UNIVERSITY OF CAPE COAST

IN-SERVICE TEACHERS' USE OF ICT IN TEACHING MATHEMATICS IN GHANA. A CASE STUDY IN THE CAPE COAST METROPOLIS

BY

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Thesis submitted to the Department of Mathematics and ICT Education of the College of Education Studies, University of Cape Coast in partial fulfilment of the requirements for award of Master of Philosophy Degree in Mathematics Education.

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DECLARATION

Candidate's Declaration

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

Signature:……………………………………. Date:……………….……….

Candidate's Name: ALOYSIUS DONKOR

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

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ABSTRACT

This study was set out to examine the barriers to ICT integration into Mathematics teaching and learning in selected Senior High Schools in the Central Region of Ghana. Specifically, the study aimed to examine the effects of internal barriers (constructive teaching beliefs, teaching experience, attitudes toward computer and technology competence) and external barriers (access to technology use, level of training in the use of technology, time adequacy, as well as, the culture of the teacher's institution) in predicting in-service teachers' usage of ICT in the teaching and learning of Mathematics.

The study employed the descriptive survey design to answer the research questions of the study. Five-point Likert scale questionnaire was the instrument for data collection. Both purposive and convenience sampling techniques were used to select 185 in-service teachers for the study. The multiple regression analysis was used to estimate the factors influencing ICT integration. The study revealed that in-service teachers' ICT integration in the teaching of Mathematics was barely low. Both internal and external factors had significant effects on ICT integration; but the external factors had stronger predictability of ICT integration than the internal factors. The study recommended that the heads of departments should organize regular ICT training towards increasing teachers' competencies and decreasing their anxiety to enhance willingness to integrate ICT in teaching and learning of Mathematics.

Keywords: ICT integration, Pedagogy, Mathematics, Constructivist

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DEDICATION

To my lovely wife, Ms. Rose S. Kornu and children, Reginald L. E. Donkor, Kimetra T. E. Donkor and Jaden R. E. Donkor and my brothers Benedictus M. Donkor and Matthias T. Brako.

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LIST OF ACRONYMS

GES	Ghana Education Service
ICT	Information and Communication Technology
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action

CHAPTER ONE

INTRODUCTION

Overview

This chapter is the introductory section of the study which presents the general background of the study, statement of the problem, purpose of the study, research questions, significance of the study, delimitations and limitations of the study and the organizational plan of the study.

Background to the Study

Educational systems are based on teacher and curriculum concepts. Effectiveness and efficiency of an educational system may rely on these two inter-related concepts and the harmony between them. Any problems appearing in either of these concepts will decrease the qualities of the educational system, as a result affecting the learners. For this reason, the quality of an educational system should be parallel to the quality of teachers trained. Moreover, the quality of a teacher will be in harmony with the curriculum focused knowledge, skills and the attitudes acquired by the teachers.

Technological and computer competencies of teachers are important dimensions of this quality. Due to large investments of technology in many educational institutions, teachers are required to integrate technology into curriculum and classroom activities (Yasemin, 2008). For this reason, teacher education programs are reshaped and enhanced with the courses trying to infuse the use of various technologies. This enhancement includes the knowledge and skills necessary to use and integrate Information and communication technology (ICT) effectively. Besides, teachers' attitudes and beliefs toward technology usage should result in a positive one (Yasemin, 2008). Therefore, teachers should be designated in such a way that besides knowing how to use ICT effectively, they have to be empowered to integrate ICT into teaching and learning of mathematics so as to develop learners understanding and to support constructivism, cooperative learning and problem-based learning (Royer, 2002).

In Service teachers should be prepared to pedagogically integrate information and communication technology (ICT) into their teaching and learning practices. This is so because the importance of integrating technology in classroom instruction cannot be overlooked. According to the Ministry of Education, Youth and Sports and Ghana Education Service (MOEYS & GES, 2002), integrating technology in classroom instruction ensures greater motivation, increases self-esteem and confidence, enhances good questioning skills, promotes initiative and independent learning, improves presentation of information/outputs, develops problem solving capabilities, promotes better information handling skills, increasing focus time on task, and improves social and communication skills. Although large bodies of research into factors determining the integration of ICT in education emerge from developed countries, recent researches indicate that developing countries are finding means to participate effectively in the global information society and to address the challenges regarding ICT in education (Tilya, 2008).

Despite the increased availability and support for ICT integration, relatively few teachers intend to integrate ICT into their teaching activities (Ertmer, 2005). Since the introduction of educational technologies into classroom settings, teacher education has faced the challenge of improving in service teacher education for successful integration of educational technologies into their teaching and learning practices (Sang, Valcke, Van Braak, & Tondeur, 2010). ICT integration in mathematics education provides mathematics teachers with integrative teaching methods that motivate students learning, support their independent learning and active participation in the discovery of mathematical concepts and topics and as a result, helps them have deeper understanding of the mathematical ideas (Nimer, & Wajeeh, 2013). Therefore, the integration of ICT in the teaching and learning of mathematics, as a result of ICT educational affordances, helps students have better achievement in mathematics, (Nimer, & Wajeeh, 2013).

Undeniably, Integration of ICT in education has increasingly become an important concern in education not only in developed countries, but in developing countries as well including Ghana. A recent study (Agyei & Voogt, 2012); indicate that, the influence of technological advancement has necessitated the need for a curriculum that can develop the mathematical power of students. This includes a shift from a curriculum conquered by memorization of secluded facts and procedures to one that emphasizes on conceptual understanding, computational skills, problem solving and the pedagogical integration of ICT. From the early 1990s, education stakeholders in Ghana have been concerned about how teachers and students use computers in schools and how their use supports learning (Boakye & Banini, 2008).

At the beginning of the millennium, education authorities in Ghana embarked on a number of projects to introduce Information and Communication Technologies into Ghanaian education set up at all levels of education. For instance, in the middle of the 1990s, educational providers realized that Ghanaian professionals could not compete on the global market for jobs, because they were limited in skill, especially in the area of Information Technology (Nyarko, 2007). The Ministry of Education, Science and Sports opined that "the integration of ICT into Education will result in the creation of new possibilities for learners and teachers to engage in new ways of information acquisition and analysis. ICT may enhance access to education and improve the quality of education delivery on equitable basis" (Ministry of Education, Science and Sports (MOESS, 2006).

In their research study (Keong, Horani & Daniel, 2005) argued that, with the impact of technological forces on teaching and learning mathematics, it is possible to de-emphasize algorithmic skills; the resulting void may be filled by an increased emphasis on the development of mathematical concepts. In addition to that, technology saves time and gives students access to powerful new ways to explore concepts at a depth that has not been possible in the past. The power of technology and for that matter ICT leads to fundamental changes in mathematics instruction.

Also, there is substantial evidence that, in the right hands and used appropriately for specific purposes in specific contexts, ICT can be an effective tool in supporting teaching and learning (Agyei & Voogt, 2011). However, it is now firmly established that its introduction into schools does not by itself improve the quality of education or raise attainment (Hennessy, Harrison & Wamakote, 2010). Encouragingly, there is growing and widespread awareness that the pedagogical and technical expertise of the teacher is absolutely critical here. Governments in sub-Saharan Africa (SSA), and elsewhere, are emphasizing teacher development as the key to effectively implementing policy and curricula, to using ICT to enhance teaching and learning, and to raising educational standards (Hennessy et al., 2010).

Other studies (Beauchamp & Parkinson, 2008; Bottino & Robotti, 2007) sited in (Agyei & Voogt, 2011) have reported positive effects of incorporating technology in teaching mathematics such as to enhance motivation and improve students' achievement. In spite of the numerous advantages that come with technology such as better understanding of mathematics concept taught, easy delivery of mathematical concepts as well as encourage constructivist approach of teaching and learning, many Ghanaian mathematics teachers do not feel proficient in teaching mathematics lessons that take advantage of technology-rich environments (Agyei & Voogt, 2011).

In Ghana, the teacher training institutions have a leading role to play in producing technologically competent teachers who will teach in the nation's pre-tertiary institutions especially in the Basic Schools and Senior High Schools (SHS). The questions are: do this training with the intention of producing technologically competent teachers occur at these training institutions? And if yes, do these mathematics teachers at the SHS level use ICT in their teaching practices? According to (Agyei & Voogt, 2011), just a few use ICT in teaching mathematics. Hence, the need to study the SHS mathematics teacher and the barriers that influence the integration of ICT into mathematics teaching practices. ICT integration into mathematics teaching is regarded as a cardinal factor in the nations' scientific and technological advancement because of its useful links to many other fields of human endeavour (Ministry of Environment, Science and Technology (2009).

Integrating ICT tools such as computers and scientific calculators in mathematics instruction have the potential to change pedagogical approaches radically and to improve individual student learning outcome by transforming the classroom social practices (Forgasz & Prince, 2004; Goos, 2005). In view of the positive impact of ICT integration in mathematics instruction, the new educational reforms in Ghana which was launched in September, 2007 placed high emphasis on the integration of ICT in all subject areas. Integration of ICT in mathematics is not merely using computer for typing and printing questions, browsing and delivering lessons through PowerPoint but rather using ICT (computer) in teaching various topics in mathematics. It is therefore essential for in- service teachers to use technology in teaching.

In order to address a need, one must know what a problem is and use the computational skills acquired to solve mathematical problems. Despite, these positive impacts ICT makes on teaching and learning of mathematics, its integration is still a challenge (Agyei & Voogt, 2012). One of the challenges facing educators is how to ensure that the necessary combination of skills that will enable them to both effectively use today's technologies in the classroom as well as continue to develop and adapt to new technologies that emerge in the future (Gill & Dalgarno, 2008). Since teachers are the central force in tapping the learning opportunities created by ICT, In-service teachers have a leading role to play in the realization of the goals specified in the various national ICT policy which will go a long way in the production of technologically competent students who will serve as the future workforce of the nation.

Due to ICT's importance in society today and possibly in the future of education, identifying the possible obstacles to the integration of these technologies in schools would be an important step in improving the quality of teaching and learning of mathematics. Balanskat, Blamire, and Kefala (2006) argue that although educators appear to acknowledge the value of ICT in schools, difficulties continue to be encountered during the processes of adopting these technologies. Also, many studies conducted to investigate barriers to the integration of ICT in education and in Science and Mathematics education in particular (e. g. Al-Alwani, 2005; Gomes, 2005; Osborne & Hennessy, 2003; Özden, 2007).

To date, however, there has been only limited research to investigate Ghanaian teachers' use of technology in teaching and learning and the factors that support or inhibit their effective integration into classroom practice. Mereku et al. (2009), asserted that for Ghana, and Africa as a whole, to be able to fully integrate ICT into teaching and learning there is the need for frequent collection and analysis of data on ICT usage.

Their results show that most of the educators have limited skills and knowledge in ICT integration for teaching and learning. The few who claim to use ICT integration techniques in instruction basically rely on PowerPoint presentations but do not use ICT as a pedagogical tool to transform their instruction and consequently enhance their students' learning outcomes. The study revealed that availability of ICT syllabus/manual, the availability of and access to technology facilities and resources, teacher's technology skills (competence) and preparedness were some of the factors that influence pedagogical integration of ICT in Ghana. Since teachers are the central force in tapping the learning opportunities created by ICT, teachers have a very important role to play in the realization of the goals specified in the various national ICT policy documents such as Accelerated Development (ICT4AD) policy which seeks to provide a framework in which information and communication technologies will be used to transform the educational sector, allowing all Ghanaians to pursue quality life-long learning opportunities regardless of their geographical location.

Mereku et al. (2009), further pointed out that full pedagogical integration of ICT into the educational system is a distant goal unless there is reconciliation between teachers and computers despite the many importance of pedagogical integration of ICT in mathematics education. Ward (2003) goes further to claim that there is limited use of ICT in classroom practices. This, the in-service teachers need to have an understanding of how pedagogical integration of ICT can be fused into the teaching and learning of mathematics rather than just as a publication and research tool. One of the challenges facing education is how to ensure that graduate teachers have the necessary combination of skills that will enable them to both effectively use today's technologies in the classroom as well as continue to develop and adapt to new technologies that emerge in the future (Gill & Dalgarno, 2008).

Decisions made by teachers about the use of computers in their classrooms are likely to be influenced by multiple factors including the accessibility of hardware and relevant software, the nature of the curriculum, personal capabilities, culture and constraints such as time. An important factor is teachers' beliefs in their capacity to work effectively with technology. Porter and Donthu (2006), points out that, a belief about a new technology influences an individual's attitude and the use of that technology. It is therefore important for researchers to explore in-service teachers’ constructivist teaching believes, teaching experience, perceived usefulness of computers and their behaviour intention to use the software. According to Ropp (1999), the levels of computer attitude towards computers and computer anxiety, are good indicators of teachers’ ability to implement technology into their teaching practices.

Ertmer (2005) has documented, the decision regarding whether and how to use technologies for instruction rests on the shoulders of teachers. Despite the increased availability of ICT hardware (Ertmer, 1999), school related support for ICT integration (Baylor & Ritchie, 2002), and a larger consciousness of teachers about the importance of educational ICT use (Khine, 2001), relatively few teachers are willing to integrate ICT into their teaching activities (e.g. Hermans, Tondeur, van Braak, & Valcke, 2008; Wang, Ertmer, & Newby, 2004, Mereku et al., 2009). Also, beliefs and attitudes of teachers were stressed by Cuban (1993), as other factors that seem to contribute to teachers’ successful or otherwise integration of ICT, since he indicated that shape what they choose to do in their classrooms and explain the core of instructional practices that have endured over time.

Several studies have divided the barriers into two categories: extrinsic and intrinsic barriers. For instance, (Hendren 2000), as cited in (Al-Alwani, 2005) saw extrinsic barriers as pertaining to organisations rather than individuals and intrinsic barriers as pertaining to teachers, administrators, and individuals. Another perspective presents the obstacles as pertaining to two kinds of conditions: material and non-material (Pelgrum, 2001). The material conditions may be the insufficient number of computers or copies of software. The non-material obstacles include teachers' insufficient ICT knowledge and skills, the difficulty of integrating ICT in instruction, and insufficient teacher time.

Some of these studies look at the barriers in terms of the teacher, institution, or system level. However, since the purpose of this paper is to study the barriers that face in-service mathematics teachers' use of ICT in teaching mathematics that may possibly influence their pedagogical integration of ICT into their future teaching practices. (Ertmer, 2005) has categorized barriers hampering ICT implementation efforts in the classroom in two: external (first-order) barriers/factors and internal (second-order) barriers/factors. External barriers include those that are often seen as the key obstacles: such as access to technology use, training, technology competence and culture. Internal barriers are related to a teacher's philosophy about teaching and learning; they are veiled and deeply rooted in daily practices (Ertmer 1999; 2005). Examples of these internal barriers are computer self-efficacy, attitudes and Perceived Usefulness of Computers as well as teaching experience by Gorder (2008). Therefore, the need to look at the interrelationship between what Ertmer referred to as internal and external barriers of ICT integration and Gorder's teaching experience in the teaching learning processes, hence the need to develop a conceptual framework taking into account a blend of external and internal barriers categorization that may influence in-service teachers use of ICT in their teaching practices since no particular theoretical model fits into this study.

The act of integrating ICT into teaching and learning of mathematics is a complex process and one that may encounter a number of difficulties. These difficulties are known as "barriers" (Schoepp, 2005). A barrier is defined as "any condition that makes it difficult to make progress or to achieve an objective" (WordNet, 1997, as cited in Schoepp, 2005, p. 2). Ertmer (2005) has categorized barriers hampering pedagogical integration of ICT in the classroom into two groups: external (first-order) barriers and internal (second-order) barriers.

External barriers include those that are often seen as the key obstacles: such as access to technology use, training, technology competence and cultural issues. When these barriers are present, it is almost impossible to talk about technology integration. Ertmer (2005) also documented that even if the first-order (external) barriers were resolved, 'teachers do not automatically use technology to achieve advocated meaningful outcomes' (p. 51). For this reason, there is the need to consider the second-order (internal barriers) which equally hinder pedagogical integration of ICT by teachers. Internal barriers which are related to a teacher's philosophy about teaching and learning; they are veiled and deeply rooted in daily practices (Ertmer 1999, 2005). These barriers are teacher's computer self-efficacy and teacher attitudes. Empirical studies underpin the particular impact of (1) educational beliefs on the frequency and successful use of ICT in education (e.g. Hermans, Tondeur, van Braak, & Valcke, 2008; Tondeur, van Keer, van Braak, & Valcke, 2008); (2) teaching experience (e.g. Gorder, 2008, Baek, Jong & Kim 2008)); and (3) computer attitudes (e.g. van Braak, 2001).

Positive attitudes, technology competency, and access to technology tools (Agyei & Voogt, 2010), lack of availability of technological resources (Agyei & Voogt, 2014), the availability of and access to technology facilities and resources, teacher's technology skills and preparedness (Mereku et al., 2009), attitude (Sarfo, Amartei, Adentwi & Brefo, 2011) are some of the factors that seem to influence pedagogical integration of ICT in Ghana. But unfortunately, not much is done in these area and even the little known researches done in relation to ICT integration in Ghana seem to have focused on either two or three external barriers or internal barriers without looking at the combined effect of these factors and also, the direct and indirect impact of the complex interplay of these barriers: external (access to technology use, training, technology competence and culture) and the internal factor (i.e., teacher's constructivist beliefs, teacher's teaching experience, perceived computer usefulness and teacher attitudes toward ICT) on pedagogical integration of ICT (Ertmer, 2005; Gorder, 2008).

Statement of the Problem

The government of Ghana in collaboration with the Ministry of Education (teacher division), the Institute of Education, University of Cape Coast and University of Education, Winneba have made provisions to ensure that qualified teachers get access to quality education which takes into accounts the integration of ICT in instruction hence the provision of computer laboratories in all government owned training institutions in Ghana (Yidana, 2007). Also, there has been a sudden increase of computer laboratories at all levels of the school system and this testify to the potency of the use of computer technology in education delivery (Yidana & Asiedu-Addo, 2001).

Furthermore, ICT has recently become a compulsory (core) subject for every SHS student in Ghana.

In view of these, education stakeholders and policymakers in Ghana have made good strive towards the introduction of ICT so as to help contribute to knowledge production, communication and information sharing among teachers and other stakeholders in the educational system.

Hence, the study is an attempt to examine the interplay of in-service teachers' thinking processes and experience: internal barriers (i.e. Constructivist teaching beliefs, teacher's teaching experience, Computers Attitudes, Computer competence) and the external barriers (access to technology use, training, time and culture) on pedagogical integration of ICT into the teaching and learning of Mathematics.

This is crucial as the positive impact of ICT depends on how teachers use ICT in their teaching and learning programs. Porter and Donthu, (2006), points out that, a belief about a new technology influences an individual's attitude toward and use of that technology. Similarly, Sarfo, et al. (2011) conducted a study to investigate students' attitudes towards information and communication technology in Ghana; their analysis revealed that students' attitude is a contributing factor to pedagogical integration of ICT.

Purpose of the Study

Current educational practice reflects a growing integration of computer tools and technological applications into the mathematics curriculum (Koçoglu, 2009). The idea of integrating the knowledge of ICT into teaching/learning of mathematics has become apparent today since the needs of students have increased with the increased use and the need to learn with technology (Koçoglu, 2009).

The main objective of this study is to examine the effect of in-service teachers' external barriers (access to technology use, training, time and culture) and their internal barriers (constructivist teaching beliefs, teaching experience, technology competence and attitudes) toward computers on in-service teachers ICT integration in the teaching and learning of mathematics. These barriers to the use of ICT in learning and teaching environments is crucial because this knowledge could provide "guidance for ways to enhance technology integration" (Schoepp, 2005, p. 2) and encourage greater use of ICT. Identifying the fundamental barriers may assist teachers and educators to overcome these barriers and become successful technology adopters (Al-Alwani, 2005).

According to British Educational Communications and Technology (Becta, 2004), although there is a reasonable amount of research literature on the barriers to ICT in general, there are few studies that look at barriers which exist in specific subject areas. Due to this, the study focuses on the most essential external barriers (access to technology use, training, technology competence and culture) and the internal barriers (constructivist teaching beliefs, teaching experience, perceived computer usefulness, and attitudes toward computers in education) for the predictability of technology integration among SHS mathematics teachers in Ghana. The study also explores the extent to which these barriers influence pedagogical Integration of ICT among the SHS mathematics teachers.

Research Questions

1. What is the level of in-service teachers' ICT integration in their Mathematics classrooms?
2. To what extent is in-service teachers' ICT integration in teaching mathematics influenced by perceived internal barriers of ICT?
3. To what extent is in-service teachers' ICT integration in teaching mathematics influenced by perceived external barriers of ICT?
4. To what extent do internal and external barriers of ICT predict in-service teachers ICT integration levels in the mathematics classroom?

In the study, internal barriers was conceptualised by factors such as constructivist teaching beliefs, teaching experience, attitudes toward computer and technical competence. Also, external barriers was conceptualised by factors including in-service mathematics teachers access to technology use, training, time as well as culture. ICT integration was defined as the application of mathematical software such as Excel spreadsheet, scientific calculators, PowerPoint presentations, Geometer's sketchpads, as well as, attaching files on emails, and submitting assignments online.

Significance of the Study

The study is significant because it could provide insights into in-service mathematics teachers' pedagogical use of ICT at the SHS level of the educational ladder that could be sustainable and transferable to other educational institutions. The study will provide evidence on the barriers mentioned above and the influence of each on pedagogical integration of ICT use among in-service teachers at the SHS level in Ghana. This could provide guidance for policy makers and stakeholders in education when structuring and introducing any new ICT integration policies into the second cycle institutions in Ghana.

The study is to help identify some factors that could lead to successful ICT integration into the teaching and learning of mathematics by studying in-service teachers and to what extent these barriers may influence pedagogical integration of ICT in the classroom. Thus, to examine the inter relationship between the internal barriers and the external barriers and their possible influence on pedagogical integration of ICT into mathematics teaching practices among in-service mathematics teacher at the SHS level in Ghana.

Above all, the study will add to the existing literature on barriers affecting ICT integration in mathematics classroom and the possible consequences it may have on the teacher's attempt in integrating ICT into teaching mathematics at SHS level in Ghana.

Delimitation

The study was delimited to selected public SHS in Cape Coast Metropolis in the Central Region of Ghana and the outcome might be different if private SHS were included. Moreover, the participants who took part in this study were teaching in SHS in the Central region of Ghana and the outcome might be different from participants in SHS from different region and/or all mathematics teachers from all senior high schools in Ghana.

Limitations

The study had some limitations that need to be highlighted:

First, the study was limited to selected public senior secondary schools in the Cape Coast Metropolis in the Central Region of Ghana. This does not reflect real situation of secondary schools in the region since there exist some private senior secondary schools in the study area. Also, the use of relatively small sample data limits the extent of generalizability of the findings. In addition, the study examined only the factors that influenced teachers' ICT integration without taking into account the students' willingness to learn with ICT tools.

Also, the models' goodness of fit was low which suggest that several important variables affecting ICT integration were not considered. In the light of these limitations, the findings of this study should not be generalized to all in-service mathematics teachers in Ghana.

organisation of the Study

This study is organized into five chapters. Chapter one covers the introduction. Chapter two, literature review, explores among other things the conceptual framework of the study alongside the theories of ICT integration, internal and external barriers to ICT integration; empirical review of the factors influencing ICT integration. Chapter three covers the methodology of the study which comprises the population, sample and sampling procedures, data collection method and data analysis techniques. Chapter four discusses the results and discussion of findings. Chapter five outlines the summary, conclusions and recommendations from the study.

CHAPTER TWO

LITERATURE REVIEW

Overview

The purpose of this chapter is to review and discuss the literature related to what is referred to as internal and external barriers to successful ICT integration into the teaching and learning of mathematics by studying in-service teachers and to what extent these barriers may influence pedagogical integration of ICT in the classroom. Thus, to examine the inter relationship between the internal barriers and the external barriers and their possible influence on pedagogical integration of ICT into mathematics teaching practices among in-service mathematics teacher at the SHS level in Ghana. For the purpose of this study, the literature review was organized around the following themes:

1. Conceptual framework.
2. Pedagogical Integration of ICT
3. Internal Barriers/factors (constructivist teaching beliefs, teaching experience, perceived computer usefulness, and attitudes toward computers in education).
4. External barriers/factors (access to technology use, training, technology competence and culture).
5. Summary.

Conceptual Framework for the Study

Technology adoption research has flourished in recent years (Agarwal & Prasad, 1999; Venkatesh, 2000; Venkatesh & Davis, 2000; Klopping & McKinney, 2004; Chen, Gillenson, & Sherrell, 2002; Childers, Carr, Peck, &

Carson, 2001; Liaw, 2002; Lin & Lu, 2000). Some dominant theoretical models for determining the intention and readiness of in-service teachers' acceptance and the use of ICT in their instructional practices include the Technology Acceptance Model (TAM), Theory of Reasoned Action, Theory of Planned Behavior and Diffusion of Innovations.

The origins of the TAM were based on the Theory of Reasoned Action (TRA; Ajzen & Fishbein, 1977) which described how users' beliefs and attitudes are related to individuals' intentions to perform. According to the TRA, attitude toward behaviour (e.g., computer use) is determined by behavioural beliefs about the consequences of the behaviour and the affective evaluation of those consequences on the part of the individual. In this case, beliefs are defined as the individual's estimated probability that performing a given behaviour will result in a given consequence. However, TAM is less general than the TRA in that, the former was designed to apply to only computer usage behaviour (Davis, 1989). The TAM was developed to explain and predict computer-usage behaviour. TAM is an information theory that models how users come to accept and use a computer based technology. It suggested that when users are presented with a software package, a number of factors influence their decision about how and when they will use it. This seems to be the disadvantage of TAM as it specifies on only the causal linkages between two key sets of constructs: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU).

TAM seems to be one of the most popular theories that is widely accepted and used to explain information system usage. In spite of its popularity, many studies (Moon & Kim, 2001; Venkatesh & Davis, 2000) have recommended changes in the originally proposed model due the fact that it is only on the linkage between PU and PEOU. Thus, just like most of the other theories, the major limitation of TAM lies in its weakness to include other important factors such as user behavioral intentions, accessibility, and training, teaching experience and others in the model.

Because new technologies such as personal computers are complex and an element of uncertainty exists in the minds of decision makers with respect to the successful adoption of them, people form attitudes and intentions toward trying to learn to use the new technology prior to initiating efforts directed at using. Attitudes towards usage and intentions to use may be ill-formed or lacking in conviction or else may occur only after preliminary strivings to learn to use the technology evolve. Thus, actual usage may not be a direct or immediate consequence of such attitudes and intentions (Bagozzi, Davis & Warshaw, 1992).

Recent studies employing the TAM as the framework have also showed perceived usefulness and perceived ease of use to be significant predictors of attitude towards technology use and intention to use (Cheung & Huang, 2002; Teo, 2008a; Teo, Lee, & Chai, 2008). Some researchers have also ignored attitude toward use and/or intention to use (Venkatesh, Davies, Morris & Davis, 2003), and instead focused on the direct effect of ease of use and usefulness on system usage.

These theories including the TAM represent an important theoretical contribution toward understanding the use of ICT by teachers and ICT acceptance behaviours. Chen (2004) found that teachers increased their confidence in using computer technology by having experiences from a previous computer course. Chen (2004) asserts that "teachers need to have the confidence and positive attitudes towards computers that will motivate them to integrate ICTs into their instructional strategies" (p. 50).

In all, Ertmer (2005) has categorized some of these factors hampering ICT implementation in the classroom into two: external (first-order) barriers which include access, technology use, training, technology competence and culture. Internal barriers are related to a teacher's philosophy about teaching and learning; they are veiled and deeply rooted in daily practices (Ertmer, 1999; 2005). Examples of these internal barriers are teacher's constructivist teaching beliefs, perceived usefulness of computers and teacher attitudes. Also, Gorder (2008) reported that teacher experience is a Factor influencing teachers' adoption and integration of ICT.

Hence, the study considers internal barriers as teacher's constructivist teaching beliefs, perceived usefulness of computers, teacher attitudes and teaching experience which is a combination of Ertmer's (2005) internal factors, Davis' (1989) perceived usefulness and that of Gorder (2008) teaching experience which can as well be referred to as the 'teacher factor'. Also, the external factors are; access, technology use, training, technology competence and culture, Ertmer (2005). As a result, a particular theory may not be applicable to this study, hence, no single existing overarching theory can be chosen as a framework to guide the conduct of this study since the study intend looking at the inter-play of the combined effects of both the external and internal barriers on the integration of ICT. Therefore, this study relates Ertmer (2005) factors to Davis (1989) as well as Gorder (2008), conditions for some critical barriers affecting pedagogical integration of ICT into mathematics teaching and used these critical factors as the standard barriers: internal [teacher's constructivist teaching beliefs (C T Bs), technology competence (Tech. com), teacher attitudes (C Attitudes) and teaching experience (T. Exp.)] and external [access to computer (Access to…), time adequacy (Time), training (Trg), and culture to examine in detailed the current work. In the study, literature on these internal and external barriers and their effects on pedagogical integration of ICT into mathematics teaching practices are presented in Figure 1.

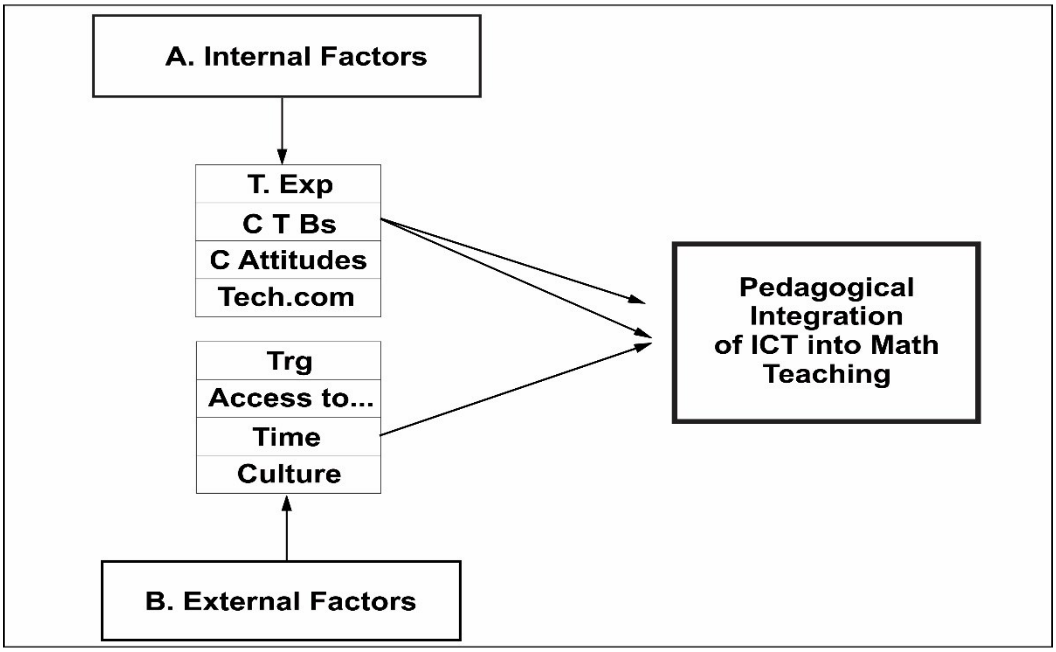

Figure 1: Conceptual Framework for ICT integration

Pedagogical Integration of ICT

Pedagogy in this work focuses on the thinking and practice of teachers who look to accompany learners; care for and about them; and bring learning into life (real life situation). Teaching is just one aspect of their practice and a pedagogy is simply seen as the art and science (and maybe even craft) of teaching (Rouse, 2014). Integration on the other hand generally means combining parts so that they work together or form a whole and ICT (information and communications technology - or technologies) is an umbrella term that includes any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as video conferencing and distance learning, Rouse (2014). Hence, pedagogical integration of ICT is the art and science of using ICT to teach.

Adoption of technology is conceived as a process that develops through different stages. From being aware and informed about the possibilities of ICT in education to a more routine utilization of ICT in classroom practice and finally to creative uses of technology for teaching and learning (Christensen, 1997; Christensen & Knezek, 2002). The use of ICT in the mathematics classroom has long been a topic for consideration by mathematics educators. Some examples of ICT use in mathematics include: portables, graphic calculators and computerized graphing, specialized software, programmable toys or floor robots, spreadsheets and databases (Agyei & Voogt, 2010).

The important role that mathematics plays in the overall personal and intellectual development of the individual cannot be underestimated. Mathematics is perceived as an interrelated structure of ideas, principles and processes and in teaching; its connections among basic concepts should be established to make learning easy for students (Reys, Suydam & Smith, 1998). Mathematics teaching and learning is crucial to the future of Ghana's developing economy and deserves a special focus in education, hence the need to use a modern technology called ICT to teach such an important subject. According to the National Council of Teachers of Mathematics, effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well (NCTM, 2000).

In the rapidly changing and technologically dependent society, students are now faced with the need for a solid understanding of mathematical skills and concepts. One of the key synergisms of mathematics is ICT (technology), and as technology advances it inevitably influences what happens in the mathematics classroom. Research indicates that ICT plays essential role in the teaching and learning of mathematics as it influences the mathematics that is taught and enhances students' learning (NCTM, 2000). Using ICT in mathematics classroom provide ample learning opportunities for the students.

According to Wahyudi (2008), pedagogical integration of ICT into mathematics teaching enables students to learn from feedback. The computer (technology) often provides fast and reliable feedback to students. It enables students to produce many examples when exploring mathematical problems. ICT helps students to see patterns and connections. The computer enables formulae, tables of numbers and graphs to be linked readily. The use of ICT in teaching and learning mathematics allows students to work with dynamic images that cannot be done within traditional teaching. Students can use computers to draw graphs and manipulate diagrams dynamically. ICT enables students to work with real data which can be represented in a variety of ways. This supports interpretation and analysis that lead students to higher order mathematical thinking skills.

A study conducted by Roschelle, Pea, Hoadley, Gordin, and Means (2000), supports the use of ICT in teaching and learning mathematics. Their finding indicates that pedagogical integration of ICT into the teaching and learning of mathematics can help support learning, and that it is especially useful in developing the higher-order skills of critical thinking, analysis, and scientific inquiry. The study explores the various ways ICT (computer technology) can be used to improve how and what children learn in the classroom by helping students understand core concepts in mathematics. According to them computer-based mathematics builds confidences and is a great tool for remediating slower learners. Furthermore, Tall and Ramos (2004) opine that pedagogical integration of ICT in mathematics instruction assist the learner in visualizing the process and concept role of symbols, which reaches great heights in calculus. ICT allows real -world applications to be more readily used in the classroom (NCTM, 2008).

Besides, Kaino (2008) argues that pedagogical integration of ICT enhances mathematics learning by furnishing visual images of mathematical ideas, facilitating the organization and analysis of data, as well as computing efficiently and accurately. Moreover, there are several reasons for incorporating technology into mathematics instruction. ICT improves the way mathematics should be taught and enhances students understanding of basic concepts. It deemphasizes algorithmic skills resulting in an increased emphasize on the development of mathematical concept. Becta (2004) however summarized the key benefits of technology in mathematics instruction as follows: firstly technology promotes greater collaboration among students and encourages communication and the sharing of knowledge.

Secondly, technology gives rapid and accurate feedback to students and this contributes towards positive motivation. Finally, the use of ICT in teaching mathematics also allows students to focus on strategies and interpretations of answers rather than spend time on tedious computational calculations. ICT also supports constructivist pedagogy, wherein students use ICT to explore and reach an understanding of mathematical concepts. This approach promotes higher order thinking and better problem solving strategies.

Several studies have highlighted mathematics teachers' use of ICT in the mathematics classroom. For instance, Loong (2003) conducted a study to investigate mathematics teachers' use of the internet for teaching in Australia. Out of the 63 secondary mathematics teachers surveyed, the findings indicated that the teachers use the Internet for finding information such as articles about research or professional issues, or as a source of data for students to analyze in mathematics lessons. No statistically significant relationships were found between use and competency, professional development, or years of teaching experience. Similarly, a study conducted by Mereku et al. (2009) indicated that ICT is used in typing examination questions in all institutions and in some cases educators use ICT in processing students' examination results. Their findings further indicated that very few teachers in Ghanaian SHS use technology in their teaching.

A report by the National Center for Education Statistics (2005) indicated that 44% of the American teachers used ICT for classroom instruction, 42% for computer applications, 12% for practice drills, 41% required research using the Internet, 27% had students conduct research using CD-ROMs, 27% assigned multi-media projects, 23% assigned graphical presentations of materials, 21% assigned demonstrations, 20% required students to use technology to solve problems and analyze data, and 7% assigned students to correspond with others using the Internet. Besides, Bukaliya and Mubika (2011) surveyed 320 secondary school teachers to find out their competence in ICT integration in mathematics teaching. Their findings indicated that only 7.5% of the teachers were knowledgeable and skilled in computer aided instruction. Their findings also revealed that 43% of the teachers used spreadsheet, 37.5% used internet and 46% used email.

Thomas, Bosley, Santos, Gray, Hong, & Loh (2006), also conducted a study to investigate technology use in the teaching of mathematics in the secondary school classroom. Their findings revealed that only 36% of mathematics departments have a technology policy, and while 68.4% of teachers had used computers in their lessons, 31.6% had not. However, 75% of teachers would like to use the computer more often, with availability of computers the primary obstacle, and lack of teacher training and confidence also important. This indicates that the level of technology use among secondary school mathematics teachers is still low.

Similarly, Keong, Horani and Daniel (2005) conducted a survey to investigate the use of technology and the barriers of integrating technology into the teaching of mathematics. Their findings indicated that the level of technology used by teachers in their instruction was low. Majority of the mathematics teachers use technology for word processing (71.1%), spreadsheets (51.2%), internet activity (44.1%), search engines (44.1%), presentation software (36.9%) and databases (21.6%). Out of the 111 mathematics teachers surveyed, 39.6% of the respondents stated that they had not used technology at all and 32.1% of them stated that they use technology infrequently. On the other hand, 22.6% of them responded that they had integrated technology into specific areas of instructional units and 5.7% stated that they had fully integrated technology into their instructional programs. Similarly, a study conducted by Boakye and Banini (2008) to investigate teachers' readiness for the use of technology in Ghanaian schools indicated that, 71% of the teachers did not use technology in classrooms, 49% of teachers use technology to prepare lesson notes, 55% of teachers have some knowledge of web browsing, 71% use email, and 78% tried to make an effort to learn how to use the computer. These low figures imply that effective integration of technology into Ghanaian classroom instruction is yet to be realized and utilized.

Also, Thomas, et. al (2006) surveyed 32 mathematics teachers to investigate technology use and the teaching of mathematics in the secondary classroom. Their findings revealed that while 68.4% of teachers had used computers in their lessons, 31.6% had not and 75% of teachers would like to use the computer more often. The findings further revealed that over 90% of the teachers had used calculators in their lessons and the majority of teachers (56.7%) would like to use graphic calculator more often in their teaching. Lau and Sim (2008) also gave a self-administered questionnaire consists of six sections to 250 secondary school mathematics and science teachers in Malaysia to explore the extent of technology adoption among them. Their findings indicated that teachers less frequently use technology for communication with peers (26%), and for personal development (12%), but frequently use internet for browsing (53%). Their findings further revealed that teachers' computer competency is possibly related to their frequent use of word processing (71%), presentation tools (50%) and courseware (63%) in preparing teaching materials and presenting lessons. However, a study conducted by Becker (2001) to find out how teachers use computers in instruction revealed that teachers generally used computer technology to support their existing practices (providing practice drills, demonstration) and communication (such as the use of email) rather than to engage students in learning that involves higher order thinking.

Further, Serhan (2009) concluded that ICT fosters autonomy by allowing educators to create their own material, thus providing more control over course content than is possible in a traditional classroom setting. Waite (2004) opines that even though most educators show great interest and motivation to learn about the potential of technology, in practice, the use of technology is relatively low and it is focused on a narrow range of applications, with word processing being the predominant use. Besides, Thomas, Bosley, Santos, Gray, Hong, and Loh (2006) surveyed 32 mathematics teachers to investigate technology use and the teaching of mathematics in the Junior/Senior Secondary classroom. Their findings revealed that while 68.4% of teachers had used computers in their lessons, 31.6% had not and 75% of teachers would like to use the computer more often. The findings further revealed that over 90% of the teachers had used calculators in their lessons and the majority of teachers (56.7%) would like to use graphic calculator (GC) more often in their teaching.

Abuhmaid (2011) surveyed 120 teachers to explore the extent of their ICT usage. The findings revealed that 45.2% of the teachers reported searching for additional sources on the Internet and 32.1% reported using ICT to prepare their lessons. However, ICT-based interaction in the school culture appeared to have minimal presence among teachers, as only 4.3% of the teachers reported using ICT for communication during teaching and learning and 11.3% of them reported uploading files (e.g. lessons) to the Internet. A study conducted by Cuban (2000) to investigate the extent of technology use in instruction revealed that very few teachers are serious users of computers in the classroom.

Hence, in the study, pedagogical integration of ICT is the use of computers and calculators to teach mathematics at the senior high schools.

Internal Factors

Constructivist teaching beliefs

Constructivism is seen today as a new approach in education that claims humans are better able to understand the information they have constructed themselves. According to constructivist theories, learning is a social advancement that involves language, real world situations, and interactions such as interacting with computers and collaboration among learners. The learner is considered to be central in the learning process. Learning is affected by our prejudices, experiences, the time in which we live, and both physical and mental maturity. When motivated, the learner exercises his will, determination, and action to gather selective information, convert it, formulate hypotheses, test these suppositions via applications, interactions or experiences, and to draw verifiable conclusions. Constructivism transforms today's classrooms into a knowledge-construction site where information is absorbed and knowledge is built by the learner but not the teacher. In constructivist classrooms, unlike the conventional lecturer, the teacher is a facilitator and a guide, who plans, organizes, guides, and provides directions to the learner, who is accountable for his own learning.

Jean Piaget and Lev Vygotsky are two eminent figures in the development of constructivist theories. They share the common belief that classrooms must be constructivist environments; however, there are differences in terms of their theories and variations as to how constructivism should be carried out in classrooms. Piaget (1980) believes that a constructivist classroom must provide a variety of activities to challenge students to accept individual differences, increase their readiness to learn, discover new ideas, and construct their own knowledge. Also, in an elementary Piagetian classroom, concrete learning experiences, such as drawing, drama and model building that involve hands-on opportunities to see, hear, touch, taste, and smell are essential. This the computer can help in terms of hands-on, seeing and touching.

Vygotsky (1978) suggests that with the help of social interaction, such as assistance from a mentor, students can comprehend concepts and schemes that they cannot know on their own. A Vygotskian classroom emphasizes creating one's own concepts and making knowledge one's property; this requires that school learning takes place in a meaningful context, alongside the learning that occurs in the real world. As seen earlier in the Piagetian classroom, this model also promotes the active participation and collaboration of distinctive learners.

Studying of constructivist beliefs, recent studies reported a strong emphasis on constructivist teaching and learning approaches and this both in-service teachers and pre-service teachers (Yuan, 2006). This can be related to the strong emphasis on the adoption of constructivist teaching and learning approaches among the Senior High Schools in Ghana, when considering the recent New Curriculum Reform (MOESS, 2007). This particular observation makes it more interesting to explore the influence of student teacher beliefs on their prospective pedagogical integration of ICT in the Ghanaian setting. A definition of Taylor, Fraser, and White (1994) about constructivist teaching refers to five critical components: scientific uncertainty, student negotiation, shared control, critical voice, and personal relevance.

The theoretical and actual influences of teachers' constructivist educational beliefs on classroom activities with or without ICT integration have also been explored by a variety of researchers (Higgins & Moseley, 2001; Riel & Becker, 2000; Tondeur et al., 2008). When considering the interrelationship between teacher beliefs and ICT integration, there is evidence that, teachers' constructivist beliefs about teaching and learning are a significant factor in determining patterns of classroom computer use by in-service teachers (Higgins & Moseley, 2001). Honey & Moeller (1990) found that teachers with student-centered pedagogical beliefs were successful at integrating technology except in cases where anxiety about computers prevented them from appropriating the technology.

It is argued that teachers' constructivist beliefs and pedagogical philosophy influence their teaching efficacy (Sung, 2007). In the literature, different authors point at the impact of constructivist beliefs on educational computer attitudes (Chai et al., 2009; Ertmer, 2005). Ertmer (2005) has documented that teachers adopting strong constructivist educational beliefs are more likely to use ICT in their classroom practice. However, as mentioned by Chai et al. (2009), how pedagogical beliefs are related to the teachers' attitudes toward computers is a less researched area. Therefore, the relationship between constructivist beliefs and teachers' attitudes toward computers needs to be examined.

There is therefore no doubt that in-service teachers' constructivist teaching beliefs have a direct effect on the pedagogical integration of ICT in ones teaching practices. Hence, the study conceptualized teacher's constructivist teaching believed as the general overview of what the in-service teacher do in the classroom during teaching and learning whether he/she believes in the constructivist approach of teaching or not.

Teaching Experience

Though some research reported that teachers' experience in teaching did not influence their use of computer technology in teaching (Niederhauser & Stoddart, 2001), most researches showed that teaching experience influence the successful use of ICT in classrooms (Wong & Li, 2008; Giordano, 2007; Hernandez-Ramos, 2005). Gorder (2008) reported that teacher experience is a factor influencing teachers' adoption and integration of ICT and significantly correlated with the actual use of technology. In her study, she revealed that effective use of computer was related to technological comfort levels and the liberty to shape instruction to teacher-perceived student needs. Also, Baek, Jong and Kim (2008) claimed that experienced teachers are less ready to integrate ICT into their teaching.

Similarly, in United States, the (U.S National Centre for Education Statistics, 2000) reported that teachers with less experience in teaching were more likely to integrate computers in their teaching than teachers with more experience in teaching. According to the report, teachers with up to three years teaching experience reported spending 48% of their time utilizing computers, teachers with teaching experience between 4 and 9 years, spend 45% of their time utilizing computers, teachers with experience between 10 and 19 years spend 47% of the time, and finally teachers with more than 20 years teaching experience utilize computers 33% of their time. The reason to this disparity may be that fresh teachers are more experienced in using the technology. Further, Lau & Sim (2008) conducted a study on the extent of ICT adoption among 250 secondary school teachers in Malaysia. Their findings revealed that older teachers frequently use computer technology in the classrooms more than the younger teachers. The major reason could be that the older teachers having rich experience in teaching, classroom management and also competent in the use of computers can easily integrate ICT into their teaching. The result is in agreement with Russell, Bebell, O'Dwyer, & O'Connor, (2003) who found that new teachers who were highly skilled with technology more than older teachers did not incorporate ICT in their teaching. The researchers cited two reasons: new teachers focus could be on how to use ICT instead of how to incorporate ICT in their teaching. Secondly, new teachers could experience some challenges in their first few years of teaching and spend most of their time in familiarizing themselves with school's curriculum and classroom management.

But in a survey of almost 3000 teachers, Russell, O'Dwyer, Bebell and Tao (2007) argued that the quality of ICT integration was related to the years of teacher service. However, Granger, Morbey, Lotherington, Owston &

Wideman (2002) conducted a qualitative survey on factors contributing to teachers' successful implementation of ICT in Canada. They interviewed 60 respondents from 12 schools. The findings found no relationship between teachers' teaching experience and experience in the use of ICT implying that teachers' ICT skills and successful implementation is complex and not a clear predictor of ICT integration. Zidon and Miller (2002) conducted a study to investigate affiliations of attitudes and experience with need for learning computer skills. Their finding indicated that weak relationship existed between years of teaching and technology usage.

Conversely, Rosen and Maguire (1990) who reviewed a literature on understanding teachers' perception towards computers and computerized instruction concluded that teachers teaching experience does not eliminate computer phobias and many experienced teachers display some wariness, discomfort and/or mild anxiety in relation to computers. Teaching experience in this study looked at how long the in-service teacher has been teaching mathematics at the Senior Secondary level and its effect on ICT integration.

Attitude towards Computers

The strong relationship of computer-related attitudes and computer use in education has been emphasized in many studies (e.g.,Van Braak, 2001). Attitudes towards computers influence teachers' acceptance of the usefulness of technology, and also influence whether teachers integrate ICT into their classroom (Akbaba & Kurubacak, 1999; Clark, 2001). Huang & Liaw (2005) also state that among the factors that affect the successful use of computers in the classroom, teachers' attitudes towards computers play a key role. Research of van Braak, Tondeur, and Valcke (2004) also supported that class use of computers was strongly affected by attitudes toward computers in education. Khine (2001) studied 184 teachers and found a significant relationship between computer attitudes and its use in the institution. Taking the importance of attitudes toward computer into consideration, it is also important to understand what influences teachers' attitudes towards computers (Fisher, 2000). These attitudes are related to other internal and external variables.

The success of any initiatives to implement technology in an educational program should depend strongly upon the support and attitudes of the implementers involved. It has been suggested that if teachers believe or perceived proposed computer programs are not beneficial, they are not likely to attempt to introduce technology into their teaching and learning in their future classrooms at all (Huang and Liaw, 2005). Among the factors that affect the successful use of computers in the classroom are teachers' attitudes towards computers (Huang and Liaw, 2005). Attitude, in turn, constitutes various dimensions. Some examples of these are perceived usefulness, computer confidence (Rovai & Childress, 2002), training (Tsitouridou & Vryzas, 2003), knowledge about computers (Yuen, Law & Chan, 1999), anxiety, confidence, and liking (Yildirim, 2000).

Much research into the barriers to the integration of ICT into education found that teachers' attitudes and an inherent resistance to change were significant barriers (Becta, 2004; Gomes, 2005; Schoepp, 2005). Watson, (1999) argued that integrating the new technologies into educational settings requires change and different teachers and for that reason teachers will handle this change differently. According to him, considering different attitudes to change is important because one's beliefs influence what he/she can do in the classrooms. Becta (2004) claims that one key area of teachers' attitudes towards the pedagogical use of ICT is their understanding of how these technologies will benefit their teaching and their students' learning. According to Empirica (2006), teachers who are not using new technology such as computers in the classroom are still of the opinion that the use of ICT has no benefits or unclear benefits. Resistance to change seems not to be a barrier itself; instead, it is an indication that something is wrong. In other words, there are reasons why resistance to change occurs.

Positive teachers' attitudes towards computing are critical if computers are to be effectively integrated into the school curriculum. Another reason for studying teachers' attitude towards computer use is that it is a major predictor for future computer use in the classroom (Myers & Halpin, 2002). If in-service teachers are to adopt ICT integration into their teaching of mathematics, they must have the right kind of attitudes toward ICT. Researchers have investigated the relationship between computer attitudes and computer adoption or uptake. The importance of attitudes and beliefs for learning to use new technologies is widely acknowledged (DeYoung & Spence, 2004; Loyd & Gressard, 1984; Ray, Sormunen, & Harris, 1999; Saade and Galloway, 2005). Regarding the meaning of attitudes, different researchers gave different but somehow related definitions of the word.

According to Ajzen and Fishbein (1977), attitudes refer to the ability to predict a person's behavior toward certain targets. Aiken (1980) described attitudes as "learned predispositions to respond positively or negatively to certain objects, situations, concepts, or persons". Some other researchers used psychological constructs to explain attitudes. Loyd and Gressard (1984), for example, divided the construct 'attitudes' into four different variables, which are: 1) compute liking; 2) computer anxiety; 3) computer confidence, and: 4) perceived usefulness of the computer. There are researchers who seemed to be satisfied with Loyd and Gressard's definition, like (Koohang, 1989; Necessary & Parish, 1996). The multidimensionality concept of attitudes towards computers is also supported by Wang, Chen and Shi (2007) when they proposed three dimensions to represent this construct. However, simple uni-dimensional perspective of the attitude toward computer is also widely applied by many researchers, for example Divine & Wilson (1997) who are contented with the dimension computer liking, and Mitra (1998) who prefers computer anxiety as the sole dimension to represent attitude toward computers.

Computer anxiety can influence the attitude of users towards using computer (Igbaria & Chakrabarti, 1990). This is also supported by other previous studies (Mahar, Henderson, & Deane, 1997; Todman & Monaghan, 1994; Ventakesh, 2000). Computer anxiety can be defined as fear of computers. Other term that has been used to explain similar attitude is computer avoidance (Bohlin, 2002). By identifying the predictors of computer anxiety, use of computers among teachers can be better explained. If teachers perceived the usefulness of computer and feel confident in using it, this will lead to more positive attitudes, thus tend to use computer more (Noiwan, Piyawat, & Norcio, 2005). Similarly, Garland & Noyes (2005) also found that confidence correlate positively towards computer attitude, whereas Gao (2005) found that perceived usefulness is positively correlated with computer attitude.

Therefore, in achieving excellence pedagogical integration of ICT in Senior High School mathematics education, it is important to ensure that teachers are able to integrate technology into the curriculum. As such, the groundwork must be laid by studying the teacher, the main implementer of any educational innovations including the use of ICT. To do otherwise is to produce future leaders with underdeveloped skills in the use of ICT technology. Besides computer experience, greater frequency of computer use equally leads to positive attitude (Teo, 2006).

Perceived Usefulness of computer

Practicing teachers should be prepared to pedagogically integrate information and communication technology (ICT) into their teaching and learning practices. This is so because the importance of integrating technology in classroom instruction cannot be overlooked. According to the Ministry of Education, Youth and Sports (MOEYS) and Ghana Education Service (GES) (2002), integrating technology in classroom instruction ensures greater motivation, increases self-esteem and confidence, enhances good questioning skills, promotes initiative and independent learning, improves presentation of information/outputs, develops problem solving capabilities, promotes better information handling skills, increasing focus time on task, and improves social and communication skills.

ICT can play various roles in learning and teaching processes. According to Bransford et al. (2000), several studies have reviewed the literature on ICT and learning and have concluded that it has great potential to enhance student achievement and teacher learning. Wong et al. (2006) point out that ICT can play a part in supporting face-to-face teaching and learning in the classroom. Many researchers and theorists assert that the use of computers can help students to become knowledgeable, reduce the amount of direct instruction given to them, and give teachers an opportunity to help those students with particular needs (Iding, Crosby, & Speitel, 2002; Shamatha, Peressini, & Meymaris, 2004; Romeo, 2006). While new technologies can help teachers enhance their pedagogical practice, they can also assist students in their learning. According to Grabe and Grabe (2007), technologies can play a role in student skills, motivation, and knowledge. They claim that ICT can be used to present information to students and help them complete learning tasks.

Other studies (Beauchamp & Parkinson, 2008; Bottino & Robotti, 2007) sited in (Agyei & Voogt, 2011) have reported positive effects of incorporating technology in teaching mathematics such as to enhance motivation and improve students' achievement. Also, there is substantial evidence that, in the right hands and used appropriately for specific purposes in specific contexts, ICT can be an effective tool in supporting teaching and learning (Agyei & Voogt, 2011). The Ministry of Education, Science and Sports opined that "the integration of ICT into Education will result in the creation of new possibilities for learners and teachers to engage in new ways of information acquisition and analysis. ICT may enhance access to education and improve the quality of education delivery on equitable basis" (Ministry of Education, Science and Sports, (MOESS) 2006).

As Brush, Glazewski and Hew (2008) have stated, ICT is used as a tool for students to discover learning topics, solve problems, and provide solutions to the problems in the learning process. ICT makes knowledge acquisition more accessible, and concepts including mathematical concepts in learning areas are easily understood while engaging students in the application of ICT, support student centered and self directed learning. ICT integration ensures more frequently engaged in the meaningful use of computers by the learners (Castro Sánchez & Alemán, 2011). They build new knowledge through accessing, selecting, organizing, and interpreting information and data.

For the purpose of this particular study, computer attitude is seen as how ICT (computer and calculator) technologies benefit the teaching and learning and the students' learning of mathematics in the classroom, thus computer and calculator liking attitudes (Divine & Wilson, 1997). These include, perceived usefulness of the computer, the affective component of the computer, computer liking attitude and the perceived control component.

Teacher Technology Competence

Competence is usually defined as having the ability to perform a specific task (Agyei & Voogt, 2010). Research into computer competencies, also indicated with the terms computer performance, computer ability, or computer achievement, is in contrast to the large attention of studies in computer attitudes (Meelissen & Drent, 2008). One's competencies in computer use is usually measured through self-report. One might argue that therefore teachers' competencies should be conceived as self-efficacy measures, which is defined as "confidence in one's competence" (Bandura, 1999). Computer competencies are positively correlated with an individual's willingness to choose and participate in computer-related activities, expectations of success in such activities, and persistence or effective coping behaviors when faced with computer-related difficulties (Smarkola, 2008). In-service teachers with higher levels of technology competencies are likely to use computers more often and experienced less computer-related anxiety in their teaching practices. On the other hand, teachers with lower levels of technology competencies become more frustrated and more anxious, and hesitate to use computers when they encounter obstacles (Agyei & Voogt, 2010).

More recent studies about teachers 'technology competencies differentiate between basic technology competencies and pedagogical technology competencies (Law et al., 2008). Also Smarkola (2008) argued that for effective integration of ICT, teachers must move beyond being "computer literate" to "technology competent". Smarkola added that being technologically competent allows educators to use computers as part of the curriculum and as a tool for authentic student engagement and learning and hence the need and must to use ICT during teaching and learning. Research shows that computer competencies influence expectations and emotional reactions regarding the effective use of modern technologies (Looney, Valacich, & Akbulut, 2004). Thus attitudes towards information technology, is linked to computer competencies since they are deemed to be significant factors in the interpretation of the frequency and success with which individuals use computers (Khorrami-Arani, 2001).

Competencies and attitudes are clearly interrelated and there appears to be a universal agreement that competency in the use of technology is a predicting factor to successful employing pedagogical integration of ICT in the teaching and learning of mathematics. In order to make an implementation succeed, Ely (1999) indicated that the people who will ultimately use the innovation must possess sufficient knowledge and skills to do the job. This is especially the case when the innovation involves the use of a certain tool or a technique. Hence, technology competence is to measure one's ability to use the computer or calculator to perform a specific mathematical task in the classroom.

External Barriers/Factors

Effective Training

The barrier most frequently referred to in the literature is lack of effective training (Albirini, 2006; Balanskat et al., 2006; Beggs, 2000; Özden, 2007; Schoepp, 2005; Toprakci, 2006). One finding of Pelgrum's (2001) study was that there were not enough training opportunities for teachers in the use of ICTs in a classroom environment. This can be attributed to the kind of formal training they had had at the training institutions. Similarly, Beggs (2000) found that one of the top three barriers to teachers' use of ICT in teaching students was the lack of training. Recent research in Turkey found that the main problem with the implementation of new ICT in science and mathematics was the insufficient amount of in-service training programs for science/mathematics teachers (Özden, 2007), and Toprakci (2006) concluded that limited teacher training in the use of ICT in Turkish schools is an obstacle.

According to Becta (2004), the issue of training is certainly complex because it is important to consider several components to ensure the effectiveness of the training. These were time for training, pedagogical training, skills training and an ICT use in the training institutions. Correspondingly, recent research by Gomes (2005) relating to mathematics (science education in general) concluded that lack of training in digital literacy, lack of pedagogic and didactic training on how to use ICT in the classroom, and lack of training concerning the use of technologies in mathematics specific areas were obstacles to using new technologies in classroom practice. Some studies reported similar reasons for failures in using pedagogical integrations of ICT: the weakness of teacher training in the use of computers, the use of a "delivery" teaching style instead of investment in modern technology (Alhamd, Alotaibi, Motwaly, & Zyadah, 2004), as well as the shortage of teachers who are qualified to use the technology confidently (Sager, 2001).

Providing pedagogical training for teachers, rather than simply training them to use ICT tools, is an important issue (Becta, 2004). Cox et al. (1999a) argue that if teachers are to be convinced of the value of using ICT in their teaching practices, their training should focus on the pedagogical issues. The results of the research by Cox et al. (1999a) showed that after teachers had attended professional development courses in ICT they still did not know how to use ICT in their classrooms; instead they just knew how to run a computer and set up a printer. They explained that this is because the courses only focused on teachers acquiring basic ICT skills and did not often teach teachers how to develop the pedagogical aspects of ICT. In line with the research by Cox et al. (1999a), Balanskat et al. (2006) indicated that inappropriate teacher training is not helping teachers to use ICT in their classrooms and in preparing lessons. They assert that this is because training programmes do not focus on teachers' pedagogical integration practices in relation to ICT but on the development of ICT skills.

However, beside the need for pedagogical training, according to Becta (2004), it is still necessary to train teachers in specific ICT skills. Schoepp (2005), claims that when new technologies need to be integrated in the classroom, teachers have to be trained in the use of these particular ICTs. According to Newhouse (2002), some initial training is needed for teachers at the teacher training institutions to develop appropriate skills, knowledge, and attitudes regarding the effective use of computers to support learning by their students. He argued that this also requires continuing provision of professional development to maintain appropriate skills and knowledge. Fundamentally, when there are new tools and approaches to teaching, teacher training is essential (Osborne & Hennessy, 2003) if they are to integrate these into their teaching.

However, according to Balanskat et al. (2006), inadequate or inappropriate training leads to teachers being neither sufficiently prepared nor sufficiently confident to carry out full integration of ICT in the mathematics classroom. Newhouse (2002), states that “teachers need to not only be computer literate but they also need to develop skills in integrating computer use into their teaching/learning programmes” (p. 45). According to Newhouse (2002), teachers need training in technology education (focusing on the study of pedagogical integration of technologies) and educational technology (support for teaching in the classroom). Similarity, Sicilia (2005) found that teachers want to learn how to use new technologies in their classrooms but the lack of opportunities for professional development obstructed them from integrating technology in certain subjects such as science or mathematics. Other problematic issues related to professional development in ICT are that training courses are not differentiated to meet the specific learning needs of teachers and the sessions are not regularly updated (Balanskat et al., 2006). Lack of ICT focus in the training institutions of education is a barrier to teachers' use of what is available in the classroom during teaching practice (Becta, 2004). Where training is ineffective, teachers may not be able to have access to ICT resources.

Besides, Forgasz (2002) examined how computers were being used in mathematics classrooms and to identify factors that acted as facilitators or hindrances to use. Most teachers felt confident or at least willing to "have a go" at using computers for teaching mathematics and had used computers with their mathematics classes, but only infrequently. A large proportion of these teachers had participated in professional development in computer education, but most of them wanted more training. Besides, Goos & Bennison (2008) also conducted a study on teachers' use of ICT in secondary mathematics. Out of 485 mathematics teachers sampled, 26% indicated they had participated in professional development courses related to computers, the internet and graphics calculators while 16.7% stated they had undertaken no professional course in any of the three types of technology.

However, Boakye and Banini (2008) also conducted a study to find out teachers' readiness for the use of technology in Ghanaian schools. Their findings indicated that out of 221 teachers surveyed, only 24% have received some form of training in the use of computers, with quite minimal training in the pedagogical integration of technology. This indicates that although mathematics teachers have realized the impact of technology in mathematics, they still need professional training on how to integrate it in their teaching.

Although, technology use in mathematics improves mathematics teaching and learning, the level of technology use in mathematics fell below average. The training in this study leads to teachers being neither sufficiently prepared nor sufficiently confident to carry out full integration of ICT in the mathematics classroom.

Lack of Time

Several recent studies indicate that many teachers have competence and confidence in using computers in the classroom, but they still make little use of technologies because they do not have enough time. A significant number of researches identified time limitations and the difficulty in scheduling enough computer time for classes as a factor to not been able to use ICT in the teaching (Al-Alwani, 2005; Becta, 2004; Shcoepp, 2005; Sicilia, 2005). According to Sicilia (2005), the most common challenge reported by all the teachers was the lack of time they had to plan technology lessons, explore the different Internet sites, or look at various aspects of educational software.

Becta's study (2004) found that the problem of lack of exists for teachers in many aspects of their work as it affects their ability to complete tasks, with some of the participant teachers specifically stating which aspects of ICT require more time. These include the time needed to locate Internet advice, prepare lessons, explore and practice using the technology, deal with technical problems and receive adequate training.

Recent studies show that lack of time is an important factor affecting the application of new technologies in mathematics and science education (Al-Alwani, 2005). According to Al-Alwani, (2005), lack of time the can seriously affect the application of ICT Saudi Arabia because of busy schedules. He indicated that, because Saudi teachers work from about 7:00 a.m. until 2:00 p.m. and the average number of class sessions taught by these teachers is 18 per week, hence limiting the number of hours for both students and teachers within a day so as making integration of CT into mathematics teaching so difficult since they will have little or no time for practices.

In Canada, Sicilia (2005) conducted a study and revealed that teachers take much more time to design projects that include the use of new ICT than to prepare traditional lessons. Teachers interviewed by Sicilia (2005) commented that “the constraints of different class schedules contributed to the lack of time spent together to work on planning classroom activities” (p. 41). Gomes (2005) concluded that one of the main reasons why teachers do not use ICT in the classroom is lack of the time necessary to accomplish plans.

Access to Technology

Several research studies indicate that lack of access to resources, including home access, is another complex barrier that discourages teachers from integrating new technologies into education and particularly into mathematics education as the following discussion illustrates. The various research studies indicated several reasons for the lack of access to technologies occurred. In Sicilia’s study (2005), teachers complained about how difficult it was to always have access to computers. The author gave reasons like “computers had to be booked in advance and the teachers would forget to do so, or they could not book them for several periods in a row when they wanted to work on several projects with the students” (p. 50). In other words, a teacher would have no access to ICT materials because most of these were shared with other teachers. According to Becta (2004), the inaccessibility of ICT resources is not always merely due to the non-availability of the hardware and software or other ICT materials within the school. It may be the result of one of a number of factors such as poor organisation of resources, poor quality hardware, inappropriate software, or lack of personal access for teachers (Becta, 2004).

The barriers related to the accessibility of new technologies for teachers are widespread and differ from country to country. Empirica's (2006) European study found that lack of access is the largest barrier and that different barriers to using ICT in teaching were reported by teachers, for example a lack of computers and a lack of adequate material. Similarly, Korte and Hüsing (2007) found that in European schools there are some infrastructure barriers such as broadband access not yet being available. They concluded that one third of European schools still do not have broadband Internet access. Pelgrum (2001) explored practitioners' views from 26 countries on what were the main obstacles to the implementation of ICT in schools. He concluded that four of the top ten barriers were related to the accessibility of ICT. These barriers were insufficient numbers of computers, insufficient peripherals, insufficient numbers of copies of software, and insufficient simultaneous Internet access.

Toprakci (2006) found that low numbers of computers, oldness or slowness of ICT systems, and scarcity of educational software in the school were barriers to the successful implementation of ICT into science and mathematics education in Turkish schools. Similarly, Al-Alwani (2005) found that having no access to the Internet during the school day and lack of hardware were impeding technology integration in Saudi schools. Recent research on Syrian schools indicated that insufficient computer resources were one of the greatest impediments to technology integration in the classroom (Albirini, 2006). Basically, there are several barriers associated with the lack of access to ICT. In his research, Gomes (2005) found a lack of appropriate infrastructure and a lack of appropriate material resources to be barriers.

However, overcoming such hardware barriers does not, in itself, ensure ICT will be used successfully. According to Balanskat et al. (2006), the accessibility of ICT resources does not guarantee its successful implementation in teaching, and this is not merely because of the lack of ICT infrastructure but also because of other barriers such as lack of high quality hardware, suitable educational software, and access to ICT resources. Newhouse (2002) asserts that poor choices of hardware and software and a lack of consideration of what is suitable for classroom teaching are problems facing many teachers. Similarly, Cox et al. (1999a) found that the majority of teachers agreed that insufficient ICT resources in the school and insufficient time to review software prevent teachers using ICT. According to Osborne and Hennessy (2003), the limitations on access and availability to hardware and software resources influenced teachers' motivation to use ICT in the classroom. Access to technology use will be looked at in terms of the availability of the computer to the in-service teacher both at home and at school as well how accessible are these computers to the teacher.

Cultural Issues

School culture encompasses the vision, plans, norms and values that are shared by school members, Maslowski, (2001). Focusing on the importance of school culture for ICT integration, Pelgrum and Law (2009) indicated that effective ICT integration depends on the perceptions and vision of school leaders rather than teachers' ICT skills. School culture has a mediating role that influences teachers' actions, beliefs, and attitudes, Chai, Hong and Teo, (2009).Therefore, in addition to the external and internal variables mentioned previously, school culture also plays an important role in successful technology integration, Tezci, (2011b).

In order to explore teacher perceptions of school culture related to the level of ICT usage, Tezci (2011b) examined Turkish teacher perceptions from both the technical and motivational perspectives. The results showed that their perceptions from both perspectives were not positive, because the majority did not believe that they would receive adequate technical and motivational support from their school. However, as the school culture became more positive, the teachers' ICT usage level increased. Ward and Parr (2010) stated that teachers need to feel confident in their ability to facilitate student learning with technology in order to integrate technology into their classrooms. To achieve this goal, more professional development is required with a focus on increasing teachers' skills so that they are able to overcome apprehensions associated with using technology.

Further, new teaching approaches and technical support should be offered by schools and colleges to allow them to retain control while facilitating learning with computers. Overall, implementing effective teaching with technology integration requires changes in teachers' knowledge, beliefs, and school culture (Ertmer & Otternbreit-Leftwich, 2010)

Ward and Parr (2010) emphasize that cultural differences need to be taken into account when studying instructional interventions. Understanding how culture influences instructional behavior and thinking process is a key issue in the research about teacher education, (Tezci, 2011; Aguinis & Roth, 2003). Different cultures generate different educational philosophies and beliefs. Based on this consensus, researchers have studied the appropriateness of transporting Western theories, constructs, and measuring instruments to be used in non-Western cultural contexts (Lin & Gorrell, 2001). For instance, Lin and Gorrell (2001) explored pre-service teacher efficacy in Taiwan and clearly argued that teacher efficacy and beliefs are largely shaped by culturally and socially shared experiences and values. If we take teacher self-efficacy as an example, studies of Chinese teachers' personal efficacy might reflect the self-effacing tendency in personal (re)presentation in collectivistic societies as well as the strong emphasis on teacher responsibilities and teacher performance in the Chinese cultural context (Ho & Hau, 2004).

Culture and context have also repeatedly been reported as obstacles to the integration of ICT in education (Chai, Hong, & Teo, 2009; Pelgrum, 2001). For instance, Chai et al. (2009) argue that culture plays a mediating factor that influences how teachers relate their beliefs to ICT use. In Human Computer Interaction, culture is defined as 'the members of one human group from those of another. Culture in this sense is a system of collectively held values' (Hofstede 1991, p.5). Also, the patterns of behaviour and thinking by which members of groups recognize and interact with one another (Scheel & Branch, 1993).

Chapter Summary

In conclusion, it can be deduced from the findings presented from the literature review that there are some key barriers/factors that influence teachers' intention to pedagogically use ICT in the teaching and learning of mathematics in their classrooms. The factors identified have been grouped into two broad barriers: Internal Barriers and External Barriers. Internal barriers- (Constructivist Teaching Beliefs, teaching experience, Attitude and Perceived Computer usefulness) as well as the external barriers (Training, technology Competence, Access to computer and Cultural Issues) have a great influence on the in-service teacher's intention and readiness to use ICT into the teaching and learning of mathematics. The context for this research study is the barriers that influence the teacher's intention to integrate ICT in the teaching and learning of mathematics and the study will attempt to relate some of the findings from literature to the data collected from the teachers at SHS level of education in Ghana.

CHAPTER THREE

RESEARCH METHODS

Overview

The goal of the study is to examine the effect of in-service teachers' external barriers/factors (access to technology use, training, technology competence and culture) and their internal barriers/factors (constructivist teaching beliefs, teaching experience, perceived computer usefulness, and attitudes toward computers) on ICT integration in the teaching and learning of mathematics into the teaching practices of the in-service teachers. Also, to examine the influence of these internal and external barriers on the pedagogical integration of ICT in the teaching and learning of SHS mathematics.

The chapter provides detailed description of the methodology employed in the study which includes the participants of the study, sampling and sampling procedures, research design, research instrument, data collection procedure and the method of data analysis.

Research Design

The study used survey research design with mixed-method approach. Survey research designs are procedures in quantitative research in which investigators administer a survey to a sample or to the entire population of people to describe the attitudes, opinions, behaviours, or characteristics of the population (Creswell, 2012). Surveys use a standard set of questions to get a broad overview of a group's opinion's, altitudes, self reported behaviours, and demographic and background information (Onley & Barnes, 2008). According to Babbie (2005) there are two basic types of surveys: cross-sectional surveys and longitudinal surveys. Cross-sectional surveys gather information on a particular population at a distinct time. Creswell (2012) argues that despite the numerous applications of surveys today, there are still only two basic types of research surveys: cross sectional and longitudinal. He further stated that, the survey researchers use cross-sectional designs to collect data about current attitudes, opinions, or beliefs. The study therefore adopted Cross-sectional survey to collect information on technology use among in-service mathematics teachers and the factors that influence their use.

Lavrakas (2008) argues that cross-sectional data are usually collected from respondents making up the sample within a relatively short time frame (field period). In a cross-sectional study, time is assumed to have random effect that produces only variance, not bias. Creswell (2012) argues that cross-sectional survey design has the advantage of measuring current attitudes or practices. It also provides information within a short period of time, such as the time required for administering the survey and collecting the information. Cross-sectional survey is preferred as a method of data collection over others in this particular study due to the fact that many questions were asked and it was possible to reach the in-service mathematics teachers within a short period of time (Fowler, 2002). Cross-sectional survey method enabled the researcher to collect information about the willingness of technology (ICT) use among mathematics teachers and the possible factors that may influence its use in mathematics teaching. Besides, respondents' anonymity was easily protected as data was collected without having to identify respondents.

Survey research design however have limitations in that they do not involve a treatment given to participants by the researcher. Because survey researchers do not experimentally manipulate the conditions, they cannot explain cause and effect; instead, they describe trends in the data rather than offer rigorous explanations. Survey researchers often correlate variables, but their focus is directed more toward learning about a population and less on relating variables or predicting outcomes (Creswell, 2012). Bell (1999) opines that surveys can provide answers to the questions what? Where? When? And How? But, it is not so easy to find out why?

The study also used the mixed-method approach. Mixed-method approach combines both qualitative and quantitative methods of research. Tashakkori and Teddlie (2003) argue that multiple methods are useful if they provide better opportunities for a researcher to answer research questions and where the methods allow a researcher to better evaluate the extent to which the research findings can be trusted and inferences to be made from them. Not only is it perfectly possible to combine quantitative and qualitative within the same piece of research, but in our experience it is often advantageous to do so (Saunders, Lewis & Thornhill, 2007). Quantitative methods enabled the researcher to ensure high levels of reliability of gathered data. The quantitative part involves the use of descriptive and inferential statistics to investigate in-service teachers' external and internal barriers of their pedagogical integration of ICT.

Qualitative research on the other hand allowed the researcher to obtain more in-depth information and to collect non-numerical data on mathematics teachers' external and internal barriers on ICT integration. The purpose of gathering different types of data was to understand more fully, to generate deeper and broader insight, to develop important knowledge claims about the extent of technology use among in-service mathematics teachers and the factors that influence their use. Each approach has its particular strengths and, when used together, could provide a thorough picture of the study (Onley & Barnes, 2008).

Population

All SHS mathematics teachers (in-service) in Cape Coast Metropolis.

Sampling Technique

Non-probability sampling was used, in particular convenience and purposive sampling. Purposive because, the sample must involve the selection of participants who have key knowledge or information related to the purpose of the study and in this study, only mathematics teachers at the SHS level was the targeted group.

According to Vanderstoep and Johnston (2009), convenience sampling often involve people whom the researcher knows or people who live close to the research site. The advantage of convenience sampling is the ease with which participants can be recruited; therefore, in-service mathematics teachers available at the time of my visit to the various schools were included in the sample. Convenience sampling is a non-probability sampling technique where subjects are selected because of their convenient accessibility and proximity to the researcher (Castillo, 2009).

A total of 185 in-service mathematics teachers from 10 public Senior High Schools in the Cape Coast Metropolis were involved (both sexes) in this study. This is because, in a study (Shuttleworth, 2009) intimated that, sampling an entire population as part of a research experiment is impossible, due to the time, expense and sheer number of subjects. Therefore, a portion of the population can be selected as a sample to represent the entire population (Fraenkel & Wallen, 2000; Muijs, 2004).

Research Instrument

After a careful review of appropriate literatures, questionnaire was chosen as the instrument to collect data to answer the questions set for this study. Questionnaire was chosen because it will take less time to administer them and also ensure the anonymity of respondents (Fraenkel & Wallen, 2000; Muijs, 2004). The questionnaire is of several sections to be able to measure all the variables under study. Also, questionnaire which include consistency of presentation of questions to the respondents, the assurance of anonymity for the respondents and the less time it takes to administer (Fraenkel & Wallen, 2000; Muijs, 2004) made it suitable to use as the instruments for this study. It is also probably, the most common data collection instrument used in educational research which is more familiar to respondents (Muijs, 2004).

In addition, as explained by (Lodic, Spaldin, & Voegtle, 2010), the survey questionnaire has the advantage of achieving rapid contact with a large number of people. It became very useful for this research project, particularly to obtain responses on the diverse indicators requiring consultations with specific populations (in-service teachers). Questionnaire enabled the researcher to collect potential information about technology use among in-service mathematics teachers and the barriers that may influence their intentions to use ICT in teaching and learning mathematics. The questionnaire had several sections which include the background information about the participant, internal barriers (constructivist teaching beliefs, teaching experience, computer attitudes and technology competence) and external barriers (training, access to technology use, time adequacy and culture).

Data Collection Procedure

The researcher visited the selected institutions and permissions sorted from the administrations of these institutions to help get access to the in-service mathematics teachers, for data to be taken from teachers of these institutions.

Questionnaire was administered personally to the participants to enable me ensure to a larger extent the independency of the responses by the various respondents. It also to a very large extent encouraged the respondents not to be intimidated by anybody as I am seen as a neutral person rather than their own colleagues administering the questionnaire. A period of six weeks was used to collect the data for this study.

Questionnaire

The general benefits of a questionnaire which include consistency of presentation of questions to the respondents, the assurance of anonymity for the respondents and the less time it takes to administer (Fraenkel & Wallen, 2000; Muijs, 2004) made it suitable to use as the instruments for this study. It is also probably, the most common data collection instrument used in educational research which is more familiar to respondents (Muijs, 2004).

Even though, questionnaires often have low response rates and cannot search deeply into respondents' opinions and feelings (Fraenkel & Wallen, 2000; Muijs, 2004), according to Walonick (2004), using questionnaire also reduces middle-man bias and minimizes verbal or visual clues that would influence respondents' responses.

The questionnaires were derived from existing survey instruments of the Microcomputer Beliefs Inventory (MBI) developed by Riggs and Enochs (1993) and also based on the Association for Mathematics Teacher Educators (AMTE) standards. The Microcomputer Beliefs Inventory (MBI) instrument (Riggs & Enochs, 1993) was used to assess participant's confidence and self believe (Belief in their own abilities with spreadsheets and its effect on the teaching and learning of the mathematics).

The in-service teachers were to respond to each item on a 5-point Likert scale (1= Strongly Disagree, 2= Disagree, 3= Agree, 4= Strongly Agree, 5= Undecided) and in other cases (1= poor, 2= learning, 3= satisfactory, 4= good, 5= excellent) specifically for computer competence. Yes or No question was also given to respondents on computer availability (See Appendix H)

Likert scale is easier to construct, interpret and also provide the opportunity to compute frequencies and percentages as well as other statistical analysis such as the mean, standard deviation, Analysis of Variance (ANOVA), T-test and regression analysis (Fraenkel & Wallen, 2000; Muijs, 2004). Additionally, likert scales are often found to provide data with relatively high reliability (Fraenkel & Wallen, 2000).

Mean scores were computed from the data to represent internal barriers (constructivist teaching beliefs, teaching experience, computer attitudes and technology competence) and external barriers (training, access to technology use, time adequacy and culture).

Reliability and Validity

According to William (2006), reliability refers to consistency or 'dependability' of the measurement or the extent to which an instrument measures the same way each time it is used under the same condition with the same subjects. Validity on the other hand determines whether the research truly measures that which it was intended to measure or how truthful the research results are (Joppe, 2000). To check for the validity of the instrument, the researcher allowed two (2) senior lecturers who were experts in the field of educational technology and mathematics at the Department of Science and Mathematics Education, University of Cape Coast, to evaluate the questionnaire for content and construct as well as face validity. After the panel's feedback was received, the necessary changes to the content of the questionnaire were made. Later, the improved questionnaire was pilot-tested to establish not only its reliability but also to identify defective items, and ensured that the instrument was clearly understood by respondents.

Reliability and validity of Instrument is the quantification of human behaviour — that is, using measurement instruments to observe human behaviour. The measurement of human behaviour belongs to the widely accepted positivist view, or empirical-analytic approach, to discern reality (Smallbone & Quinton, 2004, cited in Drost, 2011). Because most behavioural research takes place within this paradigm, measurement instruments must be reliable and valid. Reliability is the extent to which measurements are repeatable –when different persons perform the measurements, on different occasions, under different conditions, with supposedly alternative instruments which measure the same thing. In sum, reliability is consistency of measurement (Bollen, 1989), or stability of measurement over a variety of conditions in which basically the same results should be obtained (Nunnally, 1978).

Validity is concerned with the meaningfulness of research components. When researchers measure behaviours, they are concerned with whether they are measuring what they intended to measure. Bollen (1989) intimated that questions of validity can never be answered with complete certainty. Similarly, Wells and Wollack (2003) argued that formally assessing the validity of test can be a laborious and time-consuming process. Therefore, reliability is often viewed as a first-step in the test validation process. That is if test scores cannot be assigned consistently, it is impossible to conclude that the scores accurately measure the domain of interest.

Cronbach's Alpha reliability coefficient was used to test the internal consistency of the instrument. For a test to be internally consistent, estimates of reliability are based on the average inter correlations among all the single items within a test. Coefficients of internal consistency increase as the number of items goes up, to a certain point. Cronbach's alpha ranges from 0 to 1.00, with values close to 1.00 indicating high consistency.

Piloting of the Survey Instrument

It is easy to overlook mistakes and ambiguities in question layout and construction when designing a questionnaire (Wilkinson & Birmingham, 2003). Besides, Awanta and Asiedu-Addo (2008) also cautioned that it is possible to design a questionnaire that is reliable because the responses are consistent, but may be invalid because it fails to measure the concept it intend to measure. Bell (1999) stressed that all data gathering instruments should be piloted to test how long it takes recipients to complete them and also to check that all questions which do not yield any usable data are removed. In view of this, the survey instrument was pilot tested. A pilot test of a survey questionnaire is a procedure in which a researcher makes changes in an instrument based on feedback from a small number of individuals who complete and evaluate the instrument (Creswell, 2012).

Twenty (20) Mathematics teachers from Aggrey Memorial Zion SHS in Abura-Asebu-Kwamankese District in Central Region were used because they represented the targeted respondents of the study. The feedback of the respondents helped to improve the quality of the survey in terms of content coverage, content validity and reliability. In addition, the pre-test was to find out whether the instrument contained any ambiguous items that might jeopardize the collection of appropriate responses and also to test the validity and reliability of the research instrument. The instrument was further shown to my academic supervisor who scrutinized it and offered suggestions for modification. The results from the reliability test using 20 Mathematics Teachers in Aggrey Memorial Zion SHS in the Central Region of Ghana are shown in Appendix A. The column labelled "Sub-categories of the variable shows the various aspects of the construct (i.e. the variable we want to measure). For instance, computer attitude was examined from four (4) dimensions: Computer liking, computer usage, affective and perceived control. Additionally, the column labelled "Number of items" indicates the total number of statements (items) used to measure the variable on the Likert Scale. The column labelled "Cronbach's Alpha Value" is the coefficient of the estimated internal consistency for each set of statements (items) for the variables involved.

Following the inclusion criteria (ᶐ ≥ 0.70) by George and Mallery (2003), most of the items on the questionnaire must be included in the study. With regard to items on the constructivist belief scale, item two which read "I believe in involving students in their own evaluation" had a very low corrected item total correlation value. This means that item two did not correlate very well with the total correlation of the other items on the scale, hence was not a good item. This is further indicated by a higher value for alpha if item is deleted. This means that when that item was deleted, led to an improvement in reliability from a coefficient of 0.711 to 0.747.

Similarly, item 5 on the perceived control scale had lower corrected item total correlation and its removal led to an improvement in reliability of the computer control sub-scale from a value of 0.712 to 0.724. The overall internal consistency alpha value computed based on 74 items on the questionnaire was 0.921, suggesting that the instrument is reliable.

Data Processing and Analysis

The study employed mainly statistical tools for the determinants of ICT integration. Statistical Product and Service Solution (SPSS) version 22 was used for the analysis. Descriptive Statistics using mean, median, standard deviation, frequency and percentages were employed in the first instance just to help describe, show or summarize data in a meaningful way. The results were presented in tables and interpreted appropriately.

Multiple regression analysis was used to estimate the effects of internal and external factors on the integration of ICT (dependent variable). According to Cohen, et al. (2007), multiple regression technique allows for modeling and analyzing several variables, when the focus is on the relationship between dependent variable and one or more independent variables. It further helps to understand how the typical value of the dependent variable (criterion variable) changes when any one of the independent variables is varied while the other independent variables are held fixed.

T-test was conducted to test whether ICT integration differ by age and teaching experience of in-service teachers in the selected schools (see Appendix D, Table D3).

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

This chapter presents the empirical results and discussion of the factors influencing in-service teachers' ICT integration in teaching and learning of mathematics in some selected schools in the Central Region of Ghana. These factors were conceptualized as internal factors comprising in-service teachers' constructivist teaching beliefs, teaching experience, attitudes toward computer and technology competence; and external factors consisting of teachers' access to technology, level of training in the use of technology, time adequacy, as well as, the culture of the institutions in which a teacher finds himself/herself. The chapter begins with descriptive analysis of the background information of the respondents of the study which included the age and the number of years of teaching. It also highlights the model diagnostics and explains key modeling issues to enhance the understanding of the results. It also discusses the results in relation to the research questions of the study, as well as the conceptual framework of the study. Results are presented in tables and are interpreted using percentages, frequencies, means, t-values, p-values and standard deviation.

Background Information of Respondents

This study is based on a field data from a sample of 185 in-service teachers in the Central Region of Ghana. The objective is to examine the factors influencing ICT integration in mathematics teaching and learning. The average age of respondent is 37 years (i.e. Mean = 37.37); the youngest person was 23 years (Min = 23) and the oldest respondent is 55 years (Max = 55).

Most of the respondents are 40 years of age (i.e. Mode = 40); and half of the total respondents are below 38 years, whilst the other half are above 38 years (i.e. Median = 38). Appendix D (Table D1) presents the age distribution of the respondents. It can be observed from Table D1 that 50 (27%) of the respondents are between 23-32 years of age, 83 (44.9%) are between 33-42 years, 42 (22.7%) are between 43-52 years; and only 10 (5.4%) are between 53-62 years of age. About 72% of the respondents were between 23- 42 years of age (as seen from the cumulative percentage = 71.9).

Empirical evidence suggests that ICT integration is related to years of teaching experience, but the direction of the effect of experience on ICT integration is inconclusive. Some studies observed that more experienced teachers are more likely to integrate ICT in teaching and learning of mathematics than teachers with less experience (Rosen & Maguire, 1990). In other studies, it was observed that less experienced teachers are more likely than more experienced teachers to integrate ICT in mathematics. In order to contribute to the debate, this study attempts to examine years of teaching of mathematics and technology integration among in-service teachers in the selected schools in the Central Region of Ghana. Most of them have been teaching for 7 years now (i.e. mode = 7.0); and each teacher had an average of nine years of teaching experience (i.e. mean = 8.89). Appendix D Table D2 presents the distribution of years of teaching of mathematics among respondents.

As observed in Table D2, out of the 185 respondents from whom data was analyzed, 74 (40%) have been teaching mathematics for between 1-5 years now; 51 (27.6%) have been teaching for between 6-10 years; 26 (14.1%)

and 29 (15.7%) have been teaching for between 11-15 years and 16-20 years, respectively. Only 5 (2.7%) have been teaching for between 21-25 years. As observed in the cumulative percentage column, more than one-half of the respondents (i.e. 67.6%) have been teaching for between 1-10 years.

Whether teachers would integrate ICT in their teaching or not depends largely on the availability of technology resources at their disposal. As a result, technology resources available in the selected schools were examined. Appendix B Table B1 presents the distribution of technology resource availability for teaching and learning of mathematics.

As observed from Table B1, majority of in-service teachers have personal computers with internet at their homes (75%), their schools have general computer labs (75.70%) and graphical calculators (60%) and scientific calculators (81%). However, many indicated that their schools do not have special computer lab for mathematics lessons; projectors are not available for use during mathematics lessons (76.80%), most schools do not have enough computers with appropriate mathematics software (86.50%), and most schools did not have broadband internet connections in their schools (80%). This indicates that majority of schools have some technology resource at their disposal but lack the appropriate software and access to internet that promote effective technology use in teaching.

Mathematics Teachers' Rating of their Level of ICT Integration

In-service mathematics teachers' level of ICT integration was explored using means of responses gathered. This was an attempt to answer the research question one of the study. Ten statements comprising the use of computer, calculator and the internet were used to solicit the needed information. The research question one is stated and analyzed as follows.

Research Question 1: What is the level of in-service teachers' ICT integration in their mathematics classrooms?

Table 1 presents in-service teachers' rating of the level of the use of ICT (i.e. ICT integration) in mathematics lessons. The results in Table 1 show that the overall teachers' usage of ICT in teaching mathematics is fairly low (mean = 2.87, std. = 0.49). However, it was found that in-service teachers often teach students the effective use of calculators (mean =3.68, std. =0.19), make students submit assignments online (mean = 3.72, std. = 0.52), use Geometer's Sketchpad during construction lessons (mean =3.61, std. =1.19), as well as teach students how to attach files to email messages (mean = 3.84, std. = 0.24). In addition, respondents indicated that they barely use PowerPoint presentations during lessons (mean =2.49, std. = 0.31), draw scatter diagrams for bivariate distributions (mean = 2.92, std. = 0.32), investigate nature of graph of functions (mean = 2.76, std. = 0.22) and teach students how to search for information on the internet (mean = 2.95, std. = 1.17). However, respondents rarely taught students the use of Excel for statistical plots (mean = 1.45, std. = 0.44), as well as the use of multimedia operations during lessons (mean = 1.27, std. = 0.34). These results indicate that although in-service teachers use ICT in teaching mathematics they mostly limit themselves to the use of only simple applications involving Microsoft Word and unsophisticated technology resources.

Table 1: In-service Teachers' use of ICT in Mathematics (N = 185)

Item	Teachers' rating of the use of ICT in mathematics lessons	
	Mean	Standard Deviation
Teach students effective use of calculators	3.68	0.19
Use PowerPoint presentations during lessons	2.49	0.31
Students submit assignments online	3.72	0.52
Use multimedia operations (digital video) during lessons	1.27	0.34
Teach students with the use of Microsoft Excel for statistical plots	1.45	0.44
Use Geometer's sketchpad during construction lessons	3.61	1.19
Teach students how to attach files to email message	3.84	0.24
Draw scatter diagrams for bivariate distributions	2.92	0.32
Investigate the nature of graph of functions	2.76	0.22
Teach students how to search for relevant information on the internet	2.95	1.17

Source: Field data (2015), overall mean (= 2.87, Std. = 0.49)

The next section presents the empirical estimates of the factors influencing in-service teachers' ICT integration.

Multiple Regressions of the Determinants of ICT Integration

Multiple regression was employed to estimate the determinants of ICT integration into mathematics teaching and learning among in-service teachers in the Cape Coast Metropolis. The influencing factors were conceptualized as perceived internal and external factors. Three (3) separate models were estimated in all and the estimation was based on the responses received from 185 in-service teachers. The estimation was an attempt to answer the research questions two, three and four of the study. These research questions are analyzed as follows.

Research Question 2: To what extent is in-service teachers' ICT integration in teaching mathematics influenced by their perceived internal factors?

The internal factors include teachers' constructivist teaching beliefs, attitudes towards computer, technology competence and teaching experience. An attitude to computer was subdivided into four (4) which comprised computer liking, perceived usefulness, perceived control and affective components.

Analysis of the means of the internal factors was conducted, the results are presented as follows. The first internal factor explored in this study was teachers' constructivist beliefs.

Empirical evidence suggests that teachers' teaching beliefs and pedagogical philosophy influence their teaching efficiency, as well as the level of ICT integration. A constructivist class room challenges students to accept individual differences, increase readiness to learn, discover new ideas, and construct their own knowledge (Piaget, 1980). This study examined the level of in-service teachers' constructivist beliefs with regard to teaching and learning of mathematics. Table 2 presents the distribution of teachers' level of constructivist beliefs.

Table 2: Distribution of teachers' constructivist beliefs (N = 185)

Item	Teachers' mean rating of their Constructivist Belief	
	Mean	Standard Deviation (Std.)
Students work together without my direction	4.24	0.92
I believe that expanding on students' ideas is an effective way to build my curriculum	4.17	0.64
I prefer to cluster students' desk so they work together	4.10	0.71
I prefer to allow students learn and work on their individual pace	3.98	0.94
I always allow students to use try and error to create their own concept	3.82	0.76

Source: Field data (2015); overall mean (= 4.06, Std. = 0.79)

The overall teachers' constructivist beliefs score is high (mean = 4.06, std. = 0.79). Specifically, the results indicated that, teachers are perceived to allow students to work together without being directed during teaching and learning of mathematics (mean = 4.24, std. = 0.92); they believed that the effective way to build a curriculum is to expand on students' ideas (mean = 4.17, std. = 0.64); and most preferred to cluster students' desks to work together in the class room (mean = 4.10, std. = 0.71); and they reported that, students use try and error to create their own concepts (mean = 3.82, std. = 0.76). This result indicates that in-service teachers in the Central Region of Ghana have high constructivist beliefs and are expected to have high level of technology integration in teaching and learning of mathematics. The second internal factor examined in this study was computer attitudes.

A strong relationship between computer-related attitude and computer use has been established by the literature. Attitudes towards computer influence teachers' acceptance of the usefulness of technology and also whether or not it affects their ability to use ICT in their classrooms. Computer attitude was measured using 4 sub-scales: computer liking, perceived usefulness, perceived control and affective components (i.e. anxiety towards computers). The subscales were measured on a five-point Likert scale (1 = strongly disagree, and 5 = strongly agree). The scores were interpreted as 1 the lowest score, which represent a very strong negative attitude, whilst 5 is the highest possible score which represents a very strong positive attitude. On the affective component sub-scale, rescaling was done to reflect the negative worded questions. So that a high score on the computer anxiety scale can be interpreted as lack of anxiety. Respondents were asked to rate their attitudes towards computer. Appendix C Table C1 presents the mean rating of teachers' computer attitudes.

The results as depicted in Table C1 show that the overall in-service teachers had a strong positive attitudes toward the use of computers (mean = 3.82, Std. = 1.02). Thus, the teachers like using computers (mean = 3.99, Std. = 1.00); they reported high perceived usefulness (mean = 3.91, Std. = 1.04) of computers; had perceived control on the use of computers (mean = 3.23, Std. =

1.05); and they were not anxious working with computers (mean = 4.15, Std. = 0.96). Specifically, respondents agreed that the use of computers in teaching mathematics is worthwhile (mean = 4.28, std. = 0.90), working with computers enhance their self-confidence (mean = 3.66, std. = 1.08), working with computers is enjoyable and stimulating (mean = 4.20, std. = 1.06), using computers is interesting (mean = 4.15, std. = 1.14), computers are helpful for learning new mathematics concepts (mean = 4.05, std. = 0.76), and that the use of computers is helpful in performing differentiation among students (mean = 3.58, std. = 1.07). The results indicate a high level of computer liking attitudes among in-service teachers in the Cape Coast Metropolis and they are expected to integrate ICT in their teaching of mathematics.

Integration of ICT in mathematics depends on how teachers think about the usefulness of the use of computers to students and teachers themselves. Empirical evidence and theories assert that the use of computers can help students to become knowledgeable, reduce the amount of direct instructions given to them, and give teachers the opportunity to help those students with particular needs (Romeo, 2006; Iding, et al., 2002). In-service teachers were asked to rate how useful they perceived the use of computers in their classrooms. As observed from Table C1 the in-service teachers agreed that the mathematics learning process becomes efficient when using computers (mean = 3.96, std. = 1.05), using computer to teach mathematics enhances their presentations (mean = 4.04, std. = 0.76), computers help students to do their mathematics task and home works (mean = 4.00, std. = 0.95). In addition, respondents agreed that computers assist students with learning difficulties (mean = 3.55, std. = 1.24), and that the use of computer helps students to get better understanding in mathematics (mean = 4.01, std. = 1.19). An analysis of results from the questionnaire indicates that in-service teachers perceived the use of computers as very useful and for that matter they are expected to have high level of ICT integration in the teaching of mathematics.

The use of computers also depends on how the individual perceives his/her level of control in using computers. In-service teachers were asked to rate their level of control with the use of computers. Table C1 depicts the mean rating of respondents' perceived control with the use of computers. As observed in Table C1, the respondents indicated that they use computers to learn most of the things they need to know (mean = 3.51, std. = 1.30); could make computer do whatever they want it to do during lessons (mean = 3.65, std. = 1.19); and that they have complete control when using computers to teach mathematics (mean = 3.29, std. = 1.08). However, the respondents disagreed that if they get problem on their computers, they could solve it in one way or another (mean = 2.45, std. = 0.61). This result suggests that although the teachers had enough control on the use of computers they do not have the technical knowledge in terms of the operation of the software and hardware.

Evidence suggests that computer anxiety (i.e. affective components) is the most important dimension of attitude towards computer scale; indicating that teachers who are anxious about computers tend to develop a negative attitudes toward computers and oppose their use. The results as shown in Table C1 indicated that respondents disagreed that they could not think of any way to use ICT to teach mathematics (mean = 3.96, std. = 0.35), and also disagreed that employing ICT in mathematics is hard (mean = 3.51, std. =

0.20). Similarly, they disagreed that they have sinking feeling when they think of using ICT to teach mathematics (mean = 4.19, std. = 1.36); they also disagreed that they feel nervous when they are using computers (mean = 4.77, std. = 1.46). This result suggests in-service teachers in Cape Coast Metropolis are perceived to have exhibited lack of anxiety about the use of computers, and that they are expected to use ICT in teaching mathematics.

The third internal factor investigated in the study was technology competence. Technology competence is crucial in enhancing ICT integration. That is, the ability of a person to perform a specific task with computers determines his/her ICT integration. Smarkola (2008) argued that for effective ICT integration, teachers must move beyond being “computer literate” to “technology competent” since technology competency allows educators to use computers as part of the curriculum and as a tool for authentic student engagement. In-service teachers were asked to rate their technology competence with regard to some technology related activities. Table 3 shows the mean rating of respondents’ technology competence.

Table 3: Distribution of teachers' technology competence (N = 185)

Item	Teachers' mean rating of the level of Technology Competence	
	Mean	Standard Deviation (Std.)
Communication with colleagues and students on the internet	3.62	1.06
Creating Spreadsheet (MS Excel)	2.26	1.03
Making PowerPoint presentations	3.62	1.16
Draw graphs, logarithmic and trigonometric functions	2.59	1.07
Draw scatter plots for bivariate distributions	3.75	0.96
Using calculator to express recurring decimals to common fractions	3.64	1.25
Using calculator to compute the mean, median and standard deviation	3.89	1.02
Use the calculator to work depreciation of an item over a period	2.37	0.74

Source: Field data (2015); Overall mean (= 3.22, Std. = 1.02)

The overall score for teachers' technology competence is fairly high (mean = 3.22, Std. = 1.02). As observed from Table 3, respondents were proficient when it comes to the use of the internet to communicate with their colleagues and students (mean = 3.62, std. = 1.06), making PowerPoint presentations (mean = 3.62, std. = 1.16), drawing scatter plots for bivariate distributions (mean = 3.75, std. = 0.96), using calculator to express recurring decimals to common fractions (mean = 3.64, std. = 1.25) and the use of calculator to compute the mean, median and standard deviation (mean = 3.89, std. = 1.02). However, the in-service teachers were less proficient in the use of Microsoft Excel to create spreadsheet (mean = 2.26, std. = 1.03), draw graphs, logarithmic and trigonometric functions (mean = 2.59, std. = 1.07), and use the calculator to work depreciation of an item over a period (mean = 2.37, std. = 0.74). The results imply that in-service teachers in Central Region of Ghana appear to have high technology competence but their competency level is limited in the use of Excel, the use of calculator to perform logarithmic, trigonometric functions, as well as computing depreciation of an item over time.

Regression results of perceived internal factors are presented as follows:

In support of the mean analysis of the perceived internal factors, multiple regression analysis was conducted, and the results are as follow. Table 4 presents the empirical estimates of the perceived internal factors on ICT integration. As mention earlier, these factors included teachers' constructivist beliefs, technology competence, teaching experience and attitudes towards computer. Four (4) sub-scales were used to measure computer attitudes and these included computer liking, perceived control, affective component and computer usage. The R-squared of the model was 0.165 which means that the independent variables in the model explain 16.5 percent of the variations in the dependent variable (ICT integration).

The analysis produced F-value of 5.005 which was significant at 5% percent level of significance. This means that the model fit the data used in estimating the determinants of ICT integration. The R-squared is quite low but Woodridge (2005) argued that low R^2 in regression equations are common, especially for cross-sectional data analysis. Although R^2 is an indication of the goodness of fit of the model, the size of R^2 is not as important as statistical and economic significance of the covariates.

Table 4: Multiple regression estimates of perceived internal barriers on ICT Integration (N = 185)

Variables	Coefficient (B)	Standard Error	t-value	p-value
(Constant)	1.202	0.927	1.297	0.196
Constructivist Beliefs	0.302	0.144	2.097	0.022**
Technology competence	0.307	0.105	2.924	0.0018**
Teaching experience	0.017	0.014	1.214	0.600
Computer Attitudes				
Perceived control	0.232	0.084	2.763	0.006**
Computer Liking	0.254	0.094	2.702	0.009**
Affective component	-0.223	0.083	-2.691	0.038**
Computer usefulness	0.175	0.099	1.762	0.080*
R-squared	0.165			
F-value	5.005(0.000***)			

Source: Field data (2015); *p<0.10 ; **p<0.05; ***p<0.001

The results, as presented in Table 4, revealed teachers' constructivist beliefs, technology competence and computer attitude as having statistically significant effects on ICT integration. Thus, teachers with student-centered pedagogical beliefs are more likely to integrate ICT into mathematics lessons ($t = 2.097$; p-value = 0.022), and this positive relationship was significant at 5% level of significance. Similarly, teachers who are competent in the use of computers ($t = 2.924$, p-value = 0.0018), have perceived control on the use of computers ($t = 2.763$, p-value = 0.006), likes using computer ($t = 2.702$, p-value = 0.009), are more likely to integrate ICT in teaching mathematics. That is, there is a positive relationship between ICT integration, and teachers, who are perceived to be technology competent, perceived to have control on the use of computer, and likes using computers; and these relationships are statistically significant at 5% level of significance. In addition, teachers who see the use of computers as useful were perceived to be more likely to integrate ICT ($t = 1.762$, p-value = 0.08) and this positive relationship was significant at 10% level of significance. With regard to the effect of anxiety (i.e. affective component), a statistically significant negative relationship was found ($t = -2.691$, p-value = 0.038). This means that in-service teachers who fear to use and talk about computers were less likely to integrate ICT in teaching and learning of mathematics.

Therefore, the most influential variable among the internal barriers is teachers perceived technology competent level with ($t = 2.924$; p-value = 0.0018), closely followed by teachers perceived control on the use of computers ($t = 2.763$; p-value = 0.006) and then followed by perceived computer liking attitude ($t = 2.702$; p-value = 0.009). The next variable is the teachers perceived pedagogical beliefs (t = 2.097; p-value = 0.022). Also, is teachers who are perceived to see computers as useful (t = 1.762; p-value = 0.08). In-services teachers teaching experience (t = 1.214; p-value = 0.600) and the perceived affective component (anxiety of teachers; t = -2.691; p-value = 0.038) were found not to be significant and are less likely to integrate ICT in the teaching and learning of mathematics in the classroom

In an attempt to answer research question 3, the researcher did analysis on the external barriers on ICT integration in the following section.

Research Question 3: To what extent is in-service teachers' ICT integration influenced by perceived external barriers?

The perceived external barriers explored in the study included training, access to computer, time adequacy and school culture. In an attempt to answer question 3, analysis of the various barriers were conducted as follows:

Effective training opportunities for teachers in the use of ICT, the first external barrier to be considered and identified in literatures as one of the critical barriers to the use of ICT in the classroom (Pelgrum, 2001; Beggs, 2000). Aside the need to give pedagogical training to teachers, it is also necessary to train them in specific ICT skills. In an attempt to examine in-service teachers' level of training in ICT, teachers were asked to rate their level of training on some specific ICT skills and pedagogical skills. Results are presented in Table 5.

Table 5: Distribution of teachers' level of training in the use of ICT (N = 185)

Level of training in the following areas	Teachers' mean rating of their level of Training in ICT related areas	
	Mean	Standard Deviation (Std.)
Use of internet to select websites, discussions, etc.	4.38	0.31
Creating database using Microsoft Access	2.23	1.17
Use of graphical calculators	4.06	1.32
Use of scientific calculators	3.87	0.71
Use of Geometer's Sketchpad	3.73	1.29
The use of multimedia operations (such as digital video)	2.47	1.07
Subject specific training with learning software	2.16	0.68

Source: Field data (2015); Overall mean (= 3.27, Std. = 0.94)

The overall mean score for the level of training in the use of ICT is barely high (mean = 3.27, std. = 0.94). As shown in Table 5, the respondents have had high level of training in the use of the internet to select websites and discussions (mean = 4.38, std. = 0.31), the use of graphical calculators (mean = 4.06, std. = 1.32), scientific calculators (mean = 3.87, std. = 0.71), and the use of Geometer's Sketchpad (mean = 3.73, std. = 1.29). However, with regard to the use of Microsoft Access to create database, the teachers had low level of training (mean = 2.23, std. = 1.17), the use of multimedia operations such as digital video (mean = 2.47, std. = 1.07), and subject specific training with learning software (mean = 2.16, std. = 0.68). This result suggests that although the in-service teachers are computer literate, their level of training in the use of ICT is entirely moderate and can be linked to non-availability and accessibility of the technology resources in the various schools.

Lack of access to computer has been identified as one of the barriers to ICT integration among in-service teachers. Accessibility means the ease with which teachers come by the computers to be used in their teaching. In-service teachers were asked to rate their level of accessibility to computer-related technologies and the mean rating of the responses is presented in Table 6. These findings imply that in-service mathematics teachers in the Central Region of Ghana have poor level of accessibility to technology resources and this can be attributed to non-availability of such resources at their disposal.

Table 6: Distribution of teachers' level of computer accessibility (N=185)

Level of Access to Computer Technology	Teachers' mean rating of their level of Computer Accessibility	
	Mean	Standard Deviation (Std.)
Access to personal computer with internet at home	4.42	1.50
Access to general computer lab	3.71	1.35
Ability to book computer lab in advance of mathematics lessons	3.02	0.09
Access to special mathematics computer lab	1.32	0.52
Access to projectors for mathematics lessons	1.37	0.38
Access to broadband internet	1.44	0.27
Access to graphical calculators	3.90	1.52
Access to appropriate mathematics software	2.24	1.57

Source: Field data (2015); Overall mean (= 2.68, Std. = 0.90)

The overall mean score for computer accessibility is poor (mean = 2.68, std. = 0.90). As shown in Table 6, the teachers' level of computer accessibility was high with regard to their access to personal computers with internet connections at their homes (mean = 4.42, std. = 1.50), access to general computer laboratory in their schools (mean = 3.71, std. = 1.35), access to graphical calculators (mean = 3.90, std. = 1.52) and barely have access to book computer labs in advance of mathematics lessons (mean = 3.02, std. = 0.09). Teachers rarely had access to special mathematics computer labs (mean = 1.32, std. = 0.52), and projectors for mathematics lessons (mean = 1.37, std. = 0.38), and broadband internet connections (mean = 1.44, std. = 0.27). It was revealed that respondents had difficulty in accessing appropriate mathematics software (mean = 2.24, std. = 1.54).

The vision, plans, norms and values shared by school members (i.e. school culture) also influence ICT integration. Evidence suggests that effective ICT integration depends on the perception and vision of school leaders rather than teachers' ICT skills (Pelgrum & Law, 2009). In-service mathematics teachers were asked to rate the extent to which the school management encourages teachers to integrate ICT into teaching and learning of mathematics. Table 7 shows the average rating of school culture.

Table 7: School culture in promoting ICT integration (N = 185)

Item	Teachers' mean rating of School Culture in promoting ICT integration	
	Mean	Standard Deviation (Std.)
I am allowed to use ICT lab for teaching when necessary	4.23	1.38
My school provides opportunity to use ICT for teaching mathematics	3.98	1.43
The School Management encourages the use of ICT tools in teaching and learning of mathematics	3.46	0.32
ICT literacy is a requirement for appointment to teach mathematics	2.49	0.36
My school regularly undertake assessment of ICT usage in teaching mathematics	2.25	0.43
Teachers who use ICT tools to teach mathematics are rewarded by School Management	2.36	1.42

Source: Field data (2015); Overall mean (= 3.13, Std. = 0.89)

The overall mean score (mean = 3.13, std. = 0.89) implies that schools in the Cape Coast Metropolis have relatively favorable culture toward the use of ICT in teaching mathematics. As depicted in Table 7, the respondents agreed that they are allowed to use ICT for teaching when the need arises (mean = 4.23, std. = 1.38); and their school management encourages the use of ICT tools to teach mathematics (mean = 3.46, std. = 0.32). However, the respondents disagreed that their schools regularly undertake assessment of ICT usage in the work (mean = 2.25, std. = 0.43), and that there is no special reward from school management for teachers who use ICT tools to teach mathematics (mean = 2.36, std. = 1.42). Similarly, respondents disagreed that ICT literacy was a requirement for their appointment to teach mathematics in their schools (mean = 2.49, std. = 0.36. These results imply that most of the schools in the Central Region of Ghana have computer labs and culture that promotes ICT usage albeit little level of reward from school management that needs to be considered.

Adequacy of time available to teachers is crucial to their use of ICT tools in teaching mathematics. An attempt was made by the researcher to examine whether or not in-service teachers have enough time to integrate ICT in their work. Table 8 shows teachers rating of time adequacy for ICT integration.

Table 8: Distribution of teachers' time adequacy for ICT use (N = 185)

Item	Teachers' mean rating of Time adequacy for ICT integration	
	Mean	Standard Deviation (Std.)
I have enough time to plan and integrate ICT in my mathematics lessons	3.67	1.02
I can complete the syllabus if I integrate ICT in my mathematics lessons	3.23	0.86
There is little time on the time table to plan and integrate ICT in my lessons	2.29	1.03
The school time table gives enough room for ICT integration in teaching mathematics	2.27	0.52
My busy schedule does not allow me to integrate ICT in teaching mathematics	2.10	0.62
Even if I integrate ICT in my lessons, I still have time to complete the syllabus	4.43	0.39

Source: Field data (2015); Overall mean (= 2.99, Std. = 0.74)

The overall mean score on time scale is fairly low (mean = 2.99, std. = 0.74). As shown in Table 8, the teachers agreed that they have enough time to plan and integrate ICT in mathematics lessons (mean = 3.67, std. = 1.02), and that even if they integrate ICT in lessons, they will still have time to complete the syllabus (mean = 4.43, std. = 0.39). However, respondents disagreed that the school time table gives enough room for ICT integration (mean = 2.27, std. =

0.52), and also disagreed that their busy schedule does not allow them to integrate ICT in lessons (mean = 2.10, std. = 0.62).

Further analysis was conducted using multiple regression of the external barriers to ICT integration. Empirical results are presented in Table 9. Four (4) barriers which included school culture, training opportunity, time adequacy and access to technology were examined. The R-squared of the model 2 was 0.258 (see Table 9) which means that the independent variables explained 25.8% of the variation in the dependent variable (ICT integration). The analysis of variables produced an F-value of 15.676 (see Table 9) which was statistically significant at 10% level of significance. This suggests a good fit of the model to the data used in the estimation.

Table 9: Multiple regression estimates of perceived external factors on ICT integration (N = 185)

Variables	Coefficient (B)	Standard Error	t-value	p-value
School Culture	0.286	0.102	2.807	0.006**
Training	0.168	0.095	1.768	0.079*
Time	0.320	0.121	2.652	0.009**
Access to Technology	0.082	0.112	0.732	0.462
R-square	0.258			
F-value (Sig.)	15.676(0.000***)			

Source: Field data (2015); *p<0.10 ; **p< 0.05; ***p<0.001

As observed in Table 9, school culture, time and training were statistically significant external factors that influence in-service teachers' ICT integration into mathematics teaching. That is, teachers who find themselves in schools that have plans, vision and values for technology (school culture) and the most valuable variable among the external barriers ($t = 2.807$, p-value $= 0.006$) are more likely to integrate ICT in the teaching and learning of mathematics. The second most influential external barrier is time adequacy. Thus, in-service teachers who when given enough time in the curriculum ($t = 2.652$, p-value $= 0.009$) are equally likely to integrate ICT in the mathematics classroom, and lastly, teachers perceived to have enough training in the use of technology resources ($t = 1.768$, p-value $= 0.079$) are more likely to integrate ICT into mathematics teaching. Although access to technology had the expected sign (i.e. positive), but the coefficient was not statistically significant at the acceptable levels of significance ($t = 0.732$; p-value $= 0.462$).

The next section presents the analysis of the effects of both internal and external barriers on ICT integration. This is to enable the researcher know the compared strengths of both internal barriers and the external barriers on the integration of ICT in the teaching and learning of mathematics.

Research Question 4: To what extent do both internal and external barriers influence ICT integration?

The effects of both internal and external determinants of ICT integration into mathematics teaching were analyzed using the overall means and standard deviations of the relevant factors. Table 10 presents the overall means for both barriers. One each of the internal barriers (teaching experience) and the external barriers (access to computer) were omitted from the subsequent analysis since they were found not to be significant in the regression analyses.

Table 10: Distribution of scores for internal and external barriers on ICT integration (N = 185)

Items	Means	Standard deviation (std)
Internal factors (overall mean)	***3.70***	***1.02***
Constructivist beliefs	4.06	0.79
Computer attitudes	3.82	1.02
Technology competence	3.22	1.02
External factors (overall mean)	***3.13***	***0.85***
Culture	3.13	0.89
Training	3.27	0.94
Time	2.99	0.74

Source: Field data (2015)

The overall mean scores for both internal barriers (mean = 3.70, std. = 1.02) and external barriers (mean= 3.13, std. = 0.85) show fairly high in influencing in-service teachers' use of ICT to teach mathematics. The mean score for teachers' constructivist beliefs (mean = 4.06, std. = 0.79) as depicted in Table 9 revealed that teachers who are perceived to have student-centered beliefs are good integrators of ICT. Also, teachers who have positive attitudes towards computers are more likely to integrate ICT into the teaching of mathematics (mean = 3.82, std. = 1.02).

Teachers who are believed to have the skills with the use of ICT are more likely to integrate ICT (mean = 3.22, std. = 1.02). The more pronounced external factors that enhance ICT use are school culture, level of training and time adequacy. Thus, teachers who find themselves in schools that have the visions and values for the promotion of ICT use are more likely to be good integrators (mean = 3.13, std. =0.89). Teachers who have had training in the use of ICT are more likely to be good integrators (mean = 3.27, std. = 0.94). The overall mean score for time adequacy was fairly low (mean = 2.99, std. 0.74). Thus, teachers who are limited by time to plan for technology lessons are less likely to integrate ICT into the teaching of mathematics.

The effects of both internal and external barriers of ICT integration into mathematics teaching were further investigated using multiple regression analysis. The weight of each parameter and their relationships with ICT integration were determined. The results, as shown in Table 11, indicate that the R-square (R^2) from the model with only internal barriers was 0.165, which means that 16.5% of the variance in ICT integration was accounted for by in-service teachers' perceived internal barriers. The F test ($F = 5.005$, $p < 0.01$) associated with the independent variable (Internal barriers) was significant, indicating that the independent variable predicted the dependent variable if only internal barriers scale was considered in the model. In addition, adding the external barriers measure improved the predictability for ICT integration from approximately 16.5% to approximately 35.3%. The F test ($F = 12.005$, $p <0.01$) associated with the two independent variables was significant at 5% level of significance. However, the results revealed that the external barriers measure was stronger in predicting ICT integration than the internal barriers measure (as shown by R^2 change = .188).

Table 11: Estimates of the effects of internal and external barriers on ICT integration (N = 185)

ICT integration	R	R-square	F-value(sig)
Perceived Internal barriers	0.405	0.165	5.005(0.000***)
Perceived External barriers	0.594	0.353	12.005(0.000***)

Source: Field data (2015)

Discussion of Results

The study was conducted to explore the extent to which internal and external factors (i.e. barriers) influence teachers' pedagogical integration of ICT into mathematics teaching, using in-service SHS teachers in Central Region of Ghana. Internal factors included teachers' teaching beliefs, technology competence, experience and attitude towards computers. The external factors were culture, training, access to computer and time adequacy. In order to achieve the aim of the study, four (4) research questions were answered using estimates from multiple regression analysis.

The study revealed that young teachers are more likely to integrate ICT into mathematics teaching than their older peers. In addition, less experience teachers are more likely to integrate ICT than the more experience teachers. These findings were consistent with the findings by Sia (2000) on the relationship between computer anxiety and computer literacy among teachers in Miri, Sarawak, which revealed that the younger, less experienced teachers use computers in a broader, more transformational fashion since these teachers are probably more likely to be computer proficient, will have had more digitally focused teacher education courses, and will be less constrained by prior habits or attitudes than their older, more experienced colleagues. Similarly, the findings are consistent to those by Rosen and Maguire (1990) on understanding teachers' perception towards computers and computerized instruction concluded that teachers teaching experience does not eliminate computer phobias and many experienced teachers display some wariness, discomfort and/or mild anxiety in relation to computers.

Also, the study revealed that in-service teachers' use of ICT was low and is they mostly used applications involving Microsoft Word and simple technology such as calculators. These findings are in support of the findings by Boakye and Banini (2008) on teachers' readiness for the use of technology in Ghanaian schools, which indicated that, 71% of the teachers did not use technology in classrooms, 49% of teachers use technology to prepare lesson notes, 55% of teachers have some knowledge of web browsing, 71% use email, and 78% tried to make an effort to learn how to use the computer. In addition to this, the result is in line with Waite (2004) who opines that even though most educators show great interest and motivation to learn about the potential of technology, in practice, the use of technology is relatively low and it is focused on a narrow range of applications, with word processing being the predominant use.

The research question 2 investigated the extent to which in-service teachers' ICT integration is influenced by internal factors. The analysis revealed that teachers' constructivist beliefs, competency in the use of technology, favorable computer attitude (which include control on the use of computers) are more likely to encourage them to integrate ICT into mathematics teaching. However, teachers who fear to use or talk about computers (i.e. anxiety) were less likely to integrate ICT into teaching. These findings support that of Ertmer (2005) who found that teachers with strong constructivist educational beliefs are more likely to use ICT in their classroom practice. Similarly, Honey and Moeller (1990) found that teachers with student-centered pedagogical beliefs were successful at integrating technology expect in cases where anxiety about computers prevented them from appropriating the technology.

However, chai, et al. (2009) found that teachers' beliefs are related to their attitude toward computers. Haung and Liaw (2005) found that computer attitude plays key role in successful use of computers in the class room; and that the success of any initiative to implement technology in an educational program should depend strongly upon the support and attitudes of the implementers involved. Also, the findings of this study is consistent with that of Sang, et al. (2010) that in-service teachers with higher levels of technology competencies are likely to use computers more often and experienced less computer-related anxiety in their teaching practices. On the other hand, teachers with lower levels of technology competencies become more frustrated and more anxious, and hesitate to use computers when they encounter obstacles.

With regard to the research question 3 which investigated the extent to which external factors influence in-service teachers ICT integration. It was found that teachers who find themselves in schools whose values and norms (i.e. culture) promote the use of technology; availability of training opportunity for teachers; and time adequacy are the most influential factors that increase teachers' use of ICT in the classroom. These findings are supports that of Pelgrum and Law (2009) who found that effective ICT integration depend on the perception and vision of school leaders rather than teachers' skills. Tezci (2011b) found that teachers, who receive adequate technical and motivational support from their schools, are more likely to use ICT. In support of that Ward and Parr (2010) stated that teachers need to feel confident in their ability to facilitate student learning with technology in order to integrate technology into their classrooms. To achieve this goal, more professional development is required with a focus on increasing teachers' skills so that they are able to overcome apprehensions associated with using technology.

This study is also consistent with Beggs (2000) and Toprakci (2006) who found that lack of training has been the main factor impeding teachers' use of ICT in teaching. Similarly, Gomes (2005) found that lack of training in digital literacy, lack of pedagogical and didactic training on how to use ICT in the classroom and lack of training concerning the use of technologies in mathematics specific areas were obstacles to using new technologies in classroom practices. In view of that, Becta (2004) opined that teachers must be provided with pedagogical training rather than simply training them to use ICT tools.

Analysis of the research question 4 revealed that in-service teachers' use of ICT in teaching is influenced by both internal and external factors with the external factors having stronger predictability of ICT integration than the internal factors. These findings suggest that in-service teachers' beliefs, attitudes and competence must be complemented by appropriate ICT training, favorable school culture and adequate time so as to enhance ICT integration. This supports the findings by Pelgrum and Law (2009) who found that effective ICT integration depends on the perception and vision of school leaders rather than teachers' ICT skills. Chai, Hong and Teo (2001) found that teachers' actions, beliefs and attitudes must be mediated by school culture in order to ensure effective ICT integration.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

This final chapter presents a summary of major findings of the empirical study on the determinants of Information and Communication Technology (ICT) integration into Mathematics teaching and learning in selected schools in the Central Region of Ghana. It also includes the main conclusions drawn from the study and policy recommendations derived from the analysis of the available data. Suggestions for further research are also outlined.

Summary

This study was set out to examine the determinants of ICT integration into Mathematics teaching and learning in selected Senior High Schools in the Central Region of Ghana. Specifically, the study aimed to examine the effects of internal barriers (constructivist teaching beliefs, teaching experience, attitudes toward computer and technology competence) and external barriers (access to technology use, level of training in the use of technology, time adequacy, as well as, the culture of the teacher's institution) in predicting in-service teachers' usage of ICT in the teaching and learning of Mathematics.

The study employed the descriptive survey design to answer the research questions of the study. A 5-point Likert Scale questionnaire was the instrument for data collection. Both purposive and convenience sampling techniques were used to select 185 in-service teachers for the study. Cronbach's Alpha reliability test was used to examine the internal consistency and validity of the instrument. Three separate models were estimated in all and the estimation was based on the 185 teachers. The multiple regression model uses the ordinary least squares (OLS) technique to estimate the unknown coefficients. Independent t-test was employed to test whether ICT integration differs by age and experience. The Statistical Product and Service Solution (i.e. SPSS version 22) software was used for the analysis.

The major findings of the study are as follows:

The study found that respondents had personal computers with internet at their homes; majority of the schools had general computer labs, graphic and scientific calculators but do not have special computer labs, adequate computers and appropriate mathematics software for mathematics lessons. In addition, it was revealed that most of the schools do not have broadband internet connections.

Also, in-service teachers often teach students effective use of the calculator, Geometer's Sketchpad, and how to submit assignment online, as well as how to attach files to email messages. However, majority of the teachers never taught students the use of Excel for statistical plots, as well as the use of multimedia operations. In addition, the study found that although the in-service teachers were computer literate, their level of training in the use of ICT was entirely low. This low level of training was linked to non-availability and accessibility of the technology resources in the various schools.

The study revealed that in-service teachers' ICT integration in the teaching of Mathematics was fairly low as majority of them mostly used simple applications involving Microsoft Word and unsophisticated technology such as the use of calculators, Geometer's Sketchpad, attaching files and sending of emails

With regards to the effects of teachers' perceived internal factors and ICT integration, the study found that teachers' constructivist beliefs, technology competence, and computer liking attitudes had statistically significant effects on ICT integration.

The study also revealed that school culture, time adequacy, and training were the most important external factors that influenced in-service teachers' perceived use of ICT in teaching Mathematics.

Both internal and external factors had significant effects on ICT integration; but the external factors had stronger predictability of ICT integration than the internal factors.

The study also revealed that teachers between the ages of 23 to 39 years and those who had taught for less than 10 years were more likely to integrate ICT into mathematics lessons.

Conclusions

Base on the major findings of the study, the researcher makes the following conclusions:

The use of ICT among in-service teachers in Central Region was low as most of them used applications involving Microsoft Word and simple technology such as calculators. The use of spreadsheet techniques (Excel) as instructional tools to support Mathematical concept formation was a challenge.

Teachers' perceived internal factors influence ICT integration in Mathematics Education. That is, teachers perceived to have student-centered pedagogical beliefs, those perceived to be competent in the use of computers and those who have control and like to work with computer were more likely to integrate ICT into Mathematics education. In-service teachers in Central Region are not anxious with the use of ICT tools.

Teachers' perceived external barriers influence their use of ICT in teaching Mathematics. That is, teachers who find themselves in schools that have plans, vision and values for technology, and are allowed enough time in the curriculum, and have enough training in the use of technology were more likely to integrate ICT into Mathematics education.

Teachers' perceived external barriers are more influential than internal barriers in predicting ICT integration.

Young teachers are more likely to integrate ICT into mathematics teaching than their older peers. In addition, less experienced teachers are more likely to integrate ICT than the more experienced teachers.

Recommendations

Taking cognizance of the findings of the study, the following policy recommendations are proposed for enhancing the use of ICT in teaching and learning of Mathematics:

i Teachers need to be encouraged to integrate ICT in the teaching of mathematics. This encouragement might be seen by allowing mathematics teachers adequate time, making the time table flexible, regular ICT training, value the use of technology in teaching. This to a greater extent builds teachers self-efficacy and encourage them to integrate ICT.

ii The Parent Teacher Associations, school management, together with, the school boards may put more priority on the provisions of ICT facilities in schools (e.g. mathematics labs, appropriate mathematics software, computers, projectors) to facilitate and increase ICT accessibility.

iii The study revealed that favorable school culture enhances the use of ICT in teaching Mathematics. The study therefore recommends that the School management provides school environment that encourages and rewards teachers who integrate ICT in the teaching and learning of Mathematics.

iv The heads of departments may be tasked to organize regular in-service training in professional development courses for teachers. The integral part of the design of the professional development must geared towards increasing teachers' competencies and decreasing their anxiety in ICT use.

Suggestions for Further Research

Further studies could investigate the same issue using a comparative analysis between public and private schools to improve the work. In addition to this, qualitative approach to research can be conducted to unearth the reasons why people may not integrate ICT in teaching. Also, socioeconomic determinants of ICT integration can also be considered by future studies as they are crucial factors for the use of ICT in teaching Mathematics in schools.

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APPENDICES

APPENDIX A: Reliability test

Table A1: Computed Reliability Coefficients

Main Variables	Sub-categories	Number of items	Sample size	Cronbach' Alpha value
Constructivist Belief	-	5	20	0.747
	Computer Liking	6	20	0.797
Computer Attitude	Computer Usage	5	20	0.740
	Affective component	5	20	0.845
	Perceived control	4	20	0.724
Technology Competence	-	8	20	0.896
Training	-	7	20	0.887
Computer Availability	-	8	20	0.812
Computer Access	-	8	20	0.794
Culture	-	6	20	0.822
Time	-	6	20	0.813
Technology Integration	-	10	20	0.764
Over all	-	78		0.921

APPENDIX B: Technology resource availability

Table B1: Distribution of technology resources available to Teachers (N= 185)

	Yes		No	
Availability of technology resources	N	%	N	%
1. Personal computer and internet access at home	139	75.00	46	25.00
2. General computer lab at my school	140	75.70	45	24.30
3. Special computer lab for mathematics lessons	0	0.00	185	100.00
4. Projectors are readily available for mathematics lessons	43	23.20	142	76.80
5. Broadband internet connection at school	37	20.00	148	80.00
6. Graphical calculators for use by mathematics teachers during lessons	74	40.00	111	60.00
7. Enough computers with appropriate mathematics software at school	25	13.50	160	86.50
8. Enough scientific calculators for use during mathematics lessons	150	81.00	35	19.00

APPENDIX C: Analysis of computer attitudes

Table C1: Distribution of computer attitudes of respondents (N = 185)

Item	Teachers' Computer Attitudes	
	Mean	Standard Deviation (Std.)
Computer liking	***3.99***	***1.00***
The use of computers in teaching mathematics is worthwhile	4.28	0.90
Self-confidence is enhanced when working with computers	3.66	1.08
Working with computer is enjoyable and stimulating	4.20	1.06
Using computers is interesting	4.15	1.14
Computer is helpful for learning new mathematics concepts	4.05	0.76
Use of computers is helpful in performing differentiation	3.58	1.07
Perceived Usefulness	***3.91***	***1.04***
Mathematics learning process becomes efficient when using computers	3.96	1.05
Using computer to teach mathematics enhances my presentations	4.04	0.76
Computers help students do their mathematics task and home works	4.00	0.95
Computers assist students with learning difficulties	3.55	1.24
The use of computer helps students to get better understanding in mathematics	4.01	1.19
Perceived control	***3.23***	***1.05***
I use my computer to learn most of the things I need to know	3.51	1.30

I make my computer do whatever I want it to do during lessons	3.65	1.19
If I get problems on my computer, I can usually solve them in one way or another	2.45	0.61
I have complete control when I use my computer to teach mathematics	3.29	1.08
Affective components	***4.15(R)***	***0.96***
I cannot think of any way to use computer (ICT) to teach mathematics as a tutor	3.96 (R)	0.35
Employing ICT in mathematics is very hard for me	3.51(R)	0.20
I get a sinking feeling when I think of trying to use ICT to teach mathematics	4.19 (R)	1.36
I hesitate to use computer for fear of making mistakes that I cannot correct	4.29 (R)	1.45
I feel very nervous when I am using a computer and for that matter ICT	4.77 (R)	1.46

Source: Field data (2015); Overall mean (= 3.82, Std. = 1.02); R = rescaled value

APPENDIX D: Background characteristics

Table D1: Age distribution of Respondents

Age categories	Frequency	Percentage	Cumulative percentage
23-32	50	27.0	27.0
33-42	83	44.9	71.9
43-52	42	22.7	94.6
53-62	10	5.4	100.0
Total	185	100.0	

Source: Field data (2015)

Table D2: Distribution of years of teaching of mathematics

Years of teaching	Frequency	Percentage	Cumulative percentage
1-5	74	40.0	40.0
6-10	51	27.6	67.6
11-15	26	14.1	81.6
16-20	29	15.7	97.3
21-25	5	2.7	100.0
Total	185	100.0	

Table D3: Independent t-Test of Age and Experience on ICT Integration

Factor	Categories	N	Mean	Std.	df.	t	p-value
Age	23 - 42	133	2.98	0.95	183	3.75	0.000***
	43 - 62	52	2.59	1.07			
Experience	Less than 10 years	108	2.95	0.99	183	2.76	0.007**
	10 or More	77	2.51	1.01			

Source: Field data (2015); $^{**}p< 0.05$; $^{***}p<0.001$

APPENDIX E: Estimates for internal factors

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.202	.927		1.297	.196
	ConstBlf	.302	.154	.149	1.958	.052
	TechCompt	.037	.105	.030	.348	.728
	CompLiK	.254	.094	.117	2.763	.009
	PercvCont	.232	.084	.237	2.763	.006
	Experience	.007	.014	.043	.526	.600
	AfftivCompo	-.223	.083	.201	-2.691	.038
	CompUsage	.175	.099	.133	1.762	.080

a. Dependent Variable: InservTeach

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.406[a]	.165	.132	.93773	1.908

a. Predictors: (Constant), CompUsage, PercvCont, CompLiK, AfftivCompo, ConstBlf, Experience, TechCompt

b. Dependent Variable: InservTeach

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	30.807	7	4.401	5.005	.000[b]
	Residual	155.644	177	.879		
	Total	186.451	184			

a. Dependent Variable: InservTeach

b. Predictors: (Constant), CompUsage, PercvCont, CompLiK, AfftivCompo, ConstBlf, Experience, TechCompt

APPENDIX F: Estimates for external factors

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.508[a]	.258	.242	.87649	1.907

a. Predictors: (Constant), Time, TraiN, CulT, TechAccs

b. Dependent Variable: InservTeach

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	48.170	4	12.042	15.676	.000[b]
	Residual	138.281	180	.768		
	Total	186.451	184			

a. Dependent Variable: InservTeach

b. Predictors: (Constant), Time, TraiN, CulT, TechAccs

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.646	.380		1.699	.091
	CulT	.286	.102	.328	2.807	.006
	TechAccs	.082	.112	.089	.737	.462
	TraiN	.168	.095	.152	1.768	.079
	Time	.320	.121	.227	2.652	.009

a. Dependent Variable: InservTeach

APPENDIX G: Estimates for joint effects of both factors

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.594[a]	.353	.324	.82788

a. Predictors: (Constant), CompUsage, TechCompt, CompLiK, Time, ConstBlf, TraiN, CulT, TechAccs

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	65.823	8	8.228	12.005	.000[b]
	Residual	120.628	176	.685		
	Total	186.451	184			

a. Dependent Variable: InservTeach

b. Predictors: (Constant), CompUsage, TechCompt, CompLiK, Time, ConstBlf, TraiN, CulT, TechAccs

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.426	.791		.538	.591
	ConstBlf	.446	.145	.220	3.080	.002
	TechCompt	.095	.114	.077	.833	.406
	TraiN	.171	.098	.155	1.751	.082
	TechAccs	.267	.123	.289	2.181	.030
	CulT	.396	.103	.453	3.861	.000
	Time	.449	.147	.317	3.054	.003
	CompLiK	.219	.083	.166	2.628	.009
	CompUsage	.326	.097	.249	3.369	.001

a. Dependent Variable: InservTeach

APPENDIX H: Questionnaire

Instructions

The purpose of this questionnaire is to gather data on your ICT integration into your mathematics teaching in your school. Your thoughtful and truthful responses will be greatly appreciated. Please answer each question to the best of your knowledge. Your name is not required. Your responses will be kept completely confidential. Thank you for taking time to complete this questionnaire.

A. Background information

Please tick [√] in the appropriate space provided below.

1. Age: ………………. (years)

2. Years of experience in teaching mathematics at the SHS level? ……..........

B. Constructivist Belief Scale

During teaching and learning of mathematics, rate the level for which you employ the following strategies in your lessons.	Please **CIRCLE** a number to rate EVERY option				
	Strongly Agree	**Agree**	**Undecided**	**Disagree**	**Strongly Disagree**
i. I make it a priority in my classroom to give students time to work together when I am not directing them	5	4	3	2	1
ii. I believe in involving students in	5	4	3	2	1

	evaluating their own work					
iii.	I believe that expanding on students' ideas is an effective way to help build my curriculum	5	4	3	2	1
iv.	I prefer to cluster students' desks or use tables so they can work together (group work)	5	4	3	2	1
v.	I prefer to allow students learn and work at their own individual pace	5	4	3	2	1
vi.	I always employ the idea of allowing students do "try and error" to create their own concepts	5	4	3	2	1

C. Computer Attitude Scale (CAS)

Rate your level of agreement of the following statements		Please **CIRCLE** a number to rate EVERY option				
		Strongly Agree	**Agree**	**Undecided**	**Disagree**	**Strongly Disagree**
	Computer Liking Attitude					
i.	Learning to use computers to teach mathematics is worthwhile	5	4	3	2	1
ii.	I have a lot of self-confidence when it comes to working with computers	5	4	3	2	1

iii.	I think working with computers is enjoyable and stimulating	5	4	3	2	1
iv.	I think working with computer to teach mathematics is interesting and for fun	5	4	3	2	1
v.	computer gives me opportunities to learn many new mathematical concepts	5	4	3	2	1
vi.	Computers do help me to apply differentiation among the students	5	4	3	2	1
	Computers usage scale (perceived usefulness)					
i.	The efficiency of the learning process of mathematics is increased through the use of computers	5	4	3	2	1
ii.	Computers do enhance the presentation of my work as a mathematics tutor to a degree which justifies the extra effort	5	4	3	2	1

iii.	help pupils to undertake mathematical tasks or follow up class work at home on the computer.	5	4	3	2	1
iv.	Students with learning difficulties can strongly benefit from the didactic possibilities using the computer	5	4	3	2	1
v.	The use of computer helps students to achieve better understanding of mathematical concepts	5	4	3	2	1
	Affective component					
i.	I can't think of any way that I will use ICT (e.g. computers) in my teaching career as a mathematics teacher	5	4	3	2	1
ii.	Employing ICT in mathematics teaching is very hard for me.	5	4	3	2	1
iii.	I get a sinking feeling when I think of trying to use ICT (e.g. computer,	5	4	3	2	1

	scientific calculators, etc.) to teach mathematics					
iv.	I hesitate to use a computer for fear of making mistakes I can't correct	5	4	3	2	1
v.	Working with a computer and for that matter ICT makes me very nervous	5	4	3	2	1
vi.	If there are computers in my classroom it would help me to be a better teacher	5	4	3	2	1
vii.	I always employ ICT in the teaching and learning of my mathematics teaching practices.	5	4	3	2	1
	Perceived control component					
i.	I could probably teach myself most of the things I need to know about computers	5	4	3	2	1
ii.	I can make the computer do what I want it to during my lessons.	5	4	3	2	1

iii. If I get problems using the computer, I can usually solve them one way or the other	5	4	3	2	1
iv. I am in complete control when I use a computer to teach mathematics lessons	5	4	3	2	1
v. I need an experienced person nearby when I use a computer	5	4	3	2	1

D. Technology competence

Rate your ability to do the following using ICT tools (e.g. computer, graphical calculator, etc.)	Please **CIRCLE** a number to rate EVERY option				
	Excellent (Advanced)	**Good (Proficient)**	**Satisfactory (progressing)**	**Learning (Needs improvement)**	**Poor (Can' t use it)**
i. finding information on internet for teaching	5	4	3	2	1
ii. communicating with colleagues and	5	4	3	2	1

students					
iii. use computer to create spreadsheets (MS Excel)	5	4	3	2	1
iv. computer for creating database (MS Access)	5	4	3	2	1
v. making presentations (PowerPoint)	5	4	3	2	1
vi. drawing graphs using the computer (e.g. grouped data, logarithmic and trigonometric functions)	5	4	3	2	1
vii. drawing scatter diagram for bivariate distributions using computer.	5	4	3	2	1
viii. expressing recurring decimals as common fractions using the	5	4	3	2	1

calculator.					
ix. calculating the mean, median and standard deviation using the calculator	5	4	3	2	1
x. determining the depreciation of an item over a period using calculator	5	4	3	2	1
xi. Determining the roots of quadratic functions using calculator.	5	4	3	2	1
xii. use multimedia operations such as digital videos and/or audio equipment in mathematics	5	4	3	2	1

E. Training

To what extent have you had training in the following areas of study	Please **CIRCLE** a number to rate EVERY option				
	Highly (well trained)	**Good (Bases)**	**Satisfactory**	**Poor (somewhat)**	**Never (not at all)**
i. Internet use (selection of suitable websites, user groups/discussion, etc.)	5	4	3	2	1
ii. Presentation software such as power point	5	4	3	2	1
iii. Spreadsheet such as Microsoft excel for plotting statistical graphs	5	4	3	2	1
iv. Database	5	4	3	2	1
v. Graphical calculator use	5	4	3	2	1
vi. Scientific calculator use	5	4	3	2	1
vii. Geometer's sketchpad for constructions	5	4	3	2	1
viii. Multimedia operations such as digital video and/or audio equipment in mathematics	5	4	3	2	1

ix.	Subject specific training with learning software for specific content mathematics goals (e.g. tutorials, simulations, etc.)	5	4	3	2	1

F. Computer Availability

	For each of the following, indicate its availability for teaching and learning.	Please **CIRCLE** a number to rate EVERY option	
		Yes	**No**
i.	Personal computer with Internet at home	2	1
ii.	General computer laboratory in my school	2	1
iii.	Special computer lab for mathematics lessons with mathematics-specific software	2	1
iv.	Projector(s) are readily available for use by me during mathematics lessons	2	1
v.	Broadband internet access in every part of my school	2	1
vi.	Graphical calculators for mathematics teachers to use during lessons	2	1
vii.	Enough computers with appropriate mathematical software in my school	2	1
viii.	Enough scientific calculators for use during mathematics lessons	2	1

F. Computer Access

For each of the following, indicate its accessibility for teaching and learning.	Please **CIRCLE** a number to rate EVERY option				
	Excellent (Always)	**Good (often)**	**Barely (sometimes)**	**Poor (difficult)**	**Never**
ix. Personal computer with Internet at home	5	4	3	2	1
x. General computer laboratory in my school	5	4	3	2	1
xi. Mathematics teachers can book computer lab in advance for mathematics lessons	5	4	3	2	1
xii. Special computer lab for mathematics lessons with mathematics-	5	4	3	2	1

	specific software					
xiii.	Projector(s) are readily available for use by me during mathematics lessons	5	4	3	2	1
xiv.	Broadband internet access in every part of my school	5	4	3	2	1
xv.	Graphical calculators for mathematics teachers to use during lessons	5	4	3	2	1
xvi.	Enough computers with appropriate mathematical software in my school	5	4	3	2	1

G. Culture

For each of the statements, rate your level of agreement	Please **CIRCLE** a number to rate EVERY option				
	Strongly Agree	**Agree**	**Does Not Know**	**Disagree**	**Strongly Disagree**
i. I am allowed to use ICT laboratory for teaching when necessary	5	4	3	2	1
ii. My school provides opportunity for training teachers in the use of ICT tools for teaching mathematics	5	4	3	2	1
iii. School management (i.e. headmaster and for that matter administration) encourages the use of ICT tools in teaching and learning mathematics	5	4	3	2	1
iv. ICT literacy was a requirement for appointment to teach mathematics in my school	5	4	3	2	1
v. There is regular assessment of ICT usage for teaching and learning mathematics by school management.	5	4	3	2	1
vi. School management reward teachers who use ICT tools in teaching mathematics	5	4	3	2	1

H. Time

For each of the statements, rate your level of agreement	Please CIRCLE a number to rate EVERY option				
	Strongly Agree	**Agree**	**Undecided**	**Disagree**	**Strongly Disagree**
i. I have enough time at my disposure to plan to integrate ICT in the teaching of mathematics	5	4	3	2	1
ii. I can complete the syllabus if I implore integration of ICT in the teaching and learning of mathematics	5	4	3	2	1
iii. I have enough period on my teaching time table to explore and practice the use of ICT to teach mathematics	5	4	3	2	1
iv. There is little time for me on the teaching time table to plan to integrate ICT into mathematics lessons.	5	4	3	2	1

v.	The school's teaching time table gives enough room for me to integrate ICT during mathematics lessons.	5	4	3	2	1
vi.	My busy schedules does not allow me integrate ICT in my lessons as a mathematics teacher	5	4	3	2	1
vii.	Even if I integrate ICT in my lessons, I still have enough time to complete all the topics in the syllabus	5	4	3	2	1

I. Technology integration in Mathematics:

Rate your frequency of use of ICT during mathematics lessons		Please **CIRCLE** a number to rate EVERY option				
		Always	**Very often**	**Often**	**Barely**	**Never**
i.	I allow my students to use calculators to perform calculations during lessons	5	4	3	2	1
ii.	I teach students how to use their calculators effectively	5	4	3	2	1
iii.	I usually display mathematical procedures from presentation software such as PowerPoint.	5	4	3	2	1

iv. Students submit their assignments to me online	5	4	3	2	1
v. I use multimedia operations such as digital video and/or audio equipment in mathematics lessons.	5	4	3	2	1
vi. I do assist students to use spreadsheet such as Microsoft excel for plotting statistical graphs	5	4	3	2	1
vii. I use Geometer's sketchpad for constructions during construction lessons	5	4	3	2	1
viii. I teach students how to attach files to email message	5	4	3	2	1
ix I show students how to draw scatter diagrams for bivariate distributions	5	4	3	2	1
x I show students how to Investigate the nature of graph of functions using computer	5	4	3	2	1
xi I teach students how to search for relevant information on the internet	5	4	3	2	1