has also found that TCK is the major contributor of the TPCK followed by TK. This could be attribute to the fact that, one cannot develop his/her TCK without TK, hence is the second contributor to the TCK in the prediction of TPCK. Since there were correlations between TCK and all the other constructs, one can conclude that all the other constructs indirectly

contribute to TPCK. This is because in order to develop TCK, one needs TK and CK (Koehler & Mishra, 2008). TK as second contributor is not a surprise this is because there is correlation between TK and TCK. This means there is direct linkage between TK and TCK. Therefore, one needs TK before he/she can develop his/her TCK.

Research Question Four: What Influence Does Gender Had on TPACK Constructs?

To answer this research question, the MANOVA was used to determine whether the means of two groups (male and female) are statistically significant. The study met the parametric test assumptions (such as normality, multicollinearity). Table 16 depicts the output of the Box's test of Equality of Covariance Matrices of the MANOVA test result results.

Table 16: Box's Test of Equality of Covariance Matrices^a for Qender

Box's M	270.247
F	9.132
df1	28
df2	58275.187
Sig.	.000

Box's M of 270.25 indicate that the homogeneity of the covariance matrices across groups was assumed [$F(28, 58275.19) = 9.13, p < 0.001$].

Table 17 gives the account of the results of the descriptive statistics, which shows that male teachers had high means scores for all the TPACK constructs than their female's counterparts as shown in Table 17.

Table 17: Descriptive Statistics Male and Female Science Teachers' TPACK

	Gender of respondent	Std.		
		Mean	Deviation	N
TK	M	26.0952	5.14517	84
	F	22.4590	6.17137	61
	Total	24.5655	5.86280	145
CK	M	34.9524	4.08319	84
	F	32.4918	4.68552	61
	Total	33.9172	4.49923	145
PK	M	36.0833	3.07813	84
	F	34.8361	8.14080	61
	Total	35.5586	5.78417	145
PCK	M	34.4524	3.42001	84
	F	32.2459	5.03870	61
	Total	33.5241	4.30291	145
TPK	M	25.1190	2.84289	84
	F	24.1803	8.52351	61
	Total	24.7241	5.92837	145
TCK	M	28.7262	4.12267	84
	F	26.5738	6.94852	61
	Total	27.8207	5.57234	145
TPCK	M	33.6071	3.74171	84
	F	30.6885	5.36203	61
	Total	32.3793	4.70530	145

Source: Field survey, (2023)

The inferential statistics of the MANOVA test to determine whether the means for the two groups (male and female) were statistically significant is presented on Table 18 below.

Table 18: Multivariate Tests^a of TPACK Across Respondents Gender

		Hypo Erro						
Effect		Val	F	df	r df	Sig.	PES	OP
Intercept	Pillai's Trace	.990	1946.710 ^b	7.0	137.0	.000	.990	1.0
	Wilks' Lambda	.010	1946.710 ^b	7.0	137.0	.000	.990	1.0
	Hotelling's Trace	99.4	1946.710 ^b	7.0	137.0	.000	.990	1.0
	Roy's Largest							
	Root	99.4	1946.710 ^b	7.0	137.0	.000	.990	1.0
Gender	Pillai's Trace	.173	4.084 ^b	7.0	137.0	.000	.173	.98
	Wilks' Lambda	.827	4.084 ^b	7.0	137.0	.000	.173	.98
	Hotelling's Trace	.209	4.084 ^b	7.0	137.0	.000	.173	.98
	Roy's Largest							
	Root	.209	4.084 ^b	7.0	137.0	.000	.173	.98

Source: Field survey (2023)

The MANOVA test was performed on the independent variables (Gender) and dependent variables (TPACK constructs) and the results of evaluation assumptions of normality and that of homogeneity of variance-covariance matrices across groups is assumed [$F(28, 58275.19) = 9.13, p < 0.001$], linearity and multicollinearity were achieved satisfactory. The combined Wilk's criterion showed that dependents variables (TK, CK, PK, TCK, TPK, and TPCK) were significantly different by gender (male and Female).

The results of the MANOVA showed that there is a statistically significant difference between the gender (male and female) on combined dependent variables (TPACK constructs), Wilks' $\Lambda = .83$, $F(7, 137) = 4.08$, $p < .001$; partial $\eta^2 = .17$, observed power = .98. These results from the MANOVA test indicated that there is enough evidence to reject the null hypothesis and acknowledged that there is a statistically significant influence of gender on the TPACK constructs. The effect size was large and observed power was .98, meaning that there was a 98% chance that the outcome of the results could have come out statistically significant.

To determine the source of the differences the marginal means of male and female teachers were presented in Table 17. The results suggested that male teachers had higher marginal mean than female teachers did on all the constructs of TPACK framework. The magnitude of the differences in the means was (eta squared = .17). The mean difference in that of TCK scores for males ($M = 28.72$, $SD = 4.12$) and female ($M = 26.57$, $SD = 6.94$); $F = 4.08$, $p < .001$ in favour of males. The magnitude of the differences in the means was (eta squared = .17), which can interpret as large. The mean difference in that of TPCK scores for males ($M = 33.60$, $SD = 3.74$) and female ($M = 30.68$, $SD = 5.36$); $F = 4.08$, $p < .001$ in favour of males. The magnitude of the differences in the means was (eta squared = .17). In conclusion, male teachers can be said to have significantly higher level of TPACK than female teachers; and the difference could be observed for each construct of TPACK framework. The Post Hoc Tests analyses for pair wise comparisons could not be done because the independent variables are only two (male and female).

Males have higher mean scores than females for all the TPACK constructs. The differences between group means for each construct (TK, CK, PK, PCK, TPK, TCK, and TPACK) are significant; it implies that gender influence TPACK constructs significantly. The MANOVA results provide overall multivariate effects for gender. For instance, Wilks' Lambda measures differences between groups. In summary, all these MANOVA test statistics provide information about how gender influence TPACK constructs (TK, CK, PK, PCK, TPK, TCK, and TPACK). The significant results suggest that gender indeed plays a role in TPACK constructs. The results align with the previous studies of Bulut, (2012), Erdogan and Sahin, (2010), Jang and Tsai (2013) Luik, Taimalu and Suviste (2018) who concluded that there is statistical significant difference between male and female teachers in their TPACK constructs.

Discussion on the Influence of Gender on TPACK Constructs

The findings in the current study were in line with the findings of Bulut, (2012), Erdogan and Sahin, (2010), Jang and Tsai (2013) Luik, Taimalu and Suviste (2018) who found out that there was a statistically significant difference between male and female in items of their knowledge level with respect to TPACK constructs. The means of the male teachers were statistically significant with all the TPACK constructs. Jang and Tsai (2013) concluded that gender is an important factor for the TPACK framework development of science teachers in Turkey. This claim could be true for science teachers in this study also since the male teachers scored high means than their female counterparts in all the TPACK constructs. However, the findings from the current study contradicts that of Altun (2013), Oz (2015), Karaca (2015) and Lin et al. (2013) who found that female science teachers scored high means than their male counterparts in

all the non-technological components of the constructs (PK, CK and PCK) of the TPACK framework constructs. However, they concluded that female teachers have low confidence in all Technological related constructs (TK, TCK, TPK and TPCK) than their male counterparts.

Research Question Five: What Influence Does Teaching Experience Had on TPACK Constructs?

In an attempt to answer research, question five, which state ‘what influence does teaching experience has on TPACK constructs? A multivariate analysis of variance (MANOVA) was used to compare the dependent variables and independent variable. This was done to help in determining whether the differences between the means of the TPACK framework constructs are significant according to teachers’ teaching experiences. The test of normality and other assumptions had been checked already. Table 19 gives the account of the results of the descriptive statistics, which shows teachers mean for teaching experience on TPACK constructs.

Table 19: Descriptive Statistics on Teacher Mean on Teaching Experience

	experience	Mean	Std. Deviation	N
Technological knowledge	1-5	25.7143	6.86911	42
	6-10	26.0714	3.95276	28
	11-15	24.9512	5.95379	41
	16ab	25.4118	7.00267	34
	Total	25.4966	6.13293	145
Content knowledge	1-5	31.9286	4.95538	42
	6-10	32.4286	6.11270	28
	11-15	34.3415	4.59679	41
	16abo	33.0588	4.47174	34

Table 19 Continued

	Total	32.9724	5.03591	145
Pedagogical Knowledge	1-5	32.3333	6.10344	42
	6-10	34.0000	4.40538	28
	11-15	35.7317	3.40606	41
	16ab	34.3824	5.06332	34
	Total	34.0966	5.00323	145
Pedagogical Content Knowledge	1-5	31.6667	5.54655	42
	6-10	32.1786	4.50558	28
	11-15	33.4878	5.83576	41
	16ab	33.0000	3.48155	34
	Total	32.5931	5.03529	145
Technological Pedagogical Knowledge	1-5	26.1667	9.06324	42
	6-10	24.2500	3.06262	28
	11-15	25.1951	3.99512	41
	16ab	24.5588	6.03119	34
	Total	25.1448	6.20146	145
Technological Content Knowledge	1-5	27.3095	4.09930	42
	6-10	27.1786	4.14598	28
	11-15	27.0732	4.70314	41
	16ab	30.6176	8.69348	34
	Total	27.9931	5.79691	145
Technological Pedagogical Content Knowledge	1-5	28.8571	3.92970	42
	6-10	31.5357	3.59508	28
	11-15	33.0000	4.57165	41
	16ab	35.6765	3.45289	34
	Total	32.1448	4.66217	145

Source: Field survey, (2023)

The results of the MANOVA test (Box's Test of Equality of Covariance Matrices, Multivariate Tests and Bonferroni Multiple Comparison) were presented in Table 20, 21 and 22 respectively below.

Table 20: Box's Test of Equality of Covariance Matrices for Teaching Experience

Box's M	312.694	
F		3.380
df1		84
df2	37275.346	
Sig.		.000

Source: Field survey, (2023)

The Box's M of 312.69 indicates that the homogeneity of covariance matrices across groups is assumed [$F(84, 37275.35) = 3.38, p = .000$].

Table 21: Multivariate Tests of TPACK across Respondents Teaching Experience

		Hypo		Erro		P.E.		
Effect		Value F	df	r	df	Sig.	S	OP
Intept	Pillai's Trace	.990 1929.9	7.0	135.0	.000	.990	1.0	
	Wilks' Lambda	.010 1929.9	7.0	135.0	.000	.990	1.0	
	Hotelling's Trace	100.0 1929.9	7.0	135.0	.000	.990	1.0	
	Roy's Largest R.	100.0 1929.9	7.0	135.0	.000	.990	1.0	
Teach.	Pillai's Trace	.434 3.313	21.0	411.0	.000	.145	1.0	
Experi ence	Wilks' Lambda	.602 3.568	21.0	388.2	.000	.155	1.0	
	Hotelling's Trace	.600 3.819	21.0	401.0	.000	.167	1.0	
	Roy's Largest R.	.483 9.447	7.0	137.0	.000	.326	1.0	

Source: Field survey (2023)

A multivariate analysis of variance was performed on independent variables (years of teaching) and dependent variables (TPACK constructs). The

results of homogeneity of variance-covariance matrices and evaluation assumptions of normality shows that the homogeneity of covariance matrices across groups is assumed ($F(84, 37275.35) = 3.38, p < .001$), satisfactory linearity and low multicollinearity were achieved. The combined Wilk's criterion showed that dependent variables (average TPACK constructs) were significantly different by years of teaching experience. The MANOVA results indicated that there was a statistically significant difference between the various levels of teaching experience (1-5 years, 6-10 years, 11-15 years and 16 years above) on combined dependent variables (TPACK constructs), Wilks' $\Lambda = .60$, $F(21, 388.20) = 3.57, p < .001$; partial $\eta^2 = .16$, observed power = 1.00. From the result, there was enough evidence to reject the null hypothesis and concluded that there is a statistically significant influence of teaching experience on the various constructs of TPACK Framework. The effect size ($\eta^2 = .16$) was large and observed power was 1.00, implies that there was a 100% chance that the outcome of the results could have come out statistically significant.

The researcher wanted to know the impact of each effect on the individual dependent variables; therefore, a univariate F-test using an alpha level of 0.05 was performed. The pair-wise comparison, which followed the univariate F-test, revealed statistical significant difference between teachers with teaching experience 1-5 years and those with teaching experience 11-15 years only in Pedagogical Knowledge (PK). There was also statistical significant difference between teachers with teaching experience between 1-5 years and their counterparts 6 years and above in teaching experience only in technological pedagogical knowledge (TPCK) (see Table 22).

The results on the overall TPACK indicated continuous increase in level of TPACK as the years of teaching experience increases (Average TPACK Level: 1-5years =28.8571, 6-10years=31.5357, 11-15 years=33.0000, and 16 and above=35.6765). That is, the difference between any two of the means was found to be statistically significant at the five percent significance level (p-value < 0.05).

Table 22: Bonferroni Multiple Comparison of TPACK Constructs Across Years of Experience.

DV	(I) exper	(J) exper	Mean Dif (I-J)	Std. Error	Sig.	Post Hoc
TK	1-5 years	6-10	-.3571	1.50881	1.000	
		11-15	.7631	1.35772	1.000	
		16 above	.3025	1.42669	1.000	
CK	1-5 years	6-10	-.5000	1.21914	1.000	
		11-15	-2.4129	1.09706	.177	
		16 above	-1.1303	1.15279	1.000	
PK	1-5 years	6-10	-1.6667	1.19123	.984	
		11-15	-3.3984*	1.07195	.011	11-15y >1-5y
		16 above	-2.0490	1.12640	.426	
PCK	1-5 years	6-10	-.5119	1.22793	1.000	
		11-15	-1.8211	1.10497	.609	
		16 above	-1.3333	1.16110	1.000	
TPK	1-5 years	6-10	1.9167	1.51820	1.000	
		11-15	.9715	1.36617	1.000	
		16 above	1.6078	1.43557	1.000	
TCK	1-5 years	6-10	.1310	1.38317	1.000	
		11-15	.2364	1.24467	1.000	
		16 above	-3.3081	1.30790	.075	
TPCK	1-5 years	6-10	-2.6786*	.96624	.038	6-10 >1-5years
		11-15	-4.1429*	.86948	.000	11-15>1-5years
		16 above	-6.8193*	.91365	.000	16 ab >1-5years
	6-10 years	11-15	-1.4643	.97094	.803	
		16 above	-4.1408*	1.01069	.000	16ab>6-10y
	11-15 years	16 above	-2.6765*	.91862	.025	16abo >11-15years

Source: Field survey (2023)

The MANOVA revealed that there is a statistically significant difference between different levels of teaching experience (1-5 years, 6-10 years, 11-15 years, and 16 years above) concerning combined TPACK constructs. The effect size (η^2) was large, indicating a substantial influence of teaching experience on TPACK. In summary, teaching experience plays a crucial role in shaping teachers' TPACK, with specific effects observed on different TPACK constructs based on their years of experience. It is fascinating to see how this knowledge can influence educational practices. The findings align with the previous studies of Bingimlas (2018), Jang, and Chang (2016).

Discussion on the Influence of Teaching Experience on TPACK Constructs.

The findings of the current study showed that there was statistically significant influence in science teachers' PK in terms of their teaching experience. The study found that teachers with 11–15 years teaching experience had the highest mean value in PK construct of TPACK framework than those with less teaching experience. This means that teachers with teaching experience between 11-15 years had more PK than their counterpart with teaching experience between 1-5year. This finding is consistent with the found of Bingimlas (2018) and Jang and Chang (2016) who found that there was statistically significant difference in science teachers' PK and PCK constructs based on teaching experience. Although, the current study revealed that science teachers' PK construct was significant in terms of teaching experience but PCK construct was not significant. Many past studies (Jang, Tsai & Chen, 2013, Jordan, 2013; Lee & Tsai, 2010; Mutluoglu, 2012) suggested that veteran teachers generally had less TK construct but the rest of the TPACK constructs are high. The current study also showed that teachers with teaching experience

above 6 years have high TPCK constructs and is statistically significant. This means that teachers with 6 – 10 teaching experience had more TPCK than those with teaching experience between 1 -5 years teaching experience. Those with teaching experience above 16 years are even higher than 1-5 year teaching experience in TPCK. These findings are consistent with the findings of Altun (2013), who also found that teachers with more teaching experience (6years and above) had high TPCK construct than those with less teaching experience (1-5 years).

Chapter Summary

The study established that the perception of science teachers TPACK constructs is high in KEEA municipality and Cape Coast metropolis. The teachers agreed most of the items in the instrument that means teachers had high opinion of themselves as far as various TPACK constructs are concerned. Teachers' level of technological knowledge (TK) was low. The study showed that with the exception of TK and CK, and TK and PCK, which do not correlate, the rest of the TPACK constructs correlate. The MANOVA examined the influence of gender and teaching experience of science teachers' TPACK and the result found that male science teachers have higher TPACK framework constructs than the female science teachers and the differences are statistically significant. On the influence of teaching experience and TPACK framework constructs the results suggest that PK and TPCK constructs were generally high among experienced (veteran) teachers who have taught for more than six years than less experience teachers.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter summarises the study by highlighting the study purpose, design used, limitations, key findings, conclusion drawn from the study, recommendations as well as contributions this study provide to the body of literature, practice and policy decisions. It also gives suggestions for the future enquiry.

Summary of the Findings

The purpose of this thesis was to assess Junior High School (JHS) science teachers' Technological Pedagogical Content Knowledge (TPACK). The following research questions were formulated to address the purpose of the study.

1. What are the JHS science teacher' understanding of the TPACK framework constructs?
2. What extent do other TPACK constructs correlate with TPCK?
3. Which of the TPACK constructs has the largest prediction of TPCK?
4. What influence does gender has on TPACK constructs?
5. What influence does teaching experience has on TPACK constructs?

The study used simple random sampling because its advantages if applied appropriately. All the JHS science teachers in the KEEA municipality and Cape Coast metropolis were targeted as potential respondents for the survey. A five- point Likert-type scale questionnaire was used to gather the data. The means and standard deviations for the various TPACK constructs were analysed using the means and standard deviations to answer first research question. Research question two, the correlations among the various constructs

of TPACK framework was identified using Pearson correlation analysis. Through regression analysis the third research question that sought to examine which TPACK construct has the largest predictor of the TPCK was addressed. The influence of gender and teaching experiences on TPACK constructs were also explored using MANOVA analysis. All the research questions were answered by the use of SPSS version 22.

Key Findings

Based on the gathered data and its analyses it was evident that:

1. The research suggests implementing a professional development program for Junior High School science teachers to improve their Technological Content Knowledge (TCK) and Technological Knowledge (TK). This is due to the observed lower scores in these areas, despite overall high performance on the TPACK framework. The program could include practical training through workshops, seminars, or online courses.
2. From the correlation analysis, all the primary constructs (TK, CK and PK) showed that there were statistically significant correlations between them and TPCK. There was also statistically significant correlation between the secondary constructs (PCK TPK and TCK) and TPACK as well. With the exception of TK and CK, and TK and PCK all other TPACK framework constructs significantly correlate with each other. However, TCK and TPCK had the strongest correlation followed by TK and TPCK.
3. The regression analysis revealed that Technological Content Knowledge (TCK) was the secondary construct that significantly contributes to the TPACK construct among the study respondents. In addition, Technological Knowledge (TK) was the primary constructs of TPACK that contribute significantly to the

TPACK construct at the five percent significance level. Among these constructs, TCK is the major predictor of the TPACK followed by TK. This means only one secondary constructs of TPACK framework contributes more to the TPACK construct with one of the primary constructs contributes small amount to TPACK construct. However, this does not suggest that combining the primary constructs matter less to TPACK in general but that the effectiveness of the secondary constructs may well depend on other factors that may not be present in the study setting.

4. It was also found that TPACK knowledge of male science teachers is higher than their female counterparts and the difference is statistically significant at the five percent significant level. Though the average values indicated that males still have relatively higher average knowledge rating in all the TPACK framework constructs.

5. Finally, teaching experience and TPACK framework constructs, the results from the MANOVA analysis suggests that the influence of science teachers' teaching experience on TPACK framework constructs is on only two constructs (PK and TPACK) based on Post Hoc analysis. Thus, teachers who have taught between 11-15years showed statistical significant difference in PK construct and teachers who have taught more than six years and above showed statistical significant difference in TPACK constructs. The differences were all found to be statistically significant at the five percent significance level. It was again observed that TPACK does not vary much within the first five years as compared to the next five years of teaching; difference begins after the 6 years of teaching. The results indicated that years of teaching experience strongly moderate the effects of experience on the TPACK of science teachers.

Conclusion

Based on the results from the data gathered it can be concluded that there is high understanding of perception of JHS science teachers concerning TPACK framework constructs. TPCK has a positive correlation with the other six TPACK framework constructs. The major predictor of TPCK is TCK followed by TK. This means various TPACK framework constructs have connections among themselves therefore; the development of TPACK framework should not be isolated on the various constructs but should be integrated, blended in a holistic manner to achieve unity. Other authors (e.g. Koehler & Mishra, 2005; Owusu, 2015) have asserted this.

Science teachers' TPACK based on gender suggest that the male science teachers have higher TPACK knowledge than the female science teachers do and the difference is statistically significant. On teaching experience and TPACK, the result suggests that TPACK generally was high among teachers who have taught for more than six years and above.

Recommendations

Based on the findings of this research the following recommendations are suggested:

1. The study suggests implementing a professional development program for Junior High School science teachers to improve their Technological Content Knowledge (TCK) and Technological Knowledge (TK). This is due to the observed lower scores in these areas, despite overall high performance on the TPACK framework. The program could include practical training through workshops, seminars, or online courses.

2. TPCK has a positive correlation with the other six TPACK framework constructs. Therefore, the development of TPACK framework should not be isolated on the various constructs but should be integrated, blended in a holistic manner to achieve unity.
3. The major predictor of TPCK is TCK followed by TK. Therefore, during TPACK development-training organizer should pay more attention to TCK and TK than the rest of the constructs.
4. It is also being recommended that for teachers' TPACK framework development programmes the organizers should be paying more attention to gender. Thus, it may be useful for organizers to separate the males from the females and run separate programme for each group (male and female). Since they exhibit different levels of TPACK framework constructs.
5. The study suggests that teaching experience significantly influences the development of TPACK among science teachers. It recommends providing targeted support and professional development opportunities, especially to teachers in their first five years. The study found that substantial growth in TPACK occurs after six years of teaching. Therefore, such support could speed up TPACK development in early-career teachers, improving their ability to incorporate technology effectively in their teaching methods.

Implications of the Study on Education Practice

TPACK framework model offers a robust implementation of technology in education delivery in today's digital literacy. As proposed by Jones and Hafner (2012) reconceptualised TPACK offers a model for digital literacy that bring about the affordance of digital facilities to facilitate teaching and learning. The current study can serve as a map for teacher educators and science teachers

especially, who are interested in understanding and exploring with digital tools to effectively devise ways and means to help use technology into their curriculum. From the study outcome, teacher education programmes should embrace technology integration and expose preservice teachers to varieties of digital tools to enhance and empower them to identify the necessary affordances for transformation of traditional ways of teaching in order to prepare students to embrace the future uncertainties.

TPACK model can serve as a metacognitive tool for teachers to make good use of available technological tools at their disposal to enhance integration of digital literacies in teaching and learning environment (Doering et al. 2009). Thus, through visual representations by the use of TPACK framework, teachers can be metacognitive about their teaching knowledge strengths and areas of growth. TPACK allows teachers to plan and set teaching and learning goals for themselves and their learners and, subsequently, make some thoughtful decisions to integrate technology into their teaching to achieve digital literacy practices through metacognitive awareness. To conclude, TPACK model enhances teachers' awareness of digital literacies, this will guide and pave ways for teachers to understanding how the affordance of digital media make possible the new ways of creating meaning and doing things in collaboration with others. If teachers are able to foster these new ways of creating meaning and doing things in collaboration with others, their learners will be global citizens.

Contributions to Knowledge and Literature

1. Prior to this study, in Ghanaian context there has not been much effort to look at the JHS science teachers' TPACK. The study therefore, fills this gap in literature by providing additional information about TPACK

knowledge of JHS science teachers TPACK and how this will help in training development for teachers.

2. The outcome of the study is also an extension of literature on science teachers' TPACK framework of what other researchers have done.
3. There is also little work on the effects science teachers' gender and teaching experience on their knowledge level of TPACK framework in Ghanaian context. This study is helping to fill that gap in literature.

Suggestions for Further Research

1. The study employed only quantitative design, future researchers can use mixed method approach to get in-depth knowledge about JHS science teachers' TPACK framework in the Ghanaian context.
2. The researcher thinks other factors like teachers' attitude, background could also account for teachers' TPACK level. Therefore, future researchers should explore other factors that might influence teachers' TPACK framework other than the gender and teaching experience.

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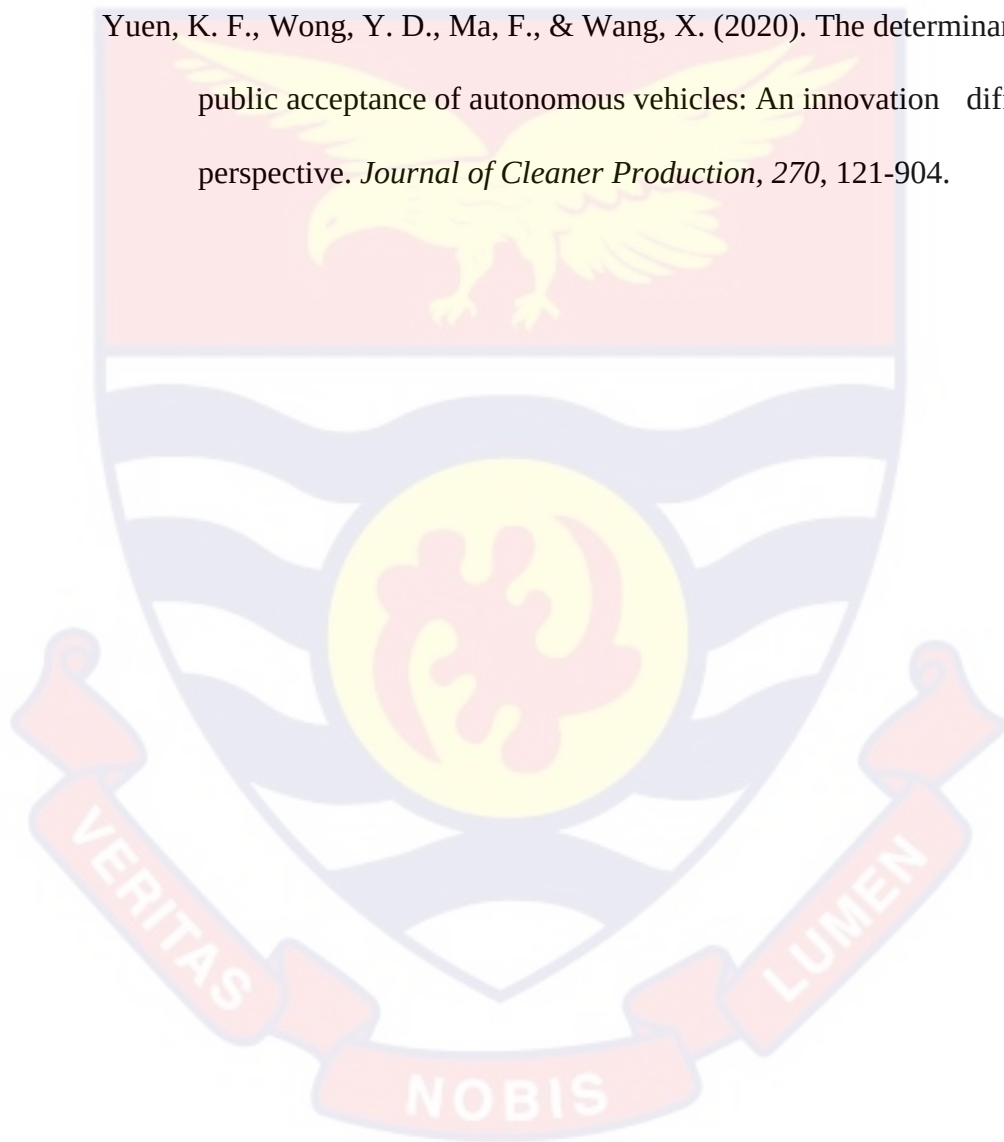
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APPENDICES

APPENDIX A

QUESTIONNAIRE FOR SCIENCE TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

Dear Respondent,

I am a graduate student pursuing Master of Philosophy in Science Education.

I am currently undertaking a research on technological pedagogical content knowledge of science teachers in Junior high school in the KEEA Municipality and Cape Coast metropolis. This is an academic research and confidentiality shall strictly be adhered to. The information you provide will be used for the purpose of the study and will be kept confidential and anonymous. Thank you.

SECTION A: background information of the respondents

1. Gender: Male [☐] Female [☐]
2. Age group of respondents
20-25 years [☐] 26-30 years [☐] 31-35 years [☐] 36-40 years [☐]
above 40 years [☐]
3. How many years have you taught?
1- 5years [☐] 6 – 10 years [☐] 11- 15 years [☐] 16 -20 years [☐] 21 – 25
years [☐] above 26 years [☐]

SECTION B: This section examines your understanding of Technology Knowledge (TK)

Tick (✓) the appropriate answer that best describes your opinion for each of the statements below. Strongly Disagree (SD) Disagree (D) Neither agree nor disagree (U) Agree (A) Strongly Agree (SA)

	Technological Knowledge (TK)	SD	D	U	A	SA
4	I abreast myself with modern technologies					
5	I am aware of a lot of different technologies					
6	I can install on my device new programs that I want to use					
7	I possess Technological knowledge on how to use modern technology.					
8	I know how to overcome challenges associated with the use of technology.					
9	On my own I can learn new software with ease.					
10	I have used different technologies to work severally					

SECTION C: This section examines your understanding of Contents Knowledge.

Tick (✓) the appropriate answer that best describes your opinion for each of the statements below. Strongly Disagree (SD) Disagree (D) Neither agree nor disagree (U) Agree (A) Strongly Agree (SA)

	Contents Knowledge (CK)	SD	D	U	A	SA
11	The science I teach I have adequate knowledge about it.					
12	I have varied methods of improving upon my subject matter content					
13	In my class, the concepts that need to be taught I can plan the scope and sequence					
14	The lessons I taught I know how to relate them to real world situations.					
15	I can reason scientifically.					
16	I understand the nature of science better					
17	I am abreast with developmental updates of my subject area					
18	I am good about the subject matter of the subject I teach					

SECTION D: This section examines your understanding of pedagogical Knowledge (PK).

Tick (✓) the appropriate answer that best describes your opinion for each of the statements below. Strongly Disagree (SD) Disagree (D) Neither agree nor disagree (U) Agree (A) Strongly Agree (SA)

	Pedagogical Knowledge (PK)	SD	D	U	A	SA
19	I am good at students' performance assessment					
20	I take into account the current understanding of my student when teaching					
21	I tried as much as possible to deal with individual differences when teaching.					
22	In my classroom setting I use different teaching approaches					
23	I am able to better assessment techniques in my classroom.					
24	I can better manage and control my classroom.					
25	I can apply suitable strategy for my lesson delivery					
26	I can develop my lesson plan for the topics I teach.					

SECTION E: This section examines your understanding of pedagogical content Knowledge (PCK),

Tick (✓) the appropriate answer that best describes your opinion for each of the statements below. Strongly Disagree (SD) Disagree (D) Neither agree nor disagree (U) Agree (A) Strongly Agree (SA).

	Pedagogical Content Knowledge (PCK)	SD	D	U	A	SA
27	Am able to choose technologies that influence teaching approaches for lesson delivery.					
28	Improving students' learning through the appropriate technologies is not a problem for me.					
29	Am able to choose best technologies to fit my teaching					
30	Am able to cater for individual teaching activity with different technologies					
31	I can effectively assess students' learning using technology					
32	Am able to manage a technology-rich classroom effectively					
33	Am able to choose technologies that influence teaching approaches for lesson delivery.					
34	Improving students' learning through the appropriate technologies is not a problem for me.					

SECTION F: This section examines your understanding of Technological Pedagogical Knowledge (TPK)

Tick (✓) the appropriate answer that best describes your opinion for each of the statements below. Strongly Disagree (SD) Disagree (D) Neither agree nor disagree (U) Agree (A) Strongly Agree (SA)

	Technological Pedagogical Knowledge (TPK)	SD	D	U	A	SA
35	I can use teaching with technology to build specific concepts in my subject matter					
36	I am able to present my subject matter with technology					
37	I can use ICT to aid my learners understanding specific					
38	I can able demonstrate specific concepts by the use of technological representation.					
39	Am able to deliver my content in my subject area with different technologies.					
40	Am able to make students observe phenomenon in my subject matter through the use of technology easily.					

SECTION G: This section examines your understanding of Technological Content Knowledge (TCK)

Tick (✓) the appropriate answer that best describes your opinion for each of the statements below. Strongly Disagree (SD) Disagree (D) Neither agree nor disagree (U) Agree (A) Strongly Agree (SA)

	Technological Content Knowledge (TCK)	SD	D	U	A	SA
41	I know about technologies that I can use for teaching specific concepts in my subject matter					
42	I know how technology can be used to present my subject matter					
43	Am able to enhance students' understanding of specific concepts through the use of technologies in my subject matter					
44	Am able to demonstrate specific concepts by the use of technological representation in my subject matter.					
45	Am able to deliver my content in my subject area with different technologies.					
46	Am able to make students observe phenomenon in my subject matter through the use of technology easily.					
47	I can use technology to create and manipulate models of scientific phenomenon (e.g. animations, modelling, etc)					

SECTION H: This section examines **your understanding of Technological Pedagogical Content Knowledge (TPCK)**

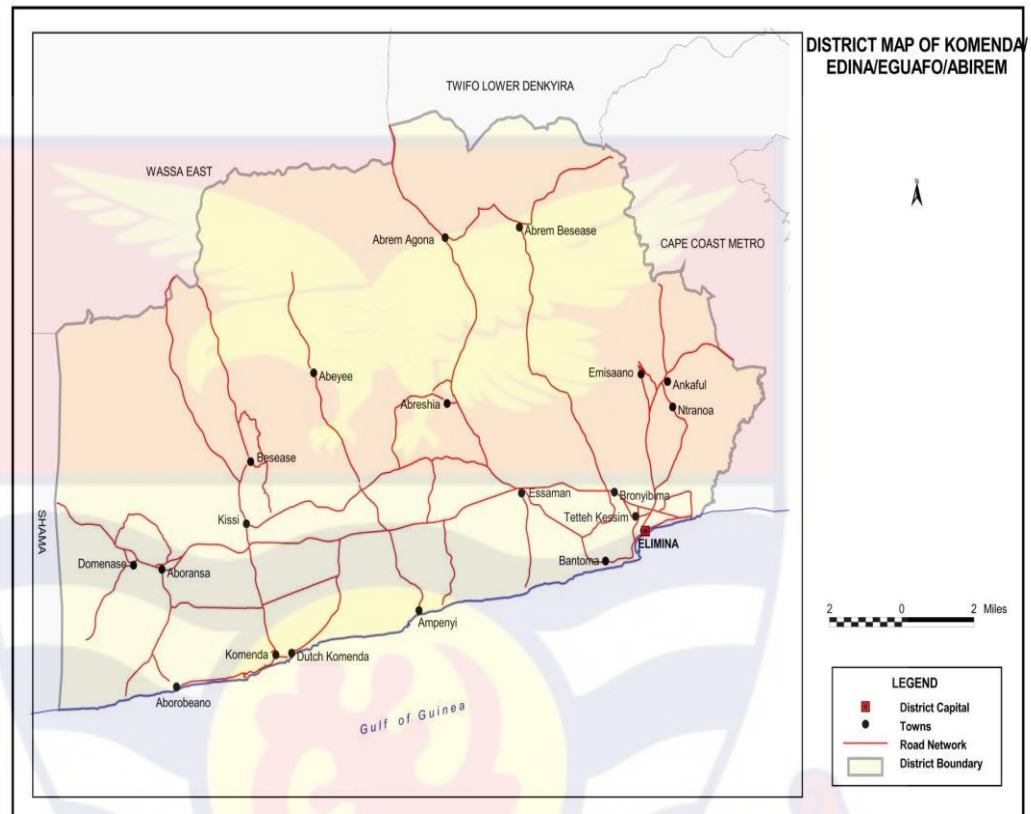
Tick (✓) the appropriate answer that best describes your opinion for each of the statements below. Strongly Disagree (SD) Disagree (D) Neither agree nor disagree (U) Agree (A) Strongly Agree (SA)

	Technological Pedagogical Content Knowledge (TPACK)	SD	D	U	A	SA
48	I am able to employ subject matter, technologies and teaching methods to deliver my lessons.					
49	Am able to apply technologies to what I teach, how I teach and what students learn.					
50	Am able blend teaching technologies in my teaching.					
51	I help my counterpart science teachers to apply technology, content and methods in their teaching					
52	I am able to select better ICTs for the understanding of my learner.					
53	I can find and use online resources for effective demonstration of specific scientific concept.					
54	I can apply ICT to enhance science classroom activities.					
55	I can manipulate ICT to achieve effective content representation that may be totally different from textbook approaches.					

Thank You.

APPENDIX B

Map of Map of Komenda Edina Eguafo Abirem (KEEA).



APPENDIX C

Map of Cape Coast Metropolis

