UNIVERSITY OF EDUCATION, WINNEBA

I C T CHALLENGES IN THE TEACHING AND LEARNING OF SHS SCIENCE

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DECLARATION

STUDENT'S DECLARATION

I, John Mawutor Adinyira, hereby declare that this dissertation, with the exception of quotations and references contained in published works which have all been identified and acknowledged, is entirely my own original work, and that it has not been submitted either in part or whole to any institution anywhere for the award of another degree.

Signature: ……

Date: ……

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and the presentation of this dissertation was supervised in accordance with the guidelines on supervision of research laid down by the University of Education, Winneba.

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DEDICATION

I dedicate this project work to the Almighty God for His numerous mercies, blessings and guidance bestowed on me throughout the course. Also to my parents, Mr. & Mrs. Robert Adinyira and to my lovely friend Bridgitte Lebene Amadotor.

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ABSTRACT

This study investigated the challenges of ICT integration in the teaching and learning of science in public senior high schools in the Akuapem North Municipality. The study was guided by four objectives: to determine the availability of ICT infrastructure in public senior high schools in the teaching of science, to determine ICT skills level of Science teachers, to establish the frequency of ICT use in the teaching of science and to identify strategies used by senior high schools to promote ICT use in the teaching of science in the Akuapem North Municipality. The study adopted the descriptive survey design where qualitative and quantitative data were collected. Using simple random sampling techniques, the researcher sampled four schools, four headmasters, twenty science teachers and eighty science students. Data collected were analyzed using descriptive statistics and were tabulated. The findings established that majority of science teachers had not acquired the requisite ICT skills and knowledge which limited their ability to integrate ICT into their lessons. On the frequency of the use of ICT in delivering lessons, it was found that Science teachers rarely used ICT to deliver their lessons. The study also found out that schools had strategies to improve ICT integration especially through in-service training of their Science teachers, building and equipping of Science laboratories and purchasing of more ICT equipment. The recommendations from this study were that the Boards of Management of the sampled schools should include ICT infrastructure in their strategic plans. The study concluded that ICT infrastructure in the selected schools influenced ICT integration and that schools that had well-established infrastructure utilized ICT application in their Science lessons.

CHAPTER ONE

INTRODUCTION

Overview

This chapter contains the background to the study and other important aspects of the research report. The research questions, significance, limitations and delimitations are also provided. The chapter ends with the inclusion of the operational definitions used in the study.

Background to the Study

Study after study has made it clear that there is an alarming crisis in relation to students' interest in Science, either as a possible future career, or as an intrinsic interest that will continue after school" (Fensham, 2008, p. 20). One factor which has contributed to low interest in Science by students is the method adopted for teaching and learning of Science.

Fensham (2008, p. 20-21) listed four views of students which contribute directly to low interest in Science:

Science teaching is predominantly transmissive, (ii) The content of school Science has an abstractness that makes it irrelevant, (iii) Learning Science is relatively difficult, for both successful and unsuccessful students, (iv) many students in considering the senior secondary years are saying: Why should I continue studying Science subjects when there are more interactive, interesting and less difficult ones to study? This unhealthy development in the disposition of students towards Science has sparked the search for and the development of alternative methods of Science teaching and learning which can stimulate students' interest and guarantee an educational system that offers equal opportunities for all.

Many students today are learning Science in a passive way in classrooms where information is organized and presented to them by their teacher (Moyer, Hackett & Everett, 2007). They noted that "often, the teacher pays little attention to what students already know about Science. In this learning model, the information transmitted by the teacher and curriculum materials is assumed to make sense and seem reasonable to the students" (p.4). This model views Science from a limited perspective. Science, seen in this way, has been influenced by the manner in which it is taught and studied. With this conception, Science is thus viewed as a collection of organized body of information about the natural world. However, another view of science is the dynamic interaction of thought processes, skills and attitudes that help learners develop a richer understanding of the natural world and its impact on society.

Moyer et al (2007, p.4) pointed out that "Science viewed in this way, sees Science as not just a body of knowledge but rather a process for producing knowledge". This latter view of Science therefore calls for a change from the transmission method of presenting Science to students to allowing the students to interact with the natural world to create knowledge. It is against this background that Ghana's Education Reforms launched in June 2007 introduced Computer literacy not only as a new subject, but also as a tool to enhance teaching and learning.

Integration of Information and Communication Technology (ICT) is high on the education reform agenda worldwide particularly in developed countries (Tilya, 2008). Often ICT is seen as an indispensable tool to fully participate in the knowledge society (Peeraer & Van Petegem, 2011).

ICT are therefore perceived to provide a window of opportunity for educational institutions and other organizations to harness and use technology to complement and

support the teaching and learning process. Although a large body of research on factors determining the integration of ICT in education emerges from developed countries, recent research indicates that developing countries are finding means to participate effectively in the global information society and to address challenges regarding ICT in education (Tilya, 2008).

ICT are basically information handling tools – a varied set of goods, applications and services that are used to produce, process, store, distribute and exchange information. They include "old" ICT such as radio, television and telephone, and the "new" ICT such as computers, mobile phones, satellite and wireless technology and the Internet with their attendant tools (MoE, 2008). ICT integration basically refers to the use of technology in communication, data processing and data storage to impart knowledge to learners.

ICT integration in lessons helps to achieve the goals of educational programmes for several reasons. The benefits of ICT seem suitable for coping with the issue of basic literacy and technological literacy, even among the poorest population sectors. Integration of ICT into Science education is important in learning and teaching process as it increases learner's motivation, makes students to understand better abstract concepts, allows collaborative learning and provides the opportunity for learning through simulation.

The origins of computer-assisted instructions where students learn from programmed computer package can be traced to the works of Skinner on his work on experiments with ICT teaching machines which came as a result of dissatisfaction with traditional methods of learning which were teacher based and did not exploit the individual student potentials.

Skinner suggested that, the experimental analysis of behaviour could be applied in the construction of a teaching machine. The ICT teaching machine would present a carefully sequenced set of ideas to a student and reinforce his or her responses to direct behavioural capabilities. Skinner's ideas led to the development of programmed learning materials (Skinner, 1954).

According to Grabe and Grabe (2007), some factors influence the likelihood that ICT will be integrated in schools. These include access to ICT facilities, teachers' expertise, ICT resourcing or cost, ICT leadership and general teaching.

On teachers' ICT expertise, there is growing and widespread awareness that the pedagogical and technical expertise of the teacher is absolutely critical in the teaching and learning process (Grabe & Grabe, 2007). Information and Communication Technology integration is primarily an individualized approach to teaching which allows students to work independently developing self-independence which encourages mastery of content thus aiding mastery of learning Science (Bell, 1986).

The effective introduction of ICT into schools is also largely dependent upon the availability and accessibility of ICT resources, that is, hardware, software, and communication infrastructure. Therefore, if the technology cannot be accessed as in many educational institutions in sub-Saharan Africa including Ghana, then, its integration is likely to face challenges. However, Bransford and Brown (2000) noted that over the past few years the situation is improving; schools are increasingly being equipped with computers for teaching, learning and administrative purposes; connectivity is improving and the students are enthusiastic about using computers for learning despite inadequate computers in the institutions.

United Nations Educational, Scientific and Cultural Organization (2009) believed that under the right conditions, utilization of ICT can have a monumental impact on the expansion of learning opportunities beyond cultural barriers and outside the confines of teaching institutions. Information and Communication Technologies are thus perceived to be critical for reaching education for all (EFA) goals by boosting the current rate of progress in developing countries so as to meet the demands of a rapidly evolving information society.

The report further notes that, ICT policy programmes exist in developing countries that stimulate its use which vary in scope, focus, budget and complexity, with slow progress where the benefits cannot be measured and demonstrated in a sound way (UNESCO, 2009).

Focusing on Ghana in particular, education is taken to be the cornerstone of economic and socio-political development. Ayot and Patel (1992) observed that the fundamental goal of education is to prepare and equip the youth to be happy and useful members of the society.

This goal can only be achieved through provision of quality education. Additionally, they asserted that quality education will entail the development of the school subjects through professionally trained teachers who are using appropriate audio-visual media and following communication techniques that help impart maximum knowledge and skills to students. They noted further that, teachers are required to improve and use instructional methods that lead the students to realize their full potential. Formulation and implementation of national polices on ICT use as outlined by Ministry of Education (2008) are additional essential prerequisites along with supportive local policies, teachers' expertise and cost of ICT.

Omufwoko (2009) studied factors influencing the use of ICT for learning among students at Technical Colleges in Nairobi focusing on time, ICT infrastructure, expertise and the cost of using ICT and a student to computer ratio in general. Akunja (2011) in her study of factors determining ICT integration in the teaching and learning in secondary schools in Kisumu City also studied factors of ICT integration with emphasis on proficiency of secondary school principals, availability of ICT infrastructure and policy framework.

Statement of the Problem

The Ghana's national ICT policy seems to remain at the national level without true reflection of its implementation on the ground (Ministry of Education, Science and Technology, 2008). Despite Ministry of Education's effort to develop digital content for schools and funding schools to purchase ICT infrastructure as well as develop a comprehensive ICT National Policy to be implemented at the pre-university level, Science teachers still continue to use conventional teaching methods (MOE, 2008).

The Ministry of Education has continued to supply schools with some computers but they are rarely used by teachers in teaching. Majority of the lessons were characterized mostly by verbal interactions (MOE, 2008). It was against this background that this study seeks to establish the challenges confronting ICT integration in the teaching of the sciences in public senior high schools in the Akuapem North Municipality of the Eastern Region of Ghana.

Purpose of the Study

The purpose of this study is to establish the challenges facing ICT integration in the teaching of Science in four public senior high schools in the Akuapem North Municipality of the Eastern Region of Ghana.

Objectives of the Study

This study was guided by the following objectives.

- To determine the knowledge level of science teachers in ICT applications.
- To establish the frequency of ICT integration in teaching of science in the Akuapem North Municipality.
- To determine ICT skill level of the science teachers in integrating ICT in teaching.
- To identify strategies used by senior high schools to promote ICT integration in the teaching and learning of science in the Akuapem North Municipality.

Research Questions

The following research questions were addressed:

1. To what extent are the science teachers competent to integrate ICT applications into their lessons?
2. How often do the science teachers utilize ICT applications in their lessons?
3. What problems do the science teachers encounter as they attempt to integrate ICT applications into their lessons?
4. What policies exist in the selected schools to promote the integration of ICT application in Science lessons?

Significance of Study

The findings of the study may be useful to heads of schools in making decisions on appropriate ICT infrastructure for their institutions. It is also expected that the findings of this study can provide valuable information to Science teachers to simplify difficult concepts. The findings can also be used by the Municipal Education

Directorate (MED) to identify areas that still require capacity building in the teaching of Biology in the municipality.

Lastly, the study can provide the Headmasters with appropriate strategies to promote teaching of Biology.

Delimitations of the Study

This study took place within the Akuapem North Municipality in the Eastern Region of Ghana. The study targeted only four public Senior High Schools in the Akuapem North Municipality, which had computers. The study dealt with Science students, Science teachers and Headmasters because they play a great role in the implementation of the Ministry of Education national ICT policy. The respondents were suitable to the study as they were involved in day to day interaction in the school, hence could provide firsthand information or data.

Limitations of the Study

The researcher encountered some challenges which affected his effectiveness in carrying out the study. One of such limitations was the suspicion with which some of the respondents viewed the study. On competency level in ICT, some respondents were insincere and unwilling to provide information on their ICT competencies. The researcher tried to mitigate these limitations by assuring the respondents on the confidentiality of their identity. On competence level of the respondents, cross tabulation was done that ensured accuracy of responses.

Basic Assumptions of the Study

The study was based on the following assumptions:-

Public schools in the Akuapem North Municipality were implementing Ministry of Education's National ICT policy. That there are certain factors that hinder Science teachers in their endeavour to integrate ICT into their lessons.

Organization of the Study

This study has five chapters where chapter one covers the background of the study, the objectives, research questions, statement of the problem, limitations and delimitations of the study, significance, basic assumptions of the study and definition of significant terms. Chapter two looks at Literature Review which focuses on background to ICT, availability to ICT infrastructure, ICT skill of Science teachers, frequency of ICT use, strategies used to promote ICT use as well as theoretical framework. Chapter three covers research methodology, design, research instruments and their reliability and validity; data collection procedures and data analysis techniques. Chapter four involves results and description of findings which was based on questionnaire return rate, demographic characteristic, ICT infrastructure, challenges facing ICT integration and strategies used to promote ICT use. Chapter five provides a summary of findings, conclusion and recommendation.

CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter will review the history of ICT integration in Education, the interest of students in the use of ICT in their learning processes, the challenges they face with the use of ICT as an integration for learning biology as well as theoretical and conceptual framework.

ICT integration: Meaning and Philosophy.

In order to appreciate what is meant by ICT integration in education, it is important that we know the origin of ICT and what it really is. Research has it that the use of computers became popular in the 1980's when personal computers became available to consumers. Again, research has shown that it is this global competition that has influenced governmental policies all over the world in ensuring that they keep pace with technological advancements. According to Pelgrum and Law (2000), history has it that towards the end of the 1980's, the term 'information technology' began to replace the word 'computer'. The term information technology, therefore, referred to computer's processing ability, indicating a shift from computing technology to the capacity to store and retrieve information. Pelgrum and Law (2000) again noted that the term ICT emerged, signaling the introduction of e–mail and electronic messaging with computer technology. Simply put, ICT is an accepted acronym of the word Information Communication Technology. It is diverse set of technological tools and resources used to communicate and to create, disseminate, store and manage information (Blurton, 1999). This means that ICT helps in the storage and management of information. On his part, Ayo (2001) defined ICT as the use of computer systems and telecommunications equipment in information processing.

Finally, ICT as described by Scott (2002) encompassed a range of applications, communications and technologies which aid information retrieval and research communication and administration. These include: Internet access, electronic mail, CD-ROMS, telephone, online databases, library services and fax machines.

The emerging phenomenon was welcomed in the 1980's that educational systems needed to prepare students to adjust to and survive in this new technologically driven society. This meant preparing students for "lifelong learning in an information society" (Pelgrum and Law 2003, p.20). Allied to this, early advocates of ICT integrated education saw it as a catalyst for change, fostering skills in problem solving and critical thinking as well as the development of student centered learning (McGrail, 2005, p.6).

According to Kozma (2008), there were three rationales for the introduction of ICT into education. The first one is the economic rationale which refers to the role it can play in preparing students as future workers and in supporting economic development. The second is the social rationale where ICT investment aims to: increase knowledge sharing, encourage cultural creativity, increase civic participation, make government services more accessible and finally enhance social cohesion. The third and final rationale is the educational and pedagogic rationale where ICT can advance educational reform and improve educational management structures. Similarly, Hepp *et al* (2004) broadly concur, identifying three reasons for the use of ICT in education: the development of new skills for the information age, increased productivity and the development of quality learning.

Whereas Kozma (2008) noted that there were three rationales for the introduction of ICT into education, Hawkridge (1990) proposed four rationales for the utilization of

computers in schools. He noted these as social, vocational, pedagogical and catalytical. The social and vocational rationales pointed to the increased use of ICT in all spheres of human activity. The pedagogical and catalytical rationales relate to the effects of technology on students and schools. According to Bigum (1997), arguments for using computers in schools stem from technological and socially determined points of view. His standpoint was that the school systems within which the computer is used is driven by computers. He argued that a change occurs within an education system that uses computers and that change is as a result of the effect of technology.

Bigum (1997) stated that the social context saw computers as neutral technology-technical means of achieving a defined purpose in education. Two contexts emerged and are used in this study; the social context and the pedagogical context. The social context ran along the lines of Hawkridge's social and vocational rationales, whiles the pedagogical context agreed with Hawkridge's pedagogical and catalytical rationales. The pedagogical context also agreed with the views of Bigum (1997).

Drent and Meelissen (2008) identified three objectives for the integration of ICT in education. They were: the use of ICT as a 'discipline or profession'; ICT as a 'teaching or learning medium' and the use of ICT as an 'object of study' (Drent and Meelissen, 2008, p.187). It can be inferred from these objectives that integration involves aiding the teaching and learning process (apart from the third objective which is a discipline in itself). Successful integration of ICT in education can lead to a number of benefits. The next session will look at some of the benefits.

Benefits of using ICT in the Teaching and Learning of Science

The ubiquity, availability and exponential growth of digital Information and Communication Technology (ICT) creates unique opportunities for learning and teaching in the Senior Secondary School Biology curriculum. Digital technologies make it possible for emerging disciplinary, knowledge and understanding of biological processes previously too small, large, slow or fast to be taught. Indeed, much of bioscience can now be effectively taught via digital technology since its representational and symbolic forms are in digital formats.

Positive Impacts of ICT on Students' Learning

There are many benefits that students can derive from the effective and efficient use of ICT in the teaching and learning process. Some of the positive impacts are:

- Increased motivation to stay on-task, behave well and produce higher quality output.
- Learn more independently and at their own pace.
- Do things they cannot do using traditional methods and resource.
- Do more work.
- Resources
- Integrate several subjects into project-based activities.

Increased Motivation

Many studies have described the motivating effect of using ICT in schools and the positive effect it can have on students' attention and efforts in the class. The ICT objectives were useful in their own right as they were key elements of the ICT curriculum through which students learn how to present information in a professional way. Most students enjoyed working on computers and if it was a novelty rather than

the norm, then that made it more motivating. Whereas the students' enjoyment is an important factor in education, adherence to the curriculum is more important and careful planning is an essential element in teaching with ICT in our schools.

Factors That Hinder ICT Integration in Schools in Ghana

There are many factors which may serve as hindrances to the integration of computer technology in high schools. Pelgrum (2001) presents a list of ten such factors that impede ICT integration in schools. Out of the ten, the research identified four major ones, namely; personal ideas about the contribution that technology can make to the processes of teaching and learning and classroom management; Teachers' lack of knowledge and skills; insufficient number of computers and ICT infrastructure; and difficulty in integrating ICT instruction in classrooms.

In a related study, Ely (1993) similarly distinguished three major conditions relevant to ICT integration in classrooms. These are: dissatisfaction with the status quo, the existence of knowledge and skills and the availability of resources. The two categories identify, more or less, the same issues: Ely's existence of knowledge and skills relates to Pelgrum's factor relating to teachers lack of knowledge and skills. Also, Ely's availability of resources is similar to Pelgrum's insufficient number of computers and ICT infrastructure. Finally, Ely's dissatisfaction with the status quo is directly related to what Zhao and Cziko (2001) termed as discrepancies that activate the individual.

The problem of teachers' **confidence** in their ICT competence as a **major** factor for integrating technology in teaching **is reported in** other studies as **well.** Mooij and Smeets (2001) explain that if teachers are not confident their ability or competence

to handle computers, it may hinder their willingness to introduce technology in their classrooms. In their study, Cox, Preston and Cox (as cited in Mooij & Smeets, 2001) also reported that the most important reason teachers give for not using ICT is that they are not familiar with ICT or they feel unsure about it. This ICT competence factor is the same as what Zhao and Cziko (2001) refer to as Control Principle. Some other important factors are also recorded as significantly influencing ICT use in schools.

Teachers claiming to follow more innovative educational practices such as use of inquiry, project-oriented work and hands-on activities, are more likely to use new technologies than those who stick to the more traditional instructional approaches Honey and Moeller (as cited in Myhre, 1998).

According to Mooij and Smeets (2001), school manager's policy and budgetary decisions and in general, the attitude of the school manager (their commitment and decisions) are expected to be relevant to the ICT innovation process.

Teacher's Attitudes and Beliefs in the Use of Computer Technology

International experience has shown that teachers play an important role in diffusing and utilizing ICT in classrooms. Teachers' attitudes and beliefs affect the way technological innovation is applied in education. They tend to use technology in ways that will shape their own personal perspectives on the curriculum and on their pedagogical practices (Cohen, 1987; Cuban, 1986; Czerniak & Lumpe, 1996; Lai *et al.,* 2001). Bullock (2004) found that teachers' attitudes are major enabling or disabling factors in the adoption of technology. Similarly, Kersaint, Horton, Stohl, and Garofalo (2003) found out that teachers who have positive attitudes toward technology feel more comfortable using it and usually incorporate it into their

teaching. Woodrow (1992) asserts that any successful transformation in educational practice requires the development of positive user attitudes toward the new technology.

The development of teachers' positive attitudes toward ICT is a key factor not only for enhancing computer integration but also for avoiding teachers' resistance to computer use (Watson, 1998). Watson warns against the severance of innovation from the classroom teacher and the idea that "the teacher is an empty vessel into which this externally defined innovation must be poured" (p. 19). Teachers' attitudes and beliefs also influence what they themselves learn from education and training programs and what didactic practices they make use of in their classrooms (Clark & Peterson, 1986; Fang, 1996; Pajares, 1992; Zeichner *et al,* 1987). Research has shown that many educational reform initiatives have failed precisely because they did not influence the beliefs or the practices of teachers (Cohen & Ball, 1990; Mehan. 1989).

However, significant positive correlations may exist between teachers' attitudes towards ICT and five independent variables namely cultural perceptions, computer competence, computer access and computer training (Imhanlahimi & Imhanlahimi, 2008).

Teacher's Knowledge and Skills in Computer Technology

The effective use of computers by teachers depends not only on their attitudes but also on the training they have received (Clark & Peterson, 1989). Teachers' competence in ICT presupposes: positive attitudes to ICT, understanding of the educational potential of ICT, ability to use ICT effectively in the curriculum, ability to manage ICT use in the classroom, ability to evaluate ICT use, ability to ensure differentiation and progression and technical capability (Grossman, Wilson, &

Shulman, 1989; Beck, 1997). It is also worth noting that inadequate pre-service and in-service training will be another obstacle for many teachers in integrating technology into their classroom teaching. There is enough literature that supports the same position that teachers should receive effective, timely and continuous training to promote technology in their teachings. (Wilson, Notar, & Yunker, 2003; Yildirim, 2000; Yildirim & Kiraz, 1999; Kasli, 2008)

In-service training is a major factor in cultivating positive attitudes to computers. (Kara & Yakar, 2008). Teachers' pedagogical decisions and actions are closely tied up to their professional growth. Their professional knowledge might change by 'means of experience, curriculum directives and in-service training. Quality in-service training can support the process of changing teachers' thinking and practice, recognizing that teaching is a difficult, complex and multifaceted process (Wood & Bennett, 2000). In a related study, Lai *et al.,* (2001) revealed that school-based professional development will be better organized and facilitated by ICT coordinators, who usually have adequate training and a deeper understanding of integrating computer technologies into their school curriculum and can provide role models for teachers. However, research into in-service training has shown what the training program has to offer to meet teachers' real needs (Kozma & Mcghee, 2003; Crook, 1994). A decisive factor in the effective integration of computer use in the school curriculum is the provision of appropriate in-service training to the teachers to show them how to use the new tools in their everyday teaching practices. The IEA study in 1989 showed that a fair number of teachers had had some experience of in-service training in computer use, but the majority of the programs at that time emphasized the need for technical rather than the pedagogical and didactic aspects of computer use. In-service training focus not on the technical but on the pedagogical

and didactic aspects of ICT use in the classroom (Lai *et al,* 2001; Pelgrum & Plomp, 1996).

Many recent research studies on the state of ICT's integration in schools also show that many institutions are failing to integrate technology into existing context. Sarfo and Elen (2007) stated in their study that although teachers had sufficient skills, were innovative and easily overcame obstacles, they did not integrate technology consistently, both as a teaching tool and as a learning tool. Reynolds, Treharne and Tripp (2003) also underlined continuing problems in the adoption of ICT by teachers and stated the need for further research on how ICT can improve education. It is worth noting that what the reviewed literature failed to explore is how the ICT policy framework supports ICT's integration in Schools in the various countries. Without any clear cut policy, ICT integration will be implemented based on the whims and caprices of the teachers.

Utilization of Computer Technology Facilities by Teachers and Students

Another important variable of ICT integration in schools is availability of ICT infrastructure. In his doctoral dissertation, Tabassum (2004) reveals that one fundamental problem facing ICT integration in schools is the lack of computer infrastructure. In a related study, Bybee *et al.,* (2008) reveal that appropriate access to technology infrastructure is another key factor in the effective technology integration process. The study reveals substantive correlation between technology access and use. In another study, Yildrim (2007) reveals that teachers agreed that access to ICT infrastructure is one of the effective means to integrate ICT in classrooms. Together, education and employment are crucial building blocks of strategies for poverty eradication. ICT is increasingly being used to improve access to education and

employment opportunities. ICT potentially help to improve young peoples' access to educational opportunities as well as to enhance the quality of that education through the new modes.

Through ICT, curricula can be more easily updated, adapted, enriched and personalized to satisfy a broad range of learning needs. Using ICT access to a curriculum can be made available more efficiently over a wider area. Even within more traditional learning environments, ICT will assist in changing the way classrooms operate; the integration of multimedia subject presentations, online research, changing teacher-student dynamics, and innovative project approaches which will make the learning process more interactive and participatory (United Nation Youth Report, 2005).

Waite (2004) indicates that even though teachers show great interest and motivation to learn about the potential of ICT, in practice, the use of ICT is relatively low and focus on a narrow range of applications, with word processing being in predominant use. The research revealed that other ICT tools such as video conferencing, emailing and the Internet are rarely used. The study revealed the lack of ICT infrastructure in schools as one of the factors for non-usage of those tools. Another research study suggests that ICT as a tool in promoting learning is not generally well embedded in teachers' practice (Cox *et al.* 1999; Dynaski *et al,* 2007; Zhao & Cziko, 2001), and that "information technology in the classroom will be used in an ineffective way and may prove difficult to integrate within traditional curriculum settings" (Van Belle & Soetaert, 2001, p. 38).

Using Computer Technology to Teach Science

Usage of ICT in schools is so diverse that it is almost impossible to list all possible applications. Taylor (1980, 2003) recognized three roles of computers in a classroom: as tutors, tools, and tutees. Introduction of ICT in science lessons will raise not only the level of knowledge but students' attitudes toward science as well (Honsell & Hill, 1989; Kubiatko & Halakova, 2009). Science teachers do distinguish between two groups of applications. The first group is generic applications used in all subjects, like word processing, searching for information, communication using e-mails and multimedia presentations. In this case, if a Science teacher does not use ICT in a classroom, the damage to the students will be limited because they can achieve missing skills with their work in other subjects or at home (Kuhlemeier & Hemker, 2007).

In the second group, applications are adapted or developed to be used in teaching Science (McFarlane & Sakellariou, 2002), like imaging systems in microscopy (McLean, 2000; Fiche, Bonvin, and Bosman, 2006), virtual dissections (O'Byrne, Patry, and Carnegie, 2008), simulations (Ramasundaram, Grunwald, Mangeot, Camerford & Bliss, 2005), virtual laboratory (Jenkins, 2004), and real laboratory exercises with data acquisition systems (Conway & Zhao, 2003). The most important difference between these two groups of applications is that if a Science teacher does not use such applications in teaching students in most cases, they will not be able to compensate loss with work in other subjects or at home. The introduction of computers into teaching and learning in Slovenian Secondary Schools has followed two general tracks. The first one was the introduction of the compulsory subjects, Computer Science and/or Informatics, into the curriculum.

The second one involved the use of computers in a rainbow of different subjects. The introduction of computers into student work in other subjects is encouraged by the authorities but the final decision about their use in teaching is left to the discretion of the teachers. The difference between these two paths is that teachers from the first group are trained professionals in Computer Science and Informatics while teachers from the second group are more or less enlightened 'computer amateurs'. Occasionally, cooperation between a teacher of Informatics and a teacher of some other subject occurs and enhances student work.

Cox *et al,* (2004) indicate that many teachers are integrating ICT into Science teaching in a way that motivates pupils and enriches learning or stimulates higher level thinking and reasoning. In view of other studies, these teachers tend to be those with an innovative pedagogical outlook. ICT for Biology teaching can support both the investigative (skills and attitudes) and more knowledge based aspects (concepts) of Biology teaching.

Therefore, to achieve successful integration of ICT into Biology teaching and learning, it must depend on an appropriate pedagogy and clear and concrete curriculum focus which support and enhance teaching and learning with the use of ICT in various schools.

Difficulty in Changing Teaching Method (Pedagogy)

Teachers have to accept that the widespread use of ICT in schools is having an impact on teaching methods and requires a significant rethinking of approach. Beckar (2000) describes two main teaching methods and their effects on the ways in which ICT is used in lessons.

Traditional transmission institution assumes that students will learn through teacher explanation or reading from texts. Skills are learnt through practicing skill in a sequence prescribed by the teacher.

Constructivist institutions assume that understanding comes from relating new ideas to the learners' prior beliefs and skills acquisition comes in as unstructured way as new skills are used as required to solve practical problems.

In conclusion, one can deduced that using ICT in lessons, the constructivist approach is more likely to lead to successful outcomes. Furthermore, teachers with the most constructivist philosophies tend to use computers more often and in a more challenging way both in classrooms and as users themselves.

Age Factor

The researcher's personal observation is that the age of an individual is a factor in the person's quest to adapt to changes, more especially in the areas of technology. It is against this backdrop that this literature is being reviewed to find out the view of other researchers.

Kumar *et al* (2008) noted in their study that with some teachers, age is a significant factor in the use of ICT. The researcher concurs with this school of thought but believes that the age factor in relation to the use of ICT is not only peculiar to teachers in the classroom but also permeates all spheres of life.

Young (2009) asserted that younger and less experienced teachers use computers more because they are more likely to be computer savvy, with a more technologically rich teacher training and are less likely to be limited by previous habits, perceptions or attitudes than older teachers.

Lee (1997) pointed out that many older teachers did not have any computer education in training schools, as a result, they are in need of training to allow them to make use of computers in their work. Cavas *et al* (2009) revealed that there is a relationship between teacher's age and their computer attitudes.

A report by the European Commission in 2002 found out that age was a factor in the use of computers and the internet, arguing that the percentage of teachers using computers falls as their age increases, although the report acknowledged that the importance of this factor is declining.

Bradley and Russell (1997) pointed out that, although computer anxiety may increase with age, this does not mean that training or professional development should be specifically targeted at older teachers. They strongly dispute the notion that because computer anxiety may increase with age, younger teachers are unlikely to need training in ICT. Despite this, a substantial body of research literature strongly argues that age has no bearing on the use of ICT by teachers (Al-Senaidi et al, 2009; Lau & Sim, 2008; Wang & Chan 1995).

Institution Related Barriers

The environment or conditions prevailing in the various institutions or schools can also be a factor that can inhibit the integration of ICT into the learning and teaching process. These conditions can be varied depending on where the school is located and the class or category of the school. Some of these include but not limited to the following:

- Technical problems and shortage of computers.
- Lack of detailed plans into how ICT can be used to enhance teaching and learning.

- Timetable difficulties.
- Willingness of school authorities to provide the needed funds when the need arises.

Technical Problems and Shortage of Computers in schools

It is important to acknowledge that ICT can have technical problems and contingency planning is necessary to ensure alternative strategies are in place. Where the infrastructure and the platform for the application are unreliable, the output may be affected and this can adversely affect student motivation.

As computers are becoming more sophisticated and the range of software used by schools continues to increase, schools must recognize the need to employ more and highly qualified technical staff. However, with constraints on budgets and competition from the commercial sector for the best staff, it is becoming increasingly difficult for schools to attract and retain technical staff with the appropriate skills and experiences.

Lack of Detailed Planning Into the Use of ICT

Much of the research highlighted the need to plan carefully the use of ICT in lessons. Sutherland (2004) summed this up as, "ICT alone does not enhance learning". How ICT is incorporated into learning activities is extremely important". Abbott *et al* (2001) also stressed the importance of detailed lesson planning when using ICT and that, students should be encouraged to understand the process involved rather than simply focusing on the output. Some teachers may use ICT as a way of encouraging independent learning. Such skills need to be planned and supervised with the teacher directing the student's activities and outputs. ICT though is an effective tool in the hands of an effective teacher and not a panacea in its own right. It would seem that the

prerequisite for success is the subject knowledge of the teacher and his ability to weave the use of ICT into the existing curriculum.

Time Table Challenges

Incorporating ICT in a curriculum requires careful timetabling and cooperation amongst departments. Sutherland *et al* (2004) pointed out that in a Science department, it may not be possible to move practical classes to ICT because of health and safety considerations or site computers in Science laboratory due to space constraints. With regard to other subjects, the time convenient for ICT may not be suitable for the schemes of work planned by the teachers. Hence, much more cross-curricular and departmental planning is required in comparison to what most schools did in the past.

Policy on ICT Education in Ghana

The government of Ghana is committed to the transformation of the agro-based economy of Ghana into an information rich and knowledge – based economy and society using the tools of Information and Communication Technology (ICT). The government of Ghana has acknowledged the need for ICT training and education in schools, colleges and Universities and the improvement of the education system as a whole (Draft Copy of ICT Policy, 2006).

The integration of ICT into education will result in the creation of new possibilities for learners and teachers alike to engage in new ways of information acquisition and analysis; ICT will thereby enhance access to education and improve the quality of education delivery on equitable basis.

The government is therefore dedicated to a comprehensive programme of rapid development and utilization of ICT within the education sector to transform the

educational system, thereby improving the lives of people. It is the government's desire that through the development of ICT in education, the culture and practice of traditional memory-based learning will be transformed into education that stimulate thinking and creativity necessary to meet the challenges of the twenty first Century. Given the magnitude of the task ahead, the government enjoins both the public and private sectors to join hands to ensure that children receive high quality teaching and learning (Draft Copy of ICT Policy 2006).

Theoretical Framework of the Study

The study is grounded on the theory of Diffusion of Innovations (Rogers, 2003). According to Rogers (2003), diffusion research centers on the conditions which increase or decrease the likelihood that members of a given culture will adopt a new idea, product, or practice. According to Rogers, people's attitude toward a new technology is a key element in its diffusion. Since Rogers uses the terms innovation and technology interchangeably (p. 12), the diffusion of innovation framework seems particularly suited for the study of the integration of ICT in the teaching and learning of Biology. Roger's Innovation Decision Process theory states that innovation diffusion is a process that occurs over time through five stages: knowledge, persuasion, decision, implementation and confirmation. Accordingly, the innovation decision process is the process through which an individual or other decision-making unit passes.

Due to the novelty of computers and their related technologies, studies concerning ICT integration in education have often focused on the first three phases of the innovation decision process. This is also because the status of computers in education is, to a great extent, still precarious. In cases where

technology has been very recently introduced into the educational system, as is the case in most developing countries, studies have mainly focused on the first two stages, knowledge of an innovation and attitudes towards it.

Diffusion of innovation theory predicts that media as well as interpersonal contacts provide information and influence opinion and judgment. Studying how innovation occurs, Rogers (2003) argued that it consists of four stages: invention, diffusion or communication through the social system, time and consequences. The information flows through networks. The nature of networks and the roles opinion leaders play in them determine the likelihood that the innovation will be adopted. There are indications that teachers proceed to adopt ICT in stages. Myhre (1998) concludes that this increased familiarity with computers allows teachers to turn their interest to the pedagogical use of technology rather than its operational uses, but also emphasizes that such change processes do not occur rapidly and are not easily achieved.

A Conceptual Framework for the Study

The purpose of the study was to provide arguments to better understand teachers' readiness for pedagogical integration of ICT and to integrate and summarize findings from a body of research on trends in ways that ICT can be understood and used to improve the quality of teaching and learning in the educational system in Ghana. Much research in the developed world has suggested many theories or models for evaluating factors that promotes or constrain individual acceptance behaviour on information technology and information systems, acceptance and diffusion of innovations, integration of ICT in education in general or use of ICT for teaching practice in particular. These models include the Theory of Reasoned Action, Theory

of Planned Behaviour, Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology and Diffusion of Innovations. TAM, proposed by Davis (1989), seems to be one of the most popular theories that is used widely 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 to its limitations. TAM has been widely used to scrutinize individual technology acceptance behaviour along only two factors: perceived usefulness and perceived ease of use. Thus, just like most of the other theories, the major limitation of TAM lies in its weakness to include other important factors such user behavioural intentions, system characteristics, user training, user participation in design, nature of the implementation process, etc. in the model. Groff and Mouza (2008) distinguish between critical factors including legislative level factors, district and school level factors, factors associated with students and teachers, factors inherent to the technology itself, and factors associated with the technology-enhanced project. Mumtaz (2000) in a review study identifies three factors for continued ICT integration which comprise institution, resources, and the teacher. In practice factors that guide human actions to change or influence technology acceptance behaviour may be varied and cannot be assumed to be static. As a result, it was difficult adopting a single existing overarching theory as a framework to guide the conduct of this study.

Therefore, the author identified critical success factors for ICT integration drawn from literature and used these critical success factors as the benchmark to analyze the current work. In this study, literature on factors driving integration of ICT in education is presented in fivefold:

- Existence of National ICT Policies;
- Availability of ICT infrastructure, including computer hardware, software, and communication network (bandwidth/access);
- Teacher preparedness and willingness; 72 Journal of Global Initiatives
- Professional development training and the lack of skilled human resources that support the achievement of teaching and learning with ICT; and
- Resistance to change from traditional pedagogical approaches of teaching to more innovative, technology-supported methods.

Factors Promoting/Constraining the Development of ICT Use in Science Education.

Existence of National ICT Policies

A large body of research has shown that a rapid integration of ICT into learning environment demands the development of effective ICT policies. Thus, an ICT policy implementation strategy or framework for a nation's education sector is very essential to revolutionizing learning and teaching processes and opening new learning opportunities. ICT needs to be enhanced by an ICT policy that ensures that people are capable of using it to source and assimilate information and transform it into useful knowledge (Tilya, 2008). Unless a specific policy exists and decision makers have a clear strategy in place, it is difficult to integrate ICT effectively and bring about desired improvements in the reach and quality of education (UNESCO, 2007). Latchem and Jung (2010) recommended that countries and institutions put in place clear visions, strategic plans, commitment, and implementation capability regarding ICT use in education. According to Kozma (2008), strategic policies can provide a rationale, a set of goals, and a vision for how education systems can best introduce and integrate ICT into education. Pick and Azari (2008) remark that the solution for a

single nation seeking improved ICT depends on political will and leadership that appreciates how multidimensional factors need to be combined for development. In the context of globalization as an economic process, researchers identify a deterministic conception of ICT (Bryderup & Kowalski, 2002; Sawchuk, 2008; Shin & Harman, 2009; Tondeur, van Braak, & Valcke, 2007), however, researchers describe a gap between rhetoric in government policy and reality of education practice (Cheng, 2009; Kozma, 2008; Selwyn, 1999; Tondeur et al., 2007). The studies emphasize that without de-centralized supportive measures, national policies will not easily result in changes in instructional practices. Tondeur et al. (2007) discusses the way forward as stressing the responsibilities of local educational institutions to translate the national ICT guidelines in an ICT plan as part of an overall school policy.

Walker (1989) has also discussed three preconditions for a successful introduction of new information technologies into an education system:

i. An appreciation by the government of the financial, resource and operational requirements and the resulting consequences.
ii. A commitment by government to give time and take responsibility for decision making and implementation strategies.
iii. A commitment to a policy of an integrated support service encompassing teacher and technician training, curriculum and assessment, together with software and hardware provision.

Walker's conditions buttress Naidoo's (2003) idea which noted that attempts to integrate

ICT into the education system will entail the leadership of the government and the education ministry, working together with other relevant ministries. Clearly, the literature suggests that leadership must have a clear vision of the mechanism that the education ministry intends to use to implement ICT. This vision then needs to be integrated with national policies and then effectively communicated and supported at the school level.

Availability of ICT Infrastructure

According to Mumtaz (2000), limited resources within schools are a great impediment to the take-up of technology. For instance, lack of computers and software in classrooms can seriously limit teachers' use of technology. Studies have shown that only a small proportion of the African population has access to computers (Murphy, Anzalone, Bosch, & Moulton, 2002) and 4% has access to the internet (Resta & Laferrière, 2008). Aguti and Fraser (2006) reiterated that lack of ready access to technologies by teachers is a key barrier to technology integration in most developing countries. Other researchers (Benson & Palaskas, 2006; Snoeyink & Ertmer 2002) have identified resources as important parts of implementation of an innovation.

Teacher Preparedness and Willingness

In order to make an implementation succeed, "the people who will ultimately use the innovation must possess sufficient knowledge and skills to do the job" (Ely, 1999, p.).

This should specifically be the case where the innovation involves the use of a certain tool or technique. Without enough preparation to use the tool or technique, the innovation will die out soon. According to Webb and Cox (2004), one of the reasons for the unenthusiastic response to ICT-based innovation amongst teachers might be

that technological knowledge and skills is either absent or lacking in the processes that underpin teachers' planning.

This idea has recently been developed by Mishra and Koehler (2006) and Harris, Mishra, and Koehler (2009), who propose that there is a tendency for teachers not to synergize their content and pedagogical knowledge with their technological knowledge and that this can result in mundane ICT implementation in the classroom. Alongside the need to develop teachers' knowledge and skills, their attitudes toward ICT integration also need to be understood. Christensen and Knezek (2008) indicated that teachers' attitude play a key role in determining computer use as a learning tool and the likelihood that teachers will effectively use ICT for teaching.

Professional Development and Training

The issue of how ICT is to be covered in pre-service teacher education and in-service teacher professional development has received significant attention. Baylor and Ritchie (2002) have indicated that training has an important influence on how well ICT is embraced in the classroom. A review of the recent teacher education research around ICT shows numerous examples of teacher education programs that have implemented instructional technology in ways that encourage integration. (for examples see Goktas, Yıldırım, 74 Journal of Global Initiatives & Yıldırım 2008; Kay, 2006). Most of these approaches have involved providing teachers and teacher candidates with experiences of real educational problems to be solved by technology. Thus, the literatures makes it explicit that there seem to be more to teacher preparation than training teachers on how to use tools - it requires appreciation of the complex set of interrelationships between artifacts, users, tools, and practices.

Resistance to Change

Over the years, there have been studies and explorations of the resistance factors that thwart diffusion and implementation efforts. Prominent among those who have journeyed into this puzzling morass are Zaltman and Duncan (1977). These authors define resistance as ". . . any conduct that serves to maintain the status quo in the face of pressure to alter the status quo." A number of studies have indicated that schools are resistant to ICT change.

For example, Mumtaz (2000) explained that due to schools' resistance to change, institutions give little time to teachers to manage and familiarize themselves with ICT-based innovation and classroom timetabling does not allow time for teaching with ICT.

Several studies (e.g., Bate, 2010; Dawson & Rakes, 2003; McGarr & Kearney, 2009) also support the claim that leadership promoting change is a key factor when it comes to merging ICT with instruction. The basic argument has been that if we knew what types of resistances exist, we could design strategies to combat them.

CHAPTER THREE

METHODOLOGY

Overview

This chapter covers the research design, location of the study as well as the population and sampling procedures. The research instruments, data collection procedures and data analysis are also presented in this chapter.

Research Design

A research design is the arrangement of conditions for collection and analysis of data in a way that aims at minimizing expenditure of efforts, time and money (Kombo & Tromp, 2006). In this study, the descriptive survey design was used. This method was preferred because information was readily obtainable from subjects in their natural environment, concerning their attitudes or beliefs on issues of interest in the study.

Location

The study was conducted in the Akuapem North Municipality of the Eastern Region of Ghana. There are a total of nine senior high schools in the municipality. The municipality was chosen for the study due to its proximity to the researcher. Besides, many of the schools offer Science as an elective programme

Target Population

The target population of the study consisted of senior high school headmasters, Science teachers and Science students in senior high schools in the Akuapem North Municipality

Science teachers were targeted in this study because they are the major agents of ICT implementation in the teaching and learning process of Science. Students were

targeted as they are expected to use ICT during the process of acquiring knowledge and skills. On the other hand, the headmasters were targeted because they are the administrators who supervise, coordinate and ensure that facilities are provided to enhance the teaching and learning of Science. The accessible population comprised school heads, Science teachers and students in the nine senior high schools in the Akuapem North Municipality.

Sampling Techniques

Four out of the nine senior high schools that offered Science elective programmes were randomly selected for the study. The study targeted students, teachers and headmasters in the selected senior high schools. In this study simple random sampling was used. The senior high schools selected for this study had equal chance of being selected. Five Science teachers from each school participated in the study. Stratified sampling was used in the selection of the teachers where two were from Biology, two from Chemistry and one teacher from the Physics unit. This allocation was because most of the teachers were biology and chemistry teachers. Students in their second year of study were targeted as they had been in the selected institutions long enough to have adequate information on the subject of study. According to Gay and Airasian (2000), sampling 10% to 20% of the population was acceptable for descriptive research.

A sample of 10% of the population was considered minimum while 20% of the total population was required in a survey study. Eighty students were randomly selected to participate in the study.

This number was appropriate as it represented 27% of the students in the selected schools. The number of research subjects selected from the school heads, science teachers and students are shown in Table 1.

Table 1: Population and Sample

Research subjects	Population	Sample
Headmasters	9	4
Teachers	55	20
Students	300	80

Research Instruments

These are the tools that were used to collect data from the sampled respondents. The tools involved were questionnaires and interview schedules.

Questionnaire

A questionnaire was administered to teachers and students who were to participate in the study. The questionnaires contained both open and closed ended questions. The closed ended questions provided easy way of coding while the open ended ones enabled the researcher to gather wide and free opinions from the participants.

The closed ended questions were used to collect quantitative data while the open ended questions were used to collect qualitative data.

Interview Schedule

The researcher also administered interview schedules to the headmasters of the selected high schools which participated in the study.

Pilot-testing of Instruments

The research instruments were pilot-tested in one of the senior high schools within the study area which was not included in the main study. During the pilot-testing, the headmaster was interviewed while five Science teachers and 20 Science students filled the questionnaires.

Validity

Content validity was used to assess whether the contents of the questionnaire measured what it was intended to measure. The instruments were presented to experts in the area of study. The experts helped in improving the instruments. The experts' feedback, in form of recommendations to the researcher, was incorporated in the final instruments.

Reliability of the Instrument

Reliability is a measure of the degree to which a research instrument yields consistent results after repeated trials (Ngechu, 2004). To establish the reliability of the instruments, a test-retest method was conducted from a similar population in one senior high school in the Akuapem North Municipality after an interval of two weeks to the same group of respondents. Scores were then correlated using the Pearson product moment correlation coefficient.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum)^2[n\sum y^2 - (\sum y)^2]}}$$

Reliability coefficients vary between -1.00 and +1.00 with reliability of 1.00 indicating perfect reliability (never attained in practice) and 0 indicating no reliably and -1.00 to 0 shows negative reliability. The coefficient indicates the extent to which a test is free from error of variance. The closer the reliability, the

extent to which a test is free from error of variance is a measure of the differences between proportions in the dimension assessed by the test (Best & Kahn, 2003). The pilot study yielded a reliability coefficient of 0.7. This indicated that the instrument was considered to be reliable for the study. Kothari (2004) confirmed that a reliability of 0.7 was adequate.

The Data Collection Procedures

The researcher obtained an introductory letter to conduct the study from the University of Education, Winneba. Before the collection of the data, the researcher contacted the participating institutions and scheduled appointments for the visits. The research entailed the administering of the questionnaire to the student participants who filled the same in the presence of the researcher. This ensured that the exercise took the shortest time possible. This also helped the research participants to fill the questionnaires appropriately since the researcher was around to make any clarification if at all they were needed. Sufficient time was given to the respondents to respond to the questionnaire and interview schedule.

Data Analysis Procedure

Before processing the responses, the completed questionnaires were edited for completeness and consistency. The quantitative data collected was analyzed by the use of descriptive statistics using SPSS and presented in percentages, means, standard deviations and frequencies. The information was displayed by the use of bar charts, graphs and pie charts. This was done by tallying responses, computing percentages of variations in response as well as describing and interpreting the data in line with the study objectives and assumptions through the use of Statistical Package for Social

Sciences (SPSS V. 20). Content analysis was used to analyze qualitative data collected from the open-ended items.

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

This section deals with the analysis and interpretation of the data collected. The presentation is organized along the thematic areas of the study objectives. It includes descriptive information obtained from respondents, ICT skills and utilization of ICT facilities. The study targeted 124 respondents comprising 4 Headmasters, 20 Science teachers and 80 Science students, in collecting data on the challenges facing the integration of ICT in the teaching and learning of Science in public senior high schools in the Akuapem North Municipality of the Eastern Region of Ghana. From the study, all the 124 respondents (4 headmasters, 20 Science teachers and 80 Science students) filled and reported the questionnaires making a response rate of 100%. This is shown in Table 2. This is a good response rate as Mugenda and Mugenda (2003) asserts that response rate of at least 70% is adequate. This high response rate was achieved by administering the questionnaires and collecting them the following day to avoid wastage and losses.

Table 2: Targeted Respondents

Category of respondents	Administered	Returned	Return Rate
Students	80	80	100%
Science Teachers	20	20	100%
Headmasters	4	4	100%

Demographic Characteristics of Respondents

Since data was collected from students, Science teachers and headmasters, an attempt was made to present data in terms of demographics of respondents, highlighting the three different groups where possible. The respondents have, therefore, been categorized according to gender, work experience, level of education, teaching experience and teaching subjects. This was followed by description of the items of the study that basically looked into the four study objectives to guide analysis and discussion.

Distribution of Respondents by Gender

The gender of the respondents was of concern to the study as it assisted the researcher to identify the dominant gender in the district and also to establish the gender that was integrating ICT most in the teaching of the sciences. In view of this, the respondents were asked to state their gender. Table 3 shows the responses by gender.

Table 3: Gender Distribution of Respondents

	Students		Science Teachers		Headmasters	
Gender	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Male	52	65.0	12	60.0	3	75.0
Female	28	35.0	8	40.0	1	25.0
Total	**80**	**100**	**20**	**100**	**4**	**100**

Table 3 shows that out of 80 students who responded to the questionnaires, 52 (65.0%) were males and 28(35.0%) were females. This showed that there were more male Science students than females in the schools in the municipality. This could be attributed to the fact that compared with the females most of the males preferred Science based subjects. Out of the 20 Science Teachers selected, 12 (60.0%) were males and 8 (40.0%) were females. This implies that there are more male Science teachers in the Akuapem North Municipality than females. In respect of the

headmasters, out of four headmasters selected 3 (75.0%) were males while 1 (25.0%) was a female. Most of the senior high schools in the Akuapem North Municipality were headed by male teachers. This proves that the assertion that Science is a male dominated discipline in most educational institutions is true. This has translated into a high gap between males and females in terms of leadership roles in educational institutions and other Science related fields, that is, the more male Science students there are, the more male teachers and or head teachers educational institutions will have. This is likely to be case especially in instances where most females do not go high on the educational ladder compared to males though they form a majority of the population in Ghana.

Table 4 shows that out the 80 students, 74 (92.5%) students, irrespective of their gender, can open a file on the computer whiles 6 (7.5%) had no idea of how to open a file on the computer.

Table 4: Opening of Files on Computer

Responses	Frequency	Percent
Yes	74	92.5
No	6	7.5
Total	**80**	**100**

The result here means that ICT is receiving attraction and that most students are getting more versatile with the use of computers. It also means that most students may have had foreknowledge of ICT before their senior high school education or they may have been introduced to ICT at the basic school level.

In Table 5 below, the number of students who can create and edit either files, documents or folders are more than those who cannot since the results confirms that 87.5% can create and edit any form of folders or documents on the computer when the need arises. This is an indication that ICT is gaining grounds in our modern society. Nonetheless, 12.5% of the students cannot create and edit folders or documents on the computer.

Table 5: Creating and Editing of Files

Responses	Frequency	Percent
Yes	70	87.5
No	10	12.5
Total	**80**	**100**

In table 6, a total number of 74 out of the 80 students, representing 92.5% noted that they can save a document in any form either with its default name or with a new file name but 7.5% maintained they could neither save a file or document with its default name nor rename it before saving.

This shows that students are abreast of the various aspects of ICT tasks such as bolding, underlying apart from saving.

Table 6: Saving of Documents

Responses	Frequency	Percent
Yes	74	92.5
No	6	7.5
Total	**80**	**100**

In respect of knowledge on writing and sending of e-mails, about 66.2% confirmed that they can write and send information through emails since they have been taught

how to create their own emails and access them. On the contrary, 33.8% ascertained that they could not perform such actions since they had little knowledge about it. This implies that students who do not get much assistance lack ideas on how to access their mails as shown in Table 7. Correspondingly, there are still close to about 34% of students who need to be taught how to send e-mails. Additionally, it shows that students who do not have any knowledge about how to compose and send mails are willing to or will be encouraged to learn them should they be inculcated into Science lessons.

Table 7: Knowledge on Writing and Sending of E-mails

Responses	Frequency	Percent
Yes	53	66.2
No	27	33.8
Total	**80**	**100**

According to responses given in Table 8, a proportion of the total sample representing 68.8% said they have registered on social sites such as Facebook, Twitter, Snap Chat, Imo, Whatsapp with the reason that it helps them to link up with their old friends and families. 31.2% said they have not registered since they do not have much interest in such social sites with the reason that it exposes students to immoral information. The number of Ghanaians and students for that matter on social media is increasing day by day, however, not all people would register on them. While some of the 31.2% may not have easy access to computers, another reason for some students' inability or refusal to register on social sites may be that they do not have the money to buy their own storage devices or to pay to access the internet, hence they cannot or do not register on social sites.

Table 8: Ownership of Storage Devices and Social Sites by Students

Responses	Frequency	Percent
Yes	55	68.8
No	25	31.2
Total	**80**	**100**

Uses of the Computer

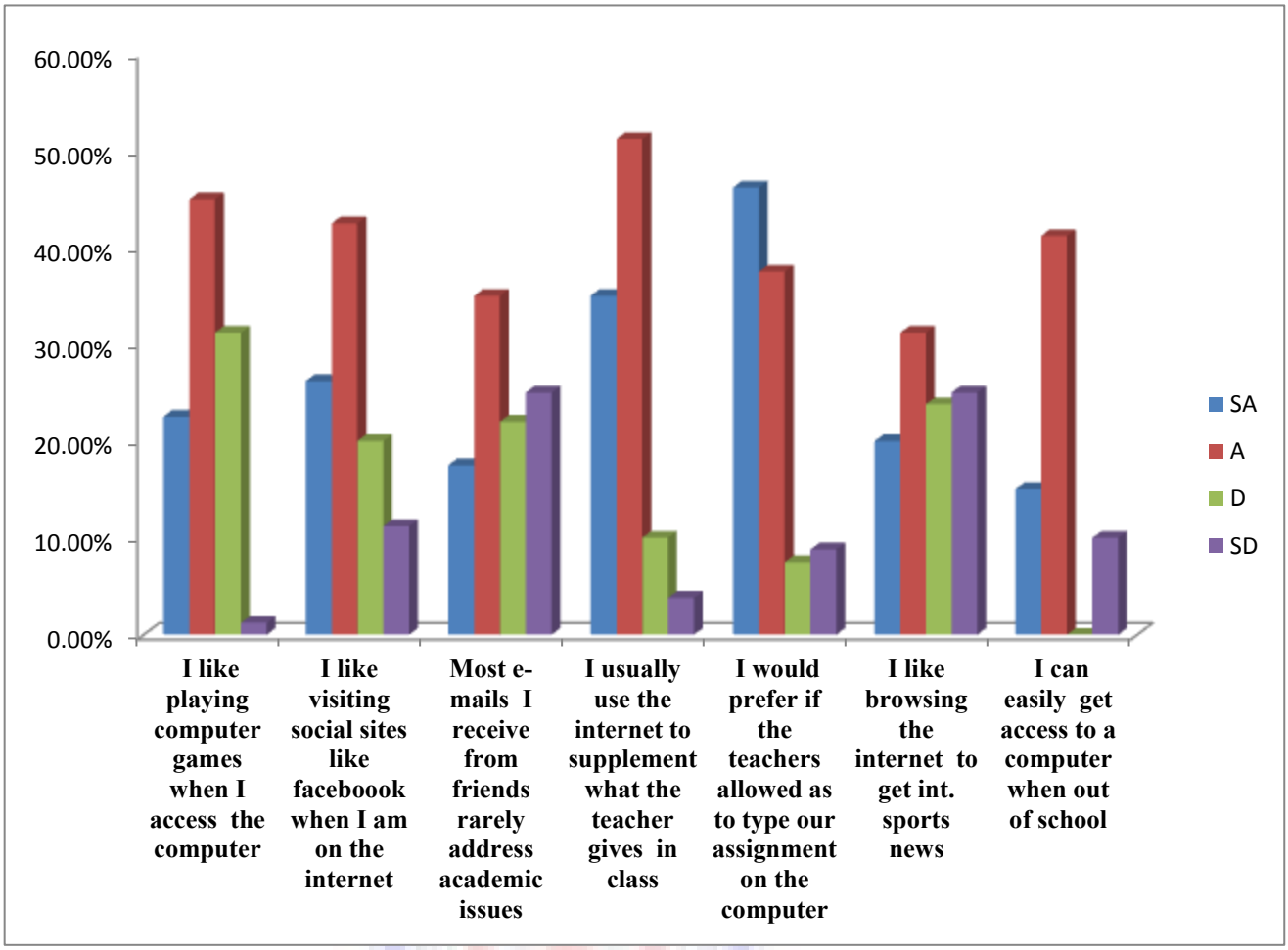
Figure 1 below demonstrates how students who have access to computers make use of them and how easily they have access to these computers. It was obvious that some students use computers for purposes other than academic such as games, sports amongst others. Various statements based on the way students make use of computers were put across and students were given the options to, on a scale; to strongly agree (SA), to agree (A), to disagree (D) or to strongly disagree (SD) with those statements.

As shown in Figure 1, whereas 51.2% of the students agree that they spend most of their time using the internet to supplement what the teacher gives in class, 35% strongly agree, 10% disagree and the rest who form 3.8% strongly disagree to this statement. A statement on whether students like playing computer games other than using computers to supplement what teachers give, gave the following responses: 1.2% strongly disagree that they like playing computer games whenever they access the computer, 46.2% strongly agree that, they prefer if the teachers allowed them to type their own assignments on the computer, on the other hand, few, representing 20% claimed they strongly agree that they browse the internet for international sports news as well as for useful information. From their views, it can be concluded that students do not access the computer for lessons, rather they go beyond what they have been taught in order to enhance their knowledge in ICT.

From Figure 1, although students have access to computers, the uses to which they put the computers vary. Admittedly, all students use computers for all the purposes stated in Figure 1, from academic purposes to sports. Comparatively, few students who use computers to supplement what teachers teach in class use these computers for emails, computer games, sports news or social sites. This is not to say that the majority of students who use computers for academic purposes entirely do not use them for the other purposes stated; as much as they do, they are few in number. Students who have computers at their disposal would easily use those computers more for learning purposes.

It can be inferred that a percentage of 51.2 students agree that they use computers to supplement what teachers give in class as compared to 38% who agreed that they prefer if the teachers allowed them to type their assignments on computers. Forty five percent (45%) agreed they like playing computer games when they get access to computers. On the other hand, 46.2% of students strongly agree that they preferred if teachers allowed them to type their assignments on computers, 35% also said they use computers to supplement what teachers give and 22.5% strongly agreed that they like playing computer games when they get access to computers. To reiterate the above analysis, should students get access to computers, most of them will use them more for learning purposes than for sports, computer games or for any other purpose. Schools and the Ministry of Education should therefore make provisions for more computers in senior high schools.

Figure 1: Uses of the Computer



Adequacy of Computers

Out of the total respondents of 80 students, 32.5% maintained that the available computers in the ICT laboratory are enough whiles 67.5% said they are not enough, as such it affects them during lessons. This implies that computers available to students are not enough, some students may have access to computers whiles others may not, hence it impedes teaching and learning as shown in

Table 9. Inadequate number of computers coupled with increasing number of students hinder a successful implementation of the ICT integration in Ghana.

Table 9: Adequacy of Computers

Responses	Frequency	Percent
Yes	26	32.5
No	54	67.5
Total	**80**	**100**

Availability/Adequacy of Internet Facilities

About thirty one percent (31%) noted that internet facilities in their school are available and adequate whiles 65% maintained that the facilities are available but inadequate. Only a few representing 3.8% said they were not available; this means integrating ICT into the teaching and learning process in these schools would pose a problem because internet facilities to help access information or lessons are not available. The summary of the data is shown in Table 10

Table 10: Adequacy of Internet Facilities

Responses	Frequency	Percent
Available and adequate	25	31.2
Available but inadequate	52	65.0
Not available	3	3.8
Total	**80**	**100**

Availability of Overhead Projector

Overhead projector is a device used to project information as well as for presentation of information. Indeed, students are not very familiar with overhead projectors since 83.8% confirmed that they do not have overhead projectors and 16.2% said they do have overhead projectors in their schools. Science teachers can present lessons or concepts easily with the help of projectors. The absence of projectors in some schools

is likely to hinder students' understanding of some complex processes or concepts. The summary of the responses is shown in Table 11

Table 11: Availability of Overhead Projector

Responses	Frequency	Percent
Yes	13	16.2
No	67	83.8
Total	**80**	**100**

Policy on the Use of ICT

About 54 (67.5%) said they have policies on the use of ICT in their schools. Additionally, 26 (32.5%) said there were no policies hence students go beyond normal instructions given them and this does not promote orderliness in the ICT laboratory for conducive learning. The analyzed data is summarized in Table 12.

Table 12: Policy on the Use of ICT

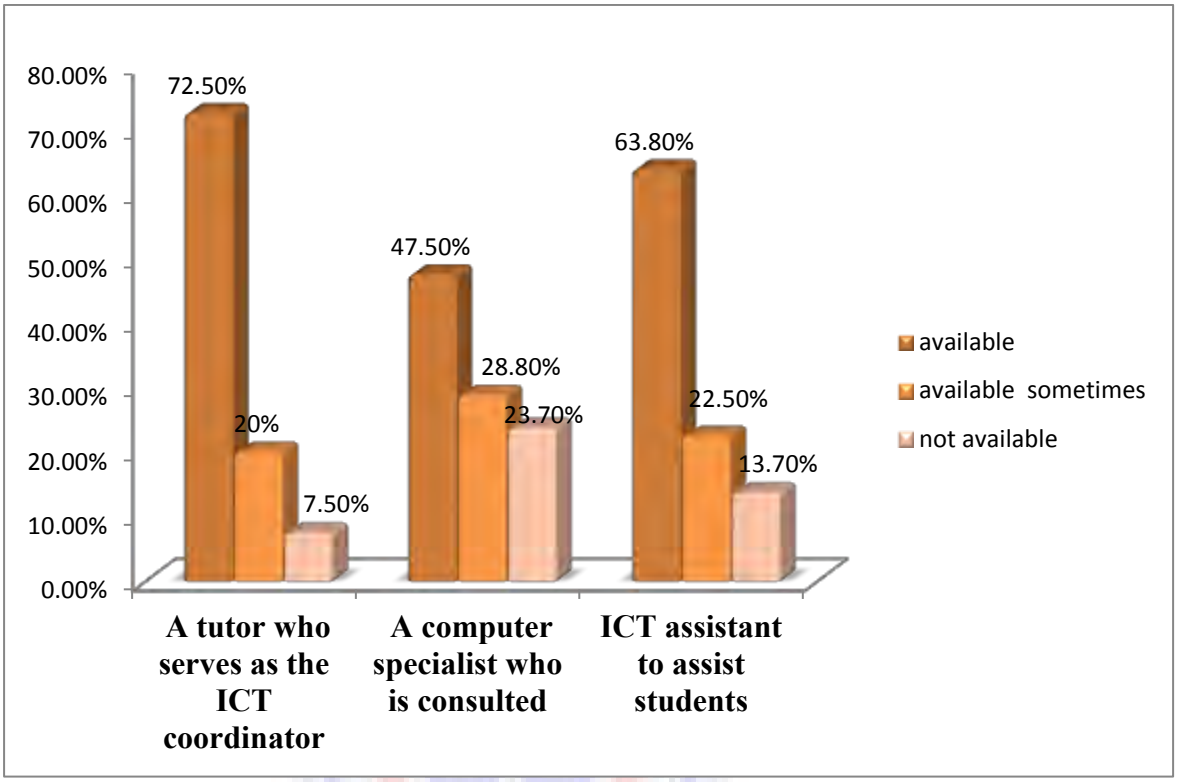
Responses	Frequency	Percent
Yes	54	67.5
No	26	32.5
Total	**80**	**100**

Availability of ICT Personnel

From Figure 2, 72.5% indicated that they have tutors who serve as ICT coordinators, 63.8% added that ICT assistants are available to assist students during lessons and 47.5% also said computer specialists are available to be consulted. In addition, 28.8% confirmed that a computer specialist is sometimes available to be consulted but 23.7% said they are not available. Lastly, 13.7% indicated that ICT assistants are not

available to assist students when they are needed but 22.50% claimed they are sometimes available.

Figure 2: Availability of ICT Personnel



Challenges Confronting Students' Use of ICT as a Learning Tool

There were many challenges confronting students in the course of accessing ICT tools such as inadequate learning materials, less supervision and assistance, limited time for accessing the laboratory, network failure as well as power outages but 30% confirmed that the major problems were limited access to internet services, 13.8% said freezing of computers and virus attacks.

Factors to Enhance the Use of ICT

Some students representing 23.8% suggested that in order to enhance the use of ICT in enhancing teaching and learning in schools there should be access to internet

always, 21.2% added deploying of more ICT tools and teachers. Also, 15.2% were of the view that teachers should assist students in areas they are finding difficulties.

Teachers' Responses

Fifty five percent (55%) of the teachers are within the age brackets of 26-35 years. This is followed by the age bracket 25 years or less which represents (25%). Twenty percent (20%) are within the age bracket of 36-45 years. This means that most of the Science teachers are in the youth group. This generally goes to prove that the youth form the major labour force in the formal sector. This data has been summarized in Table 13.

Table 13: Age of Respondents

Ages	Frequency	Percent %
25 years or less	5	25.0
26-35years	11	55.0
36-45 years	4	20.0
Total	**20**	**100.0**

Academic Qualifications

According to Table 14, most of the respondents representing 75% have Bachelor Degree qualifications, 20% have Master's Degree qualifications and one respondent has a Diploma Certificate representing 5%. This indicates that teachers are furthering their academic qualifications in order to be equipped more in their fields of study. Upgrading and retraining are therefore very necessary in ensuring quality education.

Table 14: Academic Qualification

Status	Frequency	Percent
Diploma level	1	5.0
Bachelor Degree level	15	75.0
Masters	4	20.0
Total	**20**	**100.0**

Teaching Experience

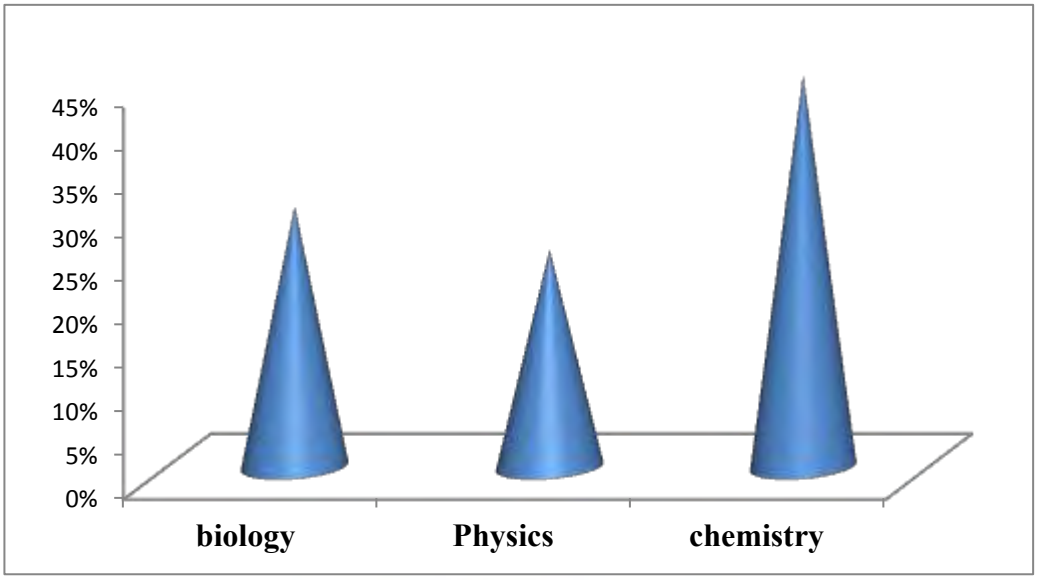
According to the years of teaching experiences, a number of teachers representing 35% have taught for about 1- 5years. Another 20% have teaching experiences of 6 to 10years. Ten percent (10%) of the teachers also have taught for 11 to 15 years whiles 35% have covered 15 years and beyond. The results have been summarized in Table 15.

Table 15: Teaching Experience

Responses	Frequency	Percent %
1-5 years	7	35.0
6-10 years	4	20.0
11-15 years	2	10.0
15+	7	35.0
Total	**20**	**100.0**

According to the data collected, 9 (45%) of the teachers teach Chemistry, 6 (30%) teach Biology and 5(25%) teach Physics. All the 20 respondents confirmed that they have personal computers or laptops. The data have been illustrated in Figure 3.

Figure 3: Subject Teachers



ICT Training

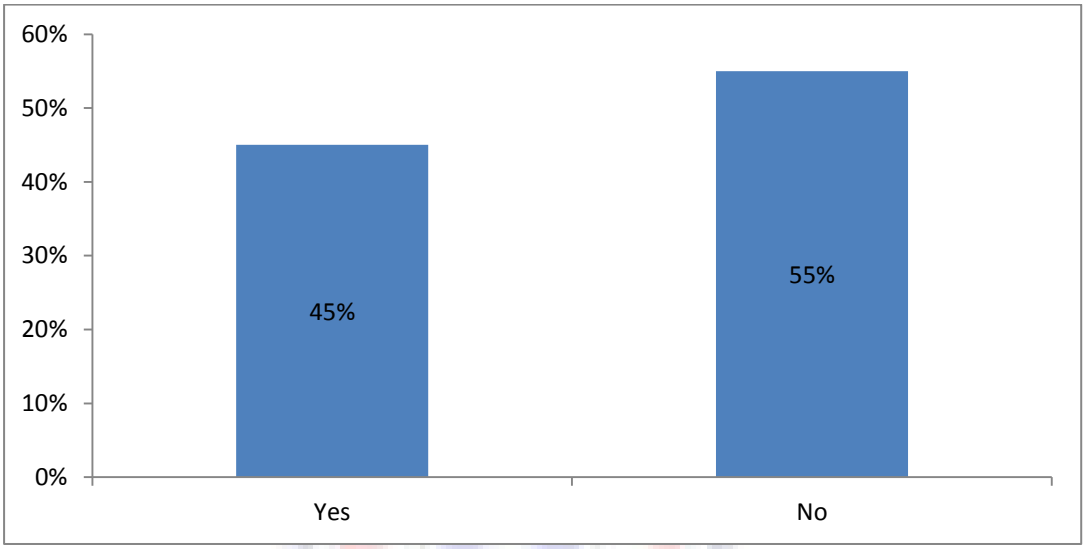
As cited above, all the Science teachers have personal computers or laptops. Fifteen percent indicated that even though they have personal computers or laptops, they have not received any form of ICT training whiles 85 percent had received training. It means those who have had training can use any form of ICT tools very efficiently without any difficulties and 15% of the Science teachers needed training to be more equipped with ICT tools. Table 16 shows the summary of the results.

Table 16: ICT Training

	Frequency	Percent
Yes	3	15.0
No	17	85.0
Total	**20**	**100.0**

From Figure 4 below, respondents confirmed that their computers are not enough and those in use are malfunctioning as indicated by 55% whiles 45% said theirs are enough and are in good state.

Figure 4: Availability of Computers



ICT Facility Use

According to the responses given as represented in Table 17, 25% said the ICT facilities are available and adequate but 50% indicated that they are available but inadequate. Twenty five percent indicated that they are not available.

Table 17: Availability of Facilities

Responses	Frequency	Percent
Available and adequate	5	25.0
Available but inadequate	10	50.0
Not available	5	25.0
Total	**80**	**100**

ICT Policy and Availability of Overhead Projector

All the respondents said they have policies on the use of ICT in the teaching and learning process. With regard to the availability of projectors, 70% said they do not have overhead projectors whiles 30% do have. This shows that schools which do not have projectors may have difficulties in integrating ICT into lessons as they cannot project lessons for students or organize lessons using PowerPoint presentations. Table 18 shows the summary of the data.

Table 18: Availability of Overhead Projector

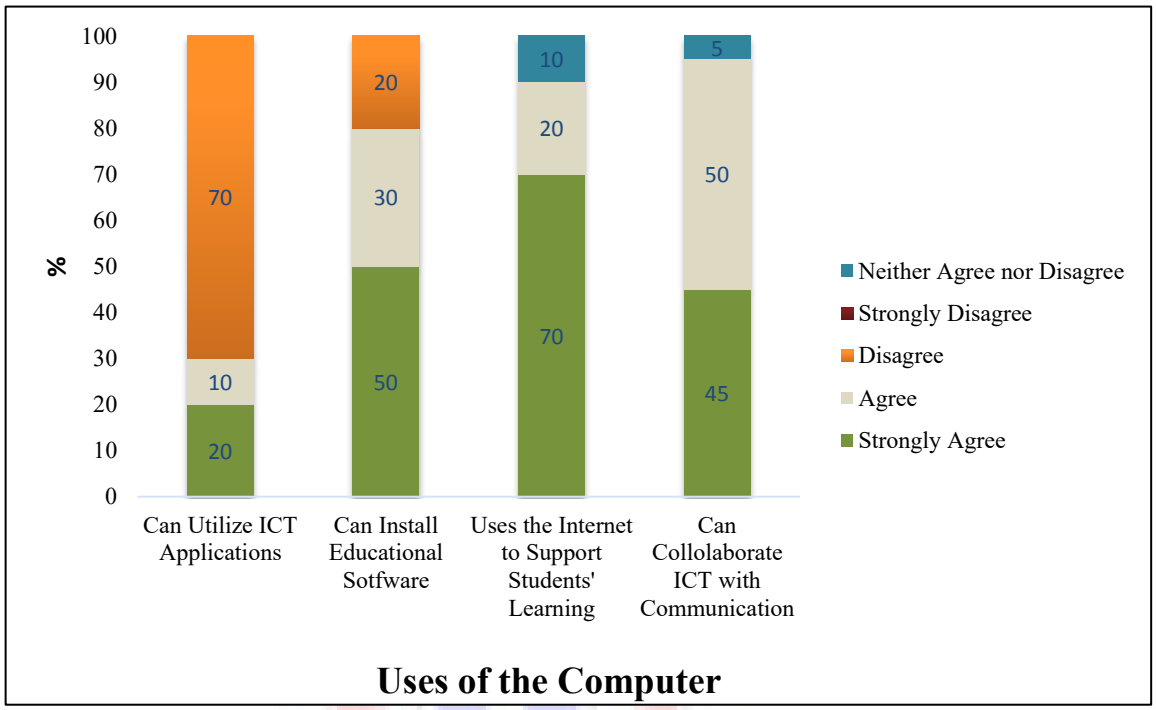
	Frequency	Percent %
Yes	6	30.0
No	14	70.0
Total	**20**	**100.0**

Uses of the Computer

Teachers were asked either to strongly agree to their capability to prepare lessons involving the use of ICT. The vast majority (80%) said they strongly disagree. Ten (10%) agreed to using computer in monitoring student's progress whiles those who disagreed represented only 40%. Out of the twenty respondents, 50% mentioned that they strongly agree that they can install educational software on their computers, 30% noted agree with the twenty percent (20%) stating that they disagree. With regard to using the internet to support student learning, majority (70%) of the respondents strongly agree that they mostly visit various sites to enrich their knowledge, in order to teach the students to their understanding whiles 20% noted they agree. In addition, 45% said they strongly agree that they can use ICT in collaboration with others such as communicating with others. Fifty (50%) stated that they agree. A further five

percent (5 %) indicated that they neither agreed nor disagreed that they possessed ICT skills.

Figure 5: Uses of computers



As can be seen from Figure 5, even though teachers use computer applications such as internet to enrich lesson plan, they are not able to integrate them during teachings/lessons.

Availability of ICT Personnel

All the teachers representing 100% confirmed that they have tutors who serve as ICT coordinators but they have inadequate computer specialists who are consulted when the machines do not function properly. Others added that even though they have specialists they are not always available.

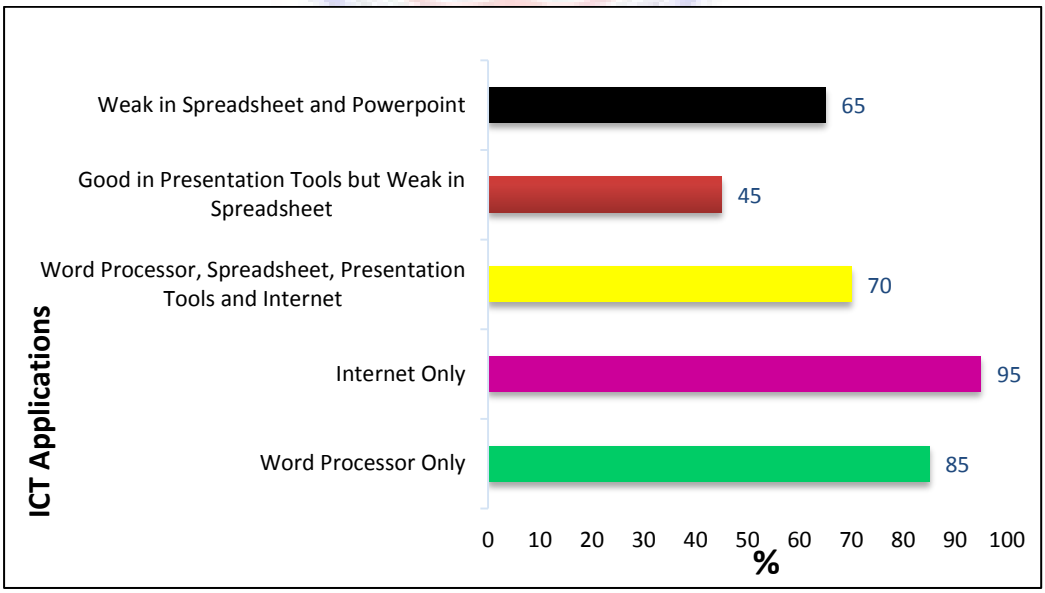
Data Presentation by Research Questions

The data collected were presented based on the research formulated for the study.

Research Question 1: To what extent are the Science teachers competent to integrate ICT applications into their lessons?

The research question sought to find out Science teachers' competencies in the integration of ICT applications into their lessons. From Figure 6 below, most respondents (teachers) representing 85% confirmed that they are very good in Word Processor whiles 95% are very good with the internet. Also, 70% claimed they are good in Word Processor, Word Spreadsheet, Presentation tools and internet browsing. On the other hand, 65% confirmed they are weak in Spreadsheets and PowerPoint Presentations. Secondly, 45% confirmed they are very good in PowerPoint and weak in Spreadsheets. This is summarised in figure 6 below.

Figure 6: Teachers' Competence in Integrating ICT Applications



This implies that the Microsoft suite contains various work sheets that teachers are familiar with. This also helps in impacting in depth knowledge to students in order to

create conducive environment for learning. Of the 20 Science teachers interviewed; majority of them are competent in ICT applications, especially in Word Processor and are at the same time competent in Spreadsheet and can integrate these applications into their Science lessons, yet only 45% which forms less than half the number of teachers could use PowerPoint. Indisputably, PowerPoint is a major application that can be used in making presentations during lessons. Teachers therefore need more training in PowerPoint presentation.

Research Question 2: How often do the science teachers utilize ICT applications in their lessons?

Table 19 shows whether Science teachers can prepare lessons that involve the use of ICT, four teachers representing (20%) said they strongly agree. Two persons representing (10%) agreed and those who disagreed were fourteen representing 70%.

Table 19: Utilizing ICT Applications in Preparing Lessons

Responses	Frequency	Percentage
Strongly Agree	4	20
Agree	2	10
Disagree	14	70
Total	**20**	**100**

Out of the twenty respondents, 50% mentioned that they strongly agree that they can find useful curriculum resources on the internet especially during examinations, 8 (40%) said they agree and two respondents representing (10%) stated that they disagree. Below is Table 20 which demonstrates the above.

Table 20: Finding Useful Curriculum Resources on the Internet

Responses	Frequency	Percentage
Strongly Agree	10	50
Agree	8	40
Disagree	2	10
Total	**20**	**100**

With regard to using computer in monitoring students' progress; the majority 14 (70%) of the respondents strongly agree that they do monitor students' progress using computers whiles four respondents representing 20% stated that they agree. Two respondents representing 10% disagreed. These contrast the percentage of those who said they can prepare lessons using ICT applications where 70% of the teachers disagreed and 10% strongly agreed. In addition, 60% said they strongly agree that they can install educational software on their computer. Ten percent (10%) stated that they agree to the statement of installing educational software on their computers. However, 30% of the respondents disagreed. Even though majority of Science teachers showed high level of competence to install educational software on their computers, they were unable to use them in the teaching and learning process.

Research Question 3: What problems do the Science teachers encounter as they attempt to integrate ICT applications into their lessons?

The research question 3 was answered by the respondents by allowing them to express themselves freely. Data in Table 21 shows the frequency of challenges faced by teachers integrating ICT in their lessons.

The study had interest in the challenges that teachers faced in integrating ICT which when well addressed the teachers will effectively adopt ICT use in their teachings. The respondents cited two major challenges which affected

integration of ICT into teaching and learning of sciences in their schools. These challenges are shown in Table 21.

Table 21: Challenges Faced in Integrating ICT

Challenge	Frequency	Percentage
Inadequate computers	55	47.8
Lack of ICT knowledge	51	44.4

The first challenge was on inadequate computers where most schools had a low student to computer ratio, which made the teachers to mainly use conventional methods of teaching. The few available computers also had network problems which affected downloading of some contents. Many schools lack LCD projectors for Powerpoint presentations and hiring of the same also proved to be expensive. Schools have also not acquired smart boards as well as relevant software to enable integration. The few computers are malfunctioning which hinders effective integration.

The second challenge was the lack of ICT knowledge where majority of teachers just had basic computer training with none having advance certificate in ICT. Possession of ICT skill provides the teacher with an opportunity to manipulate ICT equipment with regard to connection and even internet surfing to get relevant contents.

The ICT skills also enable teachers to prepare ICT enabled lessons and regular booking of ICT laboratory to deliver the prepared contents. The levels of ICT training also provide the teacher with the confidence to organize simulations using computers to avoid dangerous experiments.

Research Question 4: What policies exist in the selected schools to promote the integration of ICT applications in Science lessons?

Research question was answered based on the items summarized in Table 22. Based on the challenges experienced in the integration of ICT use in the teaching of sciences, the Science teachers suggested strategies that need to be put in place to address those challenges as shown in Table 22. To address the first challenge of inadequate computers, majority of the teachers suggested that schools should buy more computers to increase the numbers to meet recommended computer student to ratio. Some also suggested that backup generators be purchased to address power blackouts. Teachers were also of the opinion that digital contents be made available to all schools to facilitate effective integration. The table 22 shows strategies to be adopted by the schools.

Table 22. Strategies to Promote ICT Use in Teaching Science

Strategy	Frequency	Percentage
Purchasing more computers	16	80.0
In-servicing of Science teachers	19	95.0

From Table 22, majority of the teachers were of the opinion that teachers need some in-service training to upgrade their ICT skills in order to enhance integration of ICT in the teaching of Science. It is hoped that if these strategies are employed by Science teacher, then ICT integration will be effectively embraced in the teaching of the sciences.

Headmasters' Responses

A total of 315 Science students were recorded in the schools under study. Out of the four headmasters interviewed, three of them representing 75% had internet facilities which are in good condition but one of them representing 25% did not have internet at all connected to the school. Majority of them indicated that they had computers below 50 out of which few are apportioned for administrative purposes but none are given to teachers.

Furthermore, they accepted that indeed there is the need for in-service training for teachers on the use of ICT in education in order to improve students' academic performance.

In respect of overhead projectors, 25% said they do not have overhead projectors in their school whiles 75% confirmed they have overhead projectors but are not enough. The headmasters also indicated that there are policies on the use of ICTs in the teaching and learning process. This affirms what the Science teachers and Science students said about their schools' ICT policies.

From the responses indicated above, one can clearly say that the number of students reading General Science programme is increasing. However, due to the structure of the programme, there is the need for headmasters to provide the students with adequate internet facilities and other ICT infrastructure in order to enhance research work which will go a long way to improve upon students' performances in senior high schools.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

This chapter presents the summary of findings of the study and also makes inferences from what have been stated in the literature reviewed. Conclusion is then drawn by summarizing the research study. The chapter also presents recommendations that the researcher finds necessary for improving integration of ICT into the teaching and learning process in the sciences.

The study was conducted to investigate the challenges faced in integrating ICT in the teaching and learning of Science. The study was guided by the following research questions:

1. To what extent are the Science teachers competent to integrate ICT applications into their lessons?
2. How often do the Science teachers utilize ICT applications in their lessons?
3. What problems do the Science teachers encounter as they attempt to integrate ICT applications into their lessons?
4. What policies exist in the selected schools to promote the integration of ICT application in Science lessons?

Summary of Major Findings

The study investigated the challenges facing ICT integration in the teaching of Science in public senior high schools in the Akuapem North Municipality in the Eastern Region of Ghana. The study was guided by four objectives. Reviewed literature from different sources revealed that ICT infrastructure is a very important determinant in the integration of ICT in teaching of the sciences as it

influenced the type of digital contents to be used and where to use the contents. In addition, it emerged that ICT skills level was still very low and this needs to be upgraded through in-servicing to enable them manipulate ICT equipment. The literature also revealed that inadequate ICT equipment have reduced the frequency of ICT-enabled lessons in public senior high schools. The literature review also found out that there are strategies put in place to promote the use of ICT in the teaching of Science.

The following were the main findings of the study:

1. Research question one was posed to know the extent to which the Science teachers were competent to integrate ICT applications into their lessons. The study revealed that the Science teachers questioned were very good in terms of internet browsing, Word processing and presentation tools.
2. Research question two was also intended to find out how often the Science teachers utilize ICT applications in their lessons and if Science teachers can prepare lessons that involve the use of ICT. The results confirmed that they strongly agree that they can prepare lessons and do other activities with ICT applications at their own pace such as monitoring students' performances, researching and installation of educational software.

3. The question three centered on the problems Science teachers encounter as they attempt to integrate ICT applications into their lessons. There are two major problems facing Science teachers; they complained that ICT tools available to them are inadequate and they lack knowledge on some basic tools.

4. Research question 4 was posed to assess policies that exist in the selected schools to promote the integration of ICT application in Science lessons. From the data gathered, respondents recommended that in-service training be given to teachers to equip them in order to promote practical work. Also, some suggested that there should be expansion in the ICT resource centers in order to accommodate more students as well as provision of overhead projectors, computers and consistent internet supply and power supply. When all these suggestions are carried out, it will help teachers to put up their best in providing students with lessons. Teachers should assist students in areas they are finding difficulties. Others suggested that the laboratory should be spacious and ICT should be made a compulsory subject for all students. These factors when put into consideration can enhance interest in ICT tuition.

Conclusions

It is important to acknowledge that ICT can have technical problems, hence contingency planning is necessary to ensure alternative strategies are in place. Where the infrastructure and the platform for the application are unreliable, the output may be affected and this can adversely affect student motivation.

As computers are becoming more sophisticated and the range of software used by schools continues to increase, the schools must recognize the need to employ more and highly qualified technical staff.

Recommendations

- Teachers should be encouraged to use ICT applications since it will open up new ways of working which involves planning and imagination resulting in spectacular outcomes.
- Policies for integrated support service encompassing teacher and technician training, curriculum, assessment, together with software and hardware provision should be strictly adhered to in order to enhance lessons among teachers and students.
- Teachers should integrate ICT into Science teaching in a way that will motivate students as well as enrich learning or stimulate higher level thinking or reasoning.
- The Ministry of Education should make an effort to develop digital contents for schools and fund schools so that they can purchase more ICT infrastructure. They should also develop comprehensive ICT National Policies which must be enforced in all schools.
- Government should establish a comprehensive programme to ensure rapid development and utilization of ICT within the educational sector so as to transform the educational system, thereby improving the lives of individuals.
- Government should make computers affordable for teachers through subsidiary ways and also make internet accessible in senior high schools in Ghana.

Suggestions for Further Research

Despite the findings observed by the study, there are still some areas which may need further research to be able to understand determinants ICT integration in the teaching of the sciences better. These include:

i) Replication of the study in another District with a dominantly rural setting.

ii) Conducting a study on school based factors that influence ICT integration in teaching and learning in secondary schoo

REFERENCES

Akunja, M. (2011). *Factors Determining ICT Integration in Teaching and Learning in Secondary Schools in Kisumu City: A Case of Kisumu East District*, Kisumu, Kenya.

Ary, D. J. & Razariah, A. (1972). *Introduction to research in education,* New York.

Ayo, C. K. (2001). *Information technology: Trends and applications in science and business*. Concept Publications.

Ayot, H. O. & Patel, M. M. (1992). *Instructional Methods*. Educational Research and Publication, E R A P. Kenya.

Bate, F. (2010). A bridge too far? Exploring beginning teachers' use of ICT in Australian schools. *Australian Journal of Educational Technology*, *26*(27), 1042-1061.

Baylor, A. L. & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms? *Computers and Education 39*, 395-414.

Baylor, A. L., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms? *Computers & Education* 39, 395–414

Bell, B. (1986). *Converting Computer Based Learning Project. Computer Education Volume, 1* PP.43–48. Britain.

Best, W. & Kahn, V., (2003). Research in Education, 9th Edition, India.

Bigum, C. (1997). *Teachers and computers: in control or being controlled*? Australian.

Blurton, C. (1999). New directions of ICT use in education. World Communication and Information Report. UNESCO. *Journal of Education, 41* (3): 247-261

Bransford, J. & Cocking, R. (2000*). How People Learn, Brain, Mind and School.* Washington: National Academy Press.

Brown, A. (1995). Evaluation of teaching and learning process in a computer-supported mechanical engineering course. *Computers Education, 25*, 59-65.

Bryderup, I. M. & Kowalski K. (2002) The role of local authorities in the integration of ICT in learning. *Journal of Computer Assisted Learning 18*(4): 469–479.

Bybee, R., Taylor, J. et al. (2006). *The BSCS 5E instructional model: Origins and effectiveness*. Colorado Springs, CO: BSCS.

Cheng, Y. (2009). *Teacher management and educational reforms*: Paradigm shifts.

Christensen, R., & Knezek, G. (2008). Self-report measures and findings for information technology attitudes and competencies. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 349–366). New York, NY: Springer.

Clarks, C. M. & Peterson, P. L. (1989). Teachers' through process. In M.C. Witt Rock (Ed.), *Handbook of research on teaching*. New York: Macmillan.

Cohen, D. K. & Ball, D. L. (1990). Policy and practice: an overview. *Educational Evaluation and Policy Analysis, 12*(3), 347-353.

Cohen, D.K. (1987). Educational technology, policy and practice. *Educational Evaluation and Policy Analysis* 9(2), 153-170.

Conway, P. & Zhao, Y. (2003). From luddites to designers: Portraits of teachers and technology in political documents. In Y. Zhao (Ed.), *what should teachers know about technology? Perspectives and practices* (pp. 15-30). Greenwich, CO: Information Age Publishing.

Cox, M., Preston, C., & Cox, K. (1990). *What factors support or prevent teachers from using ICT in their classrooms?* Retrieved February 20, 2015 from http://www.leeds.ac.uk/educol/documents/01304.htm.

Drent, M. & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively? *Computers & Education 51*(1), pp. 187-199.

Ely, D. P. (1993). Computers in schools and universities in the United States of America. *Educational technology, 33*(9), 53-37.

Fensham, P. J. (2008). *Science education policy-making: Eleven emerging issues.* UNESCO.

Gay, L.R. & Airasian, P. (2000). *Educational research: competencies for Analysis and application (6th ed)*. Upper Saddle River, NJ: Parentice Hall.

Ghana ICT4AD Policy (2003). *A policy statement for the realization of the vision to transform Ghana into an information-rich knowledge-based society and economy through the development, deployment and exploration of ICT's within the economy and society*. Accra, Ghana: Ministry of Education.

Grabe, M. & Grabe, C., (2007). *Integrating Technology for meaningful Learning*. Boston. Houghton Mifflin.

Groff, J. & Mouza, C. (2008). A framework for addressing challenges to classroom technology use. *AACE Journal, 16*, 21-46.

Hawkridge, D. (1990). Computers in third world schools. The example of China. *British journal of educational technology. 21* (I): 4-20.

Hepp, K. P., Hinostroza, S. E., Laval, M. E., & Rehbein, L. F. (2004). "*Technology in Schools: Education, ICT and the knowledge society* "OECD. Available: www1.worldbank.org/education/pdf/ICT_report_oct04a.pdf.

Honsel, P. B. & Hills, S. R. (1989). The microcomputer and achievements and attitudes in high school biology. *Journal of Research in Science Technology, 26*, 543-549.

Imhanlahimi, O. E., & Imhanlahimi, R. E (2008). An evaluation of the effectiveness of computer assisted learning strategy and expository method of teaching biology: a case study of lumen Christi international high school, Uromi, Nigeria. *Journal of social science, 16*(3), 215-220.

Kara, I. & Yakar, H. (2008). Effects of computer supported education on the success of students on teaching of Newton's Laws of Motion. *World Applied Sciences Journal, 3*(1), 51-56.

Kersaint, G., Horton, B., Stohl, H., & Garofalo, J. (2003). Technology beliefs and practices of mathematics education faculty. *Journal of Technology and Teacher Education, 11*(4), 549-557.

Kombo, D. K. & Tromp. (2006). *Proposal and thesis writing,* Nairobi: Don Bosco Printers.

Korte, W. B. & Hüsing, T. (2007). *Benchmarking access and use of ICT in European schools 2006: Results from Head Teacher and a Classroom Teacher Surveys in 27 European countries, eLearning Papers 2*, 1: 1-6 www.elearningeuropa.info/files/media/media11563.pdf

Kothari, C. R. (2004). *Research methodology: Methods and techniques (*Rev Ed*.)* New Delhi: New Age International (p) Ltd.

Kozma R. B. (2008) Comparative analysis of policies for ICT in education. In: Voogt J., Knezek G. (eds). *International handbook of information technology in primary and secondary education, Vol. 20*. Springer, New York, pp 1083–1096.

Kozma, R. & McGhee, R. (2003). ICT and innovative classroom practices. In R. Kozma (Ed.), *Technology, innovation, and educational change: A global perspective* (pp. 43-80). Eugene, OR: International Society for Educational Technology.

Kozma, R. (1999). *World Links for Development: Accomplishments and challenges. monitoring and evaluation annual report*. California, Centre for Technology International.

Kozma, R. (2005). 'National policies that connect ICT-based education reform to economic and social development. *Human Technology, 1*(2), 117-156.

Kozma, R. B. & Anderson, R. E. (2002). 'Qualitative case studies of innovative pedagogical practices using ICT. *Journal of Computer Assisted Learning*, *18*(4), 387-394.

Kozma, R. B. & Mcghee, R. (2009). ICT and classroom practice. In R.B Kozma (Ed*.), Technology, Innovation and educational change: A global perspective* (pp. 43-80). Toronto: McGraw-Hill.

Kozma, R. B. (1994). Will media influence learning: reframing the debate. *Educational Technology Research and Development, 42*(2), 7-19.

Kuhlemeier, H. & Hemker, B. (2007). The Impact of Computer Use at Home on Students' Internet Skills. *Computers & Education, 49*(2), 460-480

Lai, K., W., Pratt, K., & Trewern, A. (2001). *Learning with technology: evaluation of the Otago secondary schools technology project.* Otago: Dunedin Press.

Latchem,C., & Jung,T. (2010). *Distance and blended learning in Asia*. New York: Routledge.

Lee, D. (1997). 'Factors influencing the success of computer skills learning among in-service.

McFarlene, A. & Sakellariou, S. (2002). The role of ICT in science education. *Cambridge Journal of Education, 32*(2), 219-232.

Ministry of Education (MOE). (2008). *Report on e-Readiness Assessment of Second Cycle Institutions in Ghana*. Accra, Ghana: ICT in Education Programmes Unit, Ministry of Education.

Mishra, P., Koehler, M. J., & Kereluik, K. (2009). The song remains the same: Looking back to the future of educational technology. Tech Trends 53(5), 48-53. doi:10.1007/s11528-009-0325-3.

Mooij, T. & Smeets, E. (2001). *Modelling and supporting ICT implementation in secondary schools*. Computers & Education, 36, 265-281.

Mooij, T. (1999). *Guidelines to pedagogical use of ICT in education*. Paper presented at the 8th Conference of the 'European Association for Research on Learning and Instruction' (EARLI). Goteborg, Sweden, August 1999.

Mooij, T. (2007). Design of educational and ICT conditions to integrate differences in learning: Contextual learning theory and a first transformation step in early education. *Computers in Human Behaviour* Vol. *23*, No. (3), Pp; 1499-1530.

Moon, J. W. & Kim, Y.G. (2001). "Extending the TAM for the World-Wide-Web context," *Information and Management* (38), pp 217-230.

Moyer, R. H., Hackett, J. K., & Everett, S.A. (2007). *Teaching science as investigation: Modeling inquiry through learning cycle lessons*. New Jersey: Pearson Merrill? Prentice Hall.

Mugenda, M. O. & Mugenda A. G., (2003). *Research methods*: *Quantitative and qualitative approaches*. Nairobi: Acts Press.

Mumtaz, S. (2000). Factors affecting teacher's use of information and communications Technology: a review of the literature. *Journal of Information technology for Teacher Education, 9* (3), 319-341.

Myhre, O.R. (1998). I think this will keep them busy: Computers in a teacher's thought and practice. *Journal of Technology and Teacher Education*, 6(23), 103-106.

Ngechu, M. (2004), Understanding the research process and methods. *An introduction to research methods*, Acts Press. Nairobi.

O'Byrne, P. J., Patry, A., Carnegie, J. A. (2008). The development of interactive online learning tools for the study of anatomy. *Medical Teacher*, *30*(8), 260-271.

Omufwoko, A.E., (2009). *Factors Influencing the Use of Information and Communication Technologies for Learning among Students at Technical Colleges in Nairobi Province*. Nairobi, Kenya.

Orodho, J. A. (2008). *Techniques of writing research proposal and reports in education and social sciences.* Maseno: Kanezja.

Peeraer, J. & Van Petegem, P. (2011). ICT in teacher education in an emerging developing country: Vietnam's baseline situation at the start of 'The Year of ICT. *Computers & Education, 56*, 974–982.

Pelgrum, W. J, (2001). Obstacles to the integration of ICT in education: Results from a worldwide educational assessment. *Computers & Education*, *37*, 163-178.

Pelgrum, W. J. & Law, N. (2003) "*ICT in Education around the World: Trends, Problems and prospects*" UNESCO-International Institute for Educational Planning. Available: www.worldcatlibraries.org/wcpa/ow/02d077080fcf3210a19afeb4da09e526.html.

Pelgrum, W. J. (2002). The Effectiveness of ICT in schools: Current trends and Future Prospects. Discussion Paper Presented at the OECD Japan Seminar: Teachers, Teacher Polices and ICT.

Ramasundaram, V., Grunwald, S., Mangeot, A., Camerford, N. B., & Bliss, C.M. (2005). Development of environmental virtual field laboratory. *Computers & education. 45*, 21-34.

Reynolds, D., Treharne, D., & Tripp, H. (2003). ICT: The hopes and the reality. *British Journal of Technology, 34(2)*, 151-167.

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.) New York: Free Press.

Sarfo, Q. & Ellen, J. (2007). Developing technical expertise in secondary/technical school: The effect of 4C/ID learning environments. *International Journal of Learning Environments, 30(25),* 27-41.

Scott, C.D. and Jaffe, D.T. (1988). "Survive and thrive in times of change", *Training and Development Journal*, April, pp. 25-7.

Scott, P., Dyson, T., & Gater, S. (1987). *A constructivist view of learning and teaching in science*. Leeds: University of Leeds.

Skinner, B. F. (1953). Science and Human Behaviour, New York: Macmillan. Small, R. V., & Grabowski, B. L. (1992). An exploratory study of information seeking behaviors and learning with hypermedia information systems. *Journal of Educational Multimedia and Hypermedia*, 1(4), 445-464.

Tabassum, R. (2004). *Effect of computer assisted instruction (CAI) on the secondary school student achievement in science*. PhD Thesis, Rawalpinda, Pakistan: University of Arid Agriculture. Retrieved on 20/04/12. Prr.hec.gov.pk/thesis/235.pdf

Taylor, R. P. (1980). Introduction to ICT. In R. P. Taylor (Eds.). *The computer in the school, tutor tool.* New York: Teachers College Press.

Taylor, R. P. (2003). Reflection on the computer in the school. Contemporary Issues in Technology and Teacher Education. *British Journal of Educational Technology*, *28*(2), 139-141.

Tilya, F. (2008). IT and educational policy in the sub-Saharan African region. In J. Voogt, & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 1145–1159). New York, NY: Springer.

Tondeur, J., van Braak, J., & Valcke, M. (in press). Curricula and the use of ICT in education. *British Journal of Educational Technology*.

UNESCO, (2009). Guide to Measuring Communication Technologies (ICT) in Education. UNESCO Institute for Statistics. Montreal, Canada.

Van Belle G.C. & Soetaert R. (2001) Breakdown into the virtual user-involved design and learning. *Journal of Technology and Teacher Education* 9, 31–42.

Voogt, J., Knezek, G., Cox, M., Knezek, D., & Ten Brummelhuis, A. (2013). Under which conditions does ICT have a positive effect on teaching and learning? A Call to Action. *Journal of Computer Assisted Learning*, 29, 4-14.

Waite S. (2004) Tools for the job: A report of two surveys of information and communications technology training and use for literacy in primary schools in the West of England. *Journal of Computer Assisted Learning 20*, 11–21.

Waite, S. (2004). Tools for the job: A report of two surveys of information and communications technology training and use for literacy in primary schools in the West of England. *Journal of Computer Assisted Learning,* (*20*), 11-21.

Watson, D. M. (1998). Blame the techno centric artifact! What research tells us about problems inhibiting teacher use of IT? In G. Marshall, & M. Ruohonen (Eds.), *Capacity building for IT in education in developing countries* (pp. 185-192). London: Chapman & Hall.

Webb, M. E., & Cox, M. J. (2004). A review of Pedagogy related to ICT. *Technology, Pedagogy and Education, 13*(3), 235-286.

Woodrow, J. E. (1992). The influence of programming training on the computer literacy and attitudes of pre-service teachers. *Journal of Research on Computing in Education*, *25*(2), 200–219.

Yildrim, S. (2007). Current utilization of ICT in Turkish basic education Schools: A review of teacher's ICT use and barriers to integration. *International Journal of Instructional Media,* 34(2)*,* 171-86.

Zaltman, G. and Duncan, R. (1977), *Strategies for Planned Change*, John Wiley & Sons, New York, NY.

Zhao. Y., & Cziko, G.A. (2001). Teacher adoption of technology: a perceptual control theory Perspective. *Journal of Technology and Teacher Education, 9, 5-30.*

APPENDIX A

QUESTIONNAIRE FOR STUDENTS

Instructions: Please enter the choice you have made by ticking (√) the answer in the space corresponding to your choice for structured questions. Write the response for the open ended questions in the spaces provided. Your name will be treated with strict confidentiality and will not be published in this study.

SCHOOL:……

Sex: Male ☐ Female ☐

Form/Level: S.H.S 1 ☐ S.H.S 2 ☐ S.H.S 3 ☐

Age: ……..

SECTION A: ICT Skills and Knowledge

1. Can you open a file on a computer?

   Yes ☐ No ☐

2. Are you able to create/edit a document on a computer?

   Yes ☐ No ☐

3. Can you save a computer document?

   Yes ☐ No ☐

4. Do you know how to write and send e-mails?

   Yes ☐ No ☐

SECTION B: Students Utilization of ICT Facilities

5. Are you registered with any of the social sites like Facebook?

Yes ☐ No ☐

6. Do you have your own storage device like a flash disc or memory card?

Yes ☐ No ☐

7. In the table below, respond by ticking the appropriate response by making use of the following key

SA- Strongly Agree A- Agree N- Neutral D- Disagree SD- Strongly Disagree

Statement	**SA**	**A**	**N**	**D**	**SD**
I like playing computer games when I access the computer					
I like visiting social sites like Facebook whenever I am on the internet					
Most e-mails I receive from friends rarely address academic issues					
I usually use the internet to supplement what the teacher gives in class					
I would prefer if the teachers allowed us to type our assignments on the computer					
I like browsing the internet to get international sports news					
I can easily get access to a computer when out of school					

SECTION C: Adequacy of ICT Resources and Personnel

8. Do you think the computers in the school are enough?

Yes ☐ No ☐

9. Comment on the adequacy of internet facilities in your school.

Available and Adequate ☐ Available but inadequate ☐ Not available ☐

10. Does your school have an overhead projector?

Yes ☐ No ☐

11. Does your school have a policy on the use of ICT in the teaching learning process?

Yes ☐ No ☐

12. Indicate by ticking (√) the availability of the following personnel in the ICT department in your school.

Personnel	Available	Available sometimes	Not available
A tutor who serves as the ICT coordinator			
A computer specialist who is consulted			
ICT assistant to assist students			

13. List any other challenges in the use of the ICT in your school?

……

……

……

14. What factors would enhance the use of ICT in enhancing teaching and learning in your school?

……

……

……

15. What possible recommendations would you make towards increasing the use of ICT in enhancing teaching and learning of Science in the senior high schools?

……

……

……

APPENDIX B

QUESTIONNAIRE FOR THE TEACHER

Instructions: Please enter the choice you have made by ticking (√) the answer in the space corresponding to your choice for structured questions. Write the response for the open-ended items in the spaces provided. Your name will be treated with strict confidentiality and will not be published in this study.

Name of School: …….

SECTION 1: Demographics

1. **Sex** Male ☐ Female ☐

2. **Age**

   25 years or less ☐ 26 -35 years ☐ 36-45 years ☐ 46-55 years ☐ 56-60 years ☐

3. Indicate your highest academic qualification

   PhD ☐ Master Degree ☐ Bachelor Degree ☐ Diploma ☐ Others ☐

4. For how long have you been teaching in this school?

   Less than a year ☐ 1-5 years ☐ 6-10 years 11-15 years ☐ More than ☐ 15 years

5. What is your teaching subject?

   Biology ☐ Chemistry ☐ Physics ☐

6. Do you own your own computer? Yes ☐ No ☐

SECTION B:

Knowledge and Skills in ICT

7. Have you ever received any form of training in ICT

   Yes ☐ No ☐

8. How do you rate your computer expertise in the following areas?

	Very Good	Good	Average	Weak
Word processing				
Spread sheets				
Internet browsing				
Presentation tools (Power point)				

9. In the table below, respond by ticking the appropriate response by making use of the following key (√).

   SA- Strongly Agree A- Agree N- Neutral D- Disagree SD- Strongly Disagree

Statement	SA	A	N	D	SD
I can prepare lessons that involve the use of ICT					
I know which teaching/learning situations are suitable for ICT use					
I can find useful curriculum resources on the internet					
I can use a computer in monitoring students' progress					
I can use ICT in giving effective presentation/explanations					
I can use ICT for collaborating with others					
I can install educational software on my computers					
I can use the internet to support student learning					

SECTION C: Adequacy of ICT Resources and Personnel

10. Do you think the computers in the school are enough?

Yes ☐ No ☐

11. Comment on the adequacy of internet facilities in the school.

Available and adequate ☐ Available but inadequate ☐ Not ☐ available

12. Does the school have a policy on the use of ICT in the teaching learning process?

Yes ☐ No ☐

13. Does the school have an overhead projector?

Yes ☐ No ☐

14. Indicate the availability of the following personnel in the ICT department.

Personnel	Available	Available sometimes	Not available
A tutor who serves as an ICT coordinator			
A computer specialist who is consulted			
ICT assistant to assist students			

15. List any other challenges in the use of ICT in the teaching and learning of Science.

……

……

16. What factors would enhance the use of ICT in enhancing teaching and learning of Science in your school?

.....

……

17. What possible recommendations would you make towards increasing the use of ICT in enhancing the teaching and learning of Science in senior high schools?

……

……

APPENDIX C

INTERVIEW SCHEDULE FOR THE HEADMASTER

1. How many Science students are in your school currently?
2. Is there an ICT department in your school?

   Yes ☐ No ☐
3. Are there internet facilities in your school?

   Yes ☐ No ☐
4. How many computers are in your school? ☐
5. How are the computers distributed for use by students, teachers and for administrative purposes?
6. Do you think there is need for in-service training for teachers on the use of ICT in education?

   Yes ☐ No ☐
7. Are there overhead projectors in your school?

   Yes ☐ No ☐
8. If yes, are they enough?

   Yes ☐ No ☐
9. Does your school have a policy on the use of ICT in the teaching and learning process?

   Yes ☐ No ☐

APPENDIX D

LETTER OF INTRODUCTION TO SCHOOLS

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION
P. O. BOX 25, WINNEBA
TEL NO. 0

TO WHOM IT MAY CONCERN

Dear Sir/Madam

LETTER OF INTRODUCTION

We write to introduce to you a [illegible] student who is a full student of the Department of Science Education at the University of Education, Winneba. Hence, he has requested for an introductory letter to enable him conduct a research on "*The Challenges facing the Integration of ICT in the Teaching and Learning of Science*" in your outfit.

We should be grateful if you could grant him the required assistance.

Thank you for your cooperation.

Yours faithfully,

VICTOR ANTWI (Ph.D)
Ag. Head of Department