UNIVERSITY OF CAPE COAST

INTEGRATING TECHNOLOGY AMONG SCIENCE TEACHERS USING CONSTRUCTIVIST LEARNING EVENTS IN COLLEGES OF EDUCATION IN CENTRAL REGION, GHANA

GODSWAY BELIEVER GBEZE

2014

UNIVERSITY OF CAPE COAST

INTEGRATING TECHNOLOGY AMONG SCIENCE TEACHERS USING CONSTRUCTIVIST LEARNING EVENTS IN COLLEGES OF EDUCATION IN CENTRAL REGION, GHANA

BY

GODSWAY BELIEVER GBEZE

Dissertation submitted to the Centre for Continuing Education of the Faculty of Education, University of Cape Coast, in partial fulfilment of the Requirements for award of Master of Education Degree in Information Technology.

JUNE, 2014

DECLARATION

Candidate's Declaration

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

Candidate's Signature:………………… Date:…………….………..

Name: Godsway Believer Gbeze

Supervisor's Declaration

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

Supervisor's Signature:…………………… Date:………………………….

Name: Professor Paul Dela Ahiatrogah

ABSTRACT

Technology is now a compelling tool in teaching and learning, offering constructivism to education. Its use across all disciplines and Science education cannot be excluded. In view of this, using a descriptive research design, this study investigated Preservice teachers use of technology and constructivist events in colleges of education in the central region, Ghana. Data were collected through the use of questionnaire from a sample of 60 preservice teachers who were on their out programme. The total sample size of the colleges of education pre-service science teachers was 212.

Participants ranged in age from 21 to 30 years, and were in their final year of a Diploma programme in three colleges of education in the Central Region of Ghana. The findings show that Preservice teachers generally do not use Technological tools in Teaching. Instead, majority of Preservice teachers and their Tutors use constructivist learning Events to teach. The inability of the Preservice teachers to use these varied technological tools is due to lack of training and also due to lack of instructional hardware and software; and the absence of technological integration units in their schools. The study recommended that technology integration units and tools should be integrated in the various schools.

ACKNOWLEDGEMENTS

I wish to express my profound gratitude to my parents Mr. and Mrs. Gbeze for their financial and spiritual support.

I also thank my able Supervisor Prof. Paul Dela Ahiatrogah of the Centre for Continuing Education, University of Cape Coast, for his timely effort towards this study. God richly bless you. The rest goes to Mr Arthur Nyarko and all office workers of the Centre of Continuing Education, all my colleagues especially Alex Osei- Gyeisi of the Computer Centre.

DEDICATION

To My Father Andy Kwakuvi Gbeze.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

Background to the Study

The goal of teacher education programmes is to help future teachers to realise just how meaningful, authentic and necessary technology can be for their teaching (Duran, 2000, p. 5). Duran (2000) dealt with the topic of how technology can be integrated into an elementary teacher education programme. One of his most important findings was that the pre service teachers whom he investigated had not been adequately trained in the integration of technology in the classroom. More specifically, they had not been given sufficient time to practice the kind of hands-on skills that a teacher needs to become a skilled practitioner in the art of integrating technology with teaching in a classroom. Duran, therefore, recommended that teaching institutions should integrate technology into their own programmes across board so that student teachers would have opportunities to acquire technological proficiency merely by engaging in their day-to-day learning activities. If Duran's advice were to be followed, information technology would be integrated into methods and curriculum courses rather than be a feature of courses specifically designed to teach technological skills.

Constructivism has been the subject of many research studies over the last decade. According to Tam (2000, p. 56), "the central tenet of constructivism is that learning is an active process and that learning is determined by the complex interplay among learners' existing knowledge, the social context, and the problem to be solved." Constructivism is, therefore, the ability to generate ideas and principles about learning that have important implications for the construction of technology-supported learning environments. One of these implications, which is also the central proposition in this study, is that there is the need to "embed learning into authentic and meaningful contexts" (Tam, 2000, p. 56; & Sahin, 2003, p.73).

Constructivism has exerted a powerful influence on teachers and curriculum developers because it has changed the way in which they see learners. Instead of defining learners as individuals who are passive and ignorant, learners are regarded as active participants in the learning process because they use multiple learning styles and methods to achieve their goals. Brooks and Brooks (1993) suggested that the following conditions need to be fulfilled if learners are to become active participants in their own learning: Learners need to be trained to engage in group activities, interpretive discussions and brainstorming in which they themselves take the initiative. Teachers need to be convinced of the necessity and importance of learner autonomy and learner initiative in the learning process.

Learning tasks need to be structured around open-ended questions. They need to be given enough time to formulate their responses to such questions. Learners will only develop higher thinking skills if they are encouraged to learn in this way. Learners need to be taught to participate freely and without self-consciousness in dialogues with their teachers and with one another. They need to be trained to formulate their own hypotheses and to challenge the hypotheses of others in the context of the free discussion and inquiry. Learners need to be taught how to use raw data, primary sources and interactive materials correctly (Brooks

& Brooks, 1993, p.p. 101-118). The kind of assessment process that is used in a constructivist classroom is unique to constructivist education. From a constructivist point of view, assessment has to be based on the process of learning. “The focus is on the quality of the learners’ understanding, its depth and its flexible application to related contexts” (Lindschitl, 1999, p. 192). Even though constructivist instructional design is extremely effective, it has been criticized for the following reasons:

i. It is expensive to develop

ii. It requires technology for its implementation.

iii. It is very difficult to evaluate (Tam, 2000, p. 32).

Statement of the Problem

From observations, despite the greater number of teachers produced by our tertiary institutions every year, there are a number of schools where teachers are not competent in the teaching of their various subject areas using technology. Also, the attitudes of these teachers in schools toward the use of computers and other forms of technology are not encouraging. This makes teaching ineffective and inefficient even where there are competent teachers to teach. It is on this premise that this study is designed to investigate the extent to which pre service teachers use technology in teaching and learning.

Purpose of the Study

The purpose of the study is to investigate pre service teachers use of Technology in teaching science using constructivist learning events in their classroom settings in Colleges of Education in the Central Region of Ghana.

Research Questions

In order to investigate the pre service teachers' attitude of integrating computers and technology in the classroom settings to achieve constructivist learning events, the following questions were raised:

1. To what extent do Tutors of pre service teachers use Technology in their classrooms?
2. To what extent do Tutors of pre service teachers use constructivist teaching and learning events in the classrooms?
3. To what extent do pre service teachers use Technology in their classrooms?
4. To what extent do pre service teachers use constructivist teaching and learning events in the classrooms?

Significance of the Study

This study was undertaken because it could provide relevant and useful information for curriculum developers, the Ministry of Education, and ICT teachers and co ordinators about the possible use of computers in teaching and learning situations in classrooms.

The findings of this study can help change the attitude of both teacher trainees and tutors of Colleges of Education towards the use of technology in the classroom.

Specifically, it would promote the use of constructivist learning events in teaching and learning.

Delimitation of the Study

Only pre service science teachers in three colleges of education in the central region were used for the study, the study was also delimited to pre service teachers in the final year of their studies.

The names of the institutions are;

1. OLA College of Education.
2. Komenda College of Education.
3. Fosu College of Education.

Limitations of the Study

Since quantitative and qualitative methodologies are based on different assumptions, it is possible that different techniques could produce different results. In some of the schools, not all the pre service science teachers were present at the time the study was conducted and this can decrease the generability of the findings.

Organization of the Rest of the Study

The remaining chapters of this study are as follows.

Chapter two discusses literature related to the study.

Chapter three describes the methodology used in the study, that is, the research design, population, sample, research instrument, procedure for data collection and the data analysis.

In chapter four, the findings are presented and discussed in relation to the literature. Finally, chapter five gives the summary conclusion, recommendations and areas for further research.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Overview

Jones and Mercer (1993) explained that modern teachers face a number of challenges as they undertake the often arduous process of integrating technology into their classroom teaching routines. Many of these teachers, if not most of them have no clear idea on how to use computers in their classrooms or how to organise and manage technology integrated classrooms. Teachers need skills and training of a very definite kind before they are fit to integrate technology with learning in the current classroom context. Behaviourist and constructivist theories of learning have become the basis upon which a more learner-centered type of instruction process has been constructed are usually used to describe how individuals succeed in learning. Jones and Mercer (1993), therefore, characterize these theories of learning as “ways of describing how people learn in terms of their individual thoughts and actions and how an individual adapts to the complexities of the society in which they live and operate” (p. 19).

In this chapter I hope to review and examine research that describes how computers have been used in the teaching and learning processes to equip pre service teachers in Colleges of Education to become skilled in techniques of integrating technology in learning in classrooms. In the process, I also discuss some of the following issues that are relevant to this theme:

i. Constructivism and behaviourism as learning theories.

ii. Cooperative learning and individual learning.

iii. The role of computers as the dominant form of technology in the modern classroom.

iv. The needs and imperatives that complex forms of technology such as the computer impose on teacher training programmes.

v. The theoretical framework – Bruner's (1966) constructivism theory and Skinner's behaviourism.

vi. Problems encountered by pre-service teachers as they attempt to integrate this kind of technology into their teaching practice

vii. Problems encountered by in-service teachers as they struggle with computer handling skill deficits.

viii. The implication of skill deficits among teachers of all kinds for learners and for the education system in general.

Learning Theories

According to Dunn (2000, p. 8), learning theories help us to understand how learning takes place; they enable us to understand the process of learning. They, therefore, provide us with a basis for analysing, discussing, and doing research in the field of learning and practice. A good learning theory will also summarize a large amount of information about the rules of learning in a fairly small space. A learning theory may also be regarded as a creative attempt to explain what learning is and why it works as it does.

The two learning theories that I will compare in this chapter are constructivism and behaviourism. A survey of the literature indicates that most researchers in the field of education proceed from the basis of constructivist (rather than behaviourist) which talks about "the nature of human learning and the conditions that best promote the varied dimensions of human learning" (Applefield, Huber, & Moallem, 2001, p.38). What is evident in this field is that there has been a wholesale movement away from pre-designed forms of instruction that are essentially behaviouristic to modes of teaching and instruction that are essentially constructivist (Cooper, 1993, p.14). According to Pechman (1992), the efforts of many professional groups to reform classroom instruction is an indication that constructivism currently exerts a decisive influence over modern education. Among professional groups who are active in these attempts to transfer from classroom instruction are the Association for Supervision and Curriculum Development, the National Council for Teachers of Mathematics, and the American Association for the Advancement of Science. Each of these groups in its own way has been influential in reforming traditional modes of instruction and implementing what are in essence constructivist modes or "active, inventive instruction".

The current literature shows that constructivism has acquired enormous prestige in the field of teaching and learning theory. It is believed that behaviourism has largely fallen from favour among concerned academics and researchers because behaviourists believe that "knowledge of the world exists independently of the learner. It then becomes internalized as it is transferred from the external reality, the teacher, to an internal reality, the learner" (Driscoll, 1994). In contrast to this, constructivism as a theory proposes that the "learner's conception of knowledge is to be derived from a meaning-making search in which learners engage in the process of constructing individual interpretations of their experiences" (Applefield et al., 2001, p. 37). This paradigm shift has affected the outlook of a whole generation of practising teachers and instructors, and it now seems natural to focus on what Applefield and others call "the meaning-making search" in which both teachers and learners are engaged. This, essentially, is what happens when constructivism is applied in practice.

The Theory of Constructivism

Hein (1991) defined constructivism in the following way: "Constructivism is a theory based on observation and the scientific study of how people learn. It says that people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences". Whenever we are confronted with information or facts about life, we are faced with the necessity of harmonising our new knowledge and experience with everything that we have understood and believed up to that point. Whether we are conscious of it or not, this is essentially a constructivist attitude in practice. New knowledge, new data, new experiences, all confront us with challenge of integrating what is new with what we already understand and believe about life and the world in general.

Faced with the new challenge, we may draw back and retreat from what disturbs us and try to rationalise it or explain it away, or we may reflect on our new experiences and integrate them into our old patterns of understanding, thereby changing such old patterns (and ourselves) in the process. Observation shows us that learners engage (whether consciously or not) in the constructivist process all the time.

They ask questions, they explore, and they assess what they know in terms of their previous knowledge and assumptions. In the process, they make new discoveries and learn new things. In other words, they construct new meanings and harmonise these new meanings with what they already believe and assume to be true (Hein, 1991).

Jonassen, Davidson, Collins, Campbell and Hagg (1995) acknowledged the constructivist approach to instruction as a theory that requires an understanding of how students create meaning. Since the creation of meaning is central to constructivist theory, it is vital for us to understand how this process takes place. The more successful teachers are in facilitating and encouraging meaning-construction activity in their pupils, the happier such pupils will be, the more successful they will be, and the more successful the teacher will be as a teacher. If learning environments are to be places where pupils can

confidently and safely expand their abilities and fulfil their aspirations, it is necessary for classrooms to become places in which knowledge construction is promoted and encouraged in an atmosphere of mutual respect between teacher and learner (Jonassen et al., 1995, p. 17).

The constructivist view is, therefore, that teaching is not a mechanistic or deterministic method or process of transferring knowledge from the mind of the teacher to the minds of learners. Constructivism is rather that process by means of which the teacher creates the kind of ambience and environment in which learners feel safe enough to become meaning-constructing partners with the teacher in the quest for knowledge, mastery and self-actualisation. Constructivist learning is therefore a process in which learners construct their own meaning from their own experience: what they experience guides them to make meaning out of what they have understood. Hein (1991, online) concured with the theory of constructivism. He understands constructivism to mean that learners construct knowledge and meaning for themselves, both individually and socially, while they learn. Learners utilise their own epistemological structures and pre-existent beliefs to extend their knowledge and process new information. Cobb (1994, p.4) pointed out that "constructivism stems from the idea that learning is a 'constructive process where students do not passively receive information but instead actively construct knowledge as they strive to make sense of their worlds'.

According to Dewey (1938), learning should be driven by cognitive dissonance as learners are confronted by new experiences and ideas and not by reinforcement (as with behaviourists). Dewey believed that this kind of traditional (behaviouristic) reinforcement of information results only in superficial learning because it does not require learners to engage all aspects of their understanding to bring various higher order abilities into play. An educator is, therefore, responsible for creating learning events in which learners are presented with problematic situations which they are then required to solve by extending their pre-existing epistemological assumptions. Bruner (1996) stated that "in constructivism, learning is an active process in which students construct new ideas or concepts based upon their current or past knowledge". (Bruner, 1996, p. 20) also said that "students select and transform information, construct hypotheses and make decisions by relying on their cognitive structure". He adds that although the constructivist "theory of learning had existed for over a hundred years now, it has not been widely accepted or applied in many public schools". By the beginning of the 21st century, constructivism has become (as we have already suggested) the theory of choice in most progressive educational schools. Both Dewey and Maria Montessori were advocates of constructivism in their day, as were Jerome Bruner and, in more recent years, Vygotsky (Campoy, 1992).

Constructivism supports learner-centered instruction because it advocates that "learning environments should have multiple perspectives or interpretations of reality, knowledge construction, context-rich experienced-based activities" (Jonassen, 1991, p. 10-11). Constructivism advocates a learning environment in which learners are specifically encouraged to draw on their previous experience, knowledge and understanding to construct new knowledge rather than to reproduce (by means of rote memorisation and regurgitation) old forms of knowledge or dogma. Constructivism assigns no specific value to virtuoso feats of memorisation as the most important criterion for defining success.

In a constructivist learning situation, knowledge and information are nearly always supplied to learners in the form of reference sources. The sources are easily accessible and retrievable printed matter, pre-selected text, books and electronic files, as well as referenceable CD-ROMS or DVDs, photographs, videos and other forms of electronic information.

What is of interest to the constructivist educator is not how readily the learner is able to access necessary information, but how skilfully the learner is able to process the information as he or she goes about solving authentic problems. The educator identifies or problems tasks that are suited to learners' levels of skill, expertise and understanding, and then invites learners individually and as a team to find appropriate solutions (Jonassen, 1991, p. 10-11). Ferguson (2001) therefore claims that the central idea of constructivist theory is that all useful learning is constructed from prior knowledge.

There is also a strong emphasis in constructivist learning on the augmentation of communication, social and dialogue skills by means of practice (i.e. being able to communicate effectively with one's teachers and peers). Teachers themselves are encouraged to facilitate rather than inform so that learners become people who discover rather than passive consumers who accept without questioning the opinions of authorities. Teachers, thus engage in constructive dialogues with learners, not because they are all knowing or even because they possess the necessary information to solve the problem in hand, but because they are trained to present the problem in a way that takes into account what their learners already know and what the conditions are that will challenge learners to move to the next level of knowledge and expertise. Constructivist learning is, therefore, often presented in terms of the metaphor of a spiral in which learners make successive iterations as they advance to new levels of knowledge. In doing this, what learners know "increases in content complexity and synthesis level" (Bruner, 1966).

The following constructivist principles were proposed by Ferguson (2001, p.48), and were endorsed in various forms by Jonassen (1991), Wilson and Cole (1991), Ernest (1995) and Honebein (1996). It is the collective wisdom of these authorities that the following recommendations need to be accepted and applied if one hopes to use technology successfully in a constructivist classroom:

i. Create “real-world” environments in which learning is relevant
ii. Focus on solving real-world problems
iii. Use instructors as guides
iv. Provide learner control
v. Negotiate instructional goals with students
vi. Use evaluation as a self-analysis tool
vii. Provide the necessary conceptual tools to help learners to interpret different perspectives
viii. Ensure that the learner is controlling and mediating learning internally
ix. Provide multiple representations of reality
x. Focus on knowledge construction, and not reproduction (Ferguson, 2001, p. 48).

Each of these principles has implications for the use of technology in the classroom.

Ferguson writes: "A constructivist technology-integrated lesson plan should be designed to bridge the transition between teacher-led instruction and self-directed learning by students" (Ferguson, 2001, p. 49). She cites evidence (referred to above) that confirms that belief that there is a direct relationship between the use of computers in classrooms and a measurable decrease crease in teacher direction of learners. The more extensive the use of computers, the more constructivist does a classroom-based learning situation become. Bruner (1996) suggests the following didactic instructional principles that make constructivist teaching and learning even more effective:

i. Instruction must be concerned with the experiences and context that make the student willing and able to learn
ii. Instruction must be structured so that it can easily be grasped by the students
iii. Instruction should be designed to facilitate extrapolation or fill in the gaps
iv. The instructor should try to encourage students to discover principles by themselves.

Because learners come from different social and ethnic backgrounds, they bring unique gifts, talents and knowledge to the constructivist learning context (Southwest Educational Development Laboratory, 1995). If learners are not to be inhibited by their differences, learning situations need to be firmly based on constructivist principles. This implies an ability on the part of learners to share without undue shame, shyness or inhibition in team situations or when working with partners. It also implies that teachers are in agreement with the following constructivist ideas, premises and principles, and are able to integrate them into their day-to-day practice:

i. Knowledge is constructed uniquely and individually, in multiple ways, through a variety of tools, resources and contexts
ii. Learning is both an active and reflective process
iii. Learning is developmental
iv. We make sense of our world by assimilating, accommodating or rejecting new information

v. Social interaction introduces multiple perspectives on learning

vi. Learning is internally controlled and mediated by the students

vii. (Southwest Educational Development Laboratory, 1995).

Shifting Roles in a Constructivist Classroom

Mann (1994, p. 174) is of the opinion that one can attribute the popularity of constructivism in the past few decades to novel forms of technology such as computers in classrooms. These new technologies include computers in schools and in teacher Colleges of Education. Such technological resources, in combination with the Internet, empower learners by giving them opportunities to work on "real-life" activities and to solve authentic problems. Any practising teacher will be able to testify to the fact that access to the Internet has transformed the classroom landscape.

Learners now have access to infinitely more information than was available to their mothers and fathers in the classrooms a few decades ago. It is possible that learners of past generations were expected to memorise clearly defined fixed forms of knowledge that their teachers provided. The exact forms of this knowledge were clearly delineated in a rigidly defined "syllabus" and no deviance from the syllabus was ever tolerated. But with the advent of computers, it is not knowledge or information that is the issue. Knowledge and information are freely available to anyone who has access to the Internet. The real problem now is for learners to make informed decisions about what information might be relevant to the problem that they need to solve.

Mann (1994, p. 172) points out what we all already know when she emphasises just how vast of a data bank on which anyone who is connected can draw. Modern learners, therefore, need to become skilled in information management rather than traditional memory skills. They also need to become adept at communicating with those who possess the kind of understanding that is necessary to interpret the sheer volume of information that is so readily available to users of the Internet.

In a technology-rich environment, the education process has to focus on the learning itself, as well as on the instructional goals of participant teachers and the school system at large. Technologies alone do not answer. Campoy (1992, p. 17) asserts that technologies in themselves are "merely tools or vehicle calls for delivering instruction". In these circumstances, it is evident that it is not the form of technology itself that guarantees success. Successful negotiation of obstacles and problems depends on how skilfully the technology is used not to mention the human gifts and talents that the learner who is using the technology brings to the solution of problems.

Strommen and Lincoln (1992) emphasize that what counts more in a constructivist classroom is what students can do by themselves, either under the guidance of the teacher or individually, as they use the new technologies.

Campoy (1992) cites studies that identify the kind of observable differences between a constructivist classroom and a traditional classroom.

Campoy notes that in a constructivist classroom, one might observe that:

There is a discernible shift away from whole-class instruction towards smallgroup instruction

i. The teacher, instead of lecturing, coaches, orientates, inspires and debates
ii. Teachers work more frequently with weaker students rather than focusing
iii. attention on brighter students (as is the case in traditional settings)
iv. Learners abandon their passivity and become more actively engaged
v. Students become more cooperative and less individually competitive
vi. Visual and verbal thinking rather than primary verbal thinking become more evident among learners (Campoy, 1992, p. 17).

In the constructivist classroom, modes of technology are there to be used by learners in activities that involve self-expression, exploration, synthesis, negotiation, collaboration and reflection. Modes of technology therefore become the means that learners use to express themselves creatively in the classroom. Technology, as such, has no intrinsic value. It is the uses to which technology is put that determines the quality of teaching and learning in a constructivist setting.

Constructivism more accurately reflects the way in which we as human beings learn new skills and abilities, as well as the ways in which we acquire new knowledge and expertise. Human beings learn by doing, by acting, and by purposeful communication with significant others (Southwest Educational Development Laboratory, 1995).

Assessment in a Constructivist Classroom

Jonassen (1991a, p. 32), quoted in Matusevich (1995),"Perhaps the thorniest issue yet to be resolved regarding the implications of constructivism for learning is how to evaluate the learning that emerges from those environments. If constructivism is a valid perspective for delivering instruction, then it should also provide a valid set of criteria for evaluating the outcomes of that instruction. That is, the assumptions constructivism should be applied to evaluation."

Jonassen (1991a, p. 32) makes the following thirteen assertions about assessment and other matters in the constructivist classroom:

i. Technology can and will force the issue of constructivism

ii. Assessment will have to become outcome-based and student-centred

iii. Assessment techniques will have to reflect instructional outcomes

iv. "Grades" must be contracted wherever grades are required

v. There must be non-graded options and portfolio assessment

vi. Self-evaluation and peer-evaluation should be carefully and thoughtfully balanced with teacher assessment

vii. Performance standards that are easy to apply in practice need to be developed

viii. A grading system must be developed which provides meaningful feedback

ix. Technology can be used to facilitate communication with parents

x. Videotapes of learners working should be included as part of their portfolio

xi. The focus should be on originality and appropriate performance rather than on regurgitation

xii. It is important to evaluate how the learner goes about constructing his or her own knowledge rather than to focus exclusively on the end-product

xiii. Assessment is context dependent (Jonassen, 1991a, p. 32).

The expanding use of technology in schools reflects an ever-increasing dependency on technology in society at large. Because most young people from affluent families grow up in technology-rich households, the extension of their skills to the management of technology in classrooms is a natural step for modern learners from privileged communities. Mann (1994) observes that many educators who were themselves educated in traditional classrooms have been slown to recognise the potential of various modes of technology in the classroom. Campoy (1992, p. 17) writes: “Many educators, as well as members of the general community, are naive about the ramifications of technology implementation, and proceed without a clear understanding of both the role of technology in schools and what are reasonable expectations

The Roles of Classroom Constructivist Teachers

Lunenburg’s (1998) opinion about the constructivist philosophy of education encouraged us quite naturally to adopt certain teaching practices. The most important of these practices are that teachers encourage learners to experiment, to take risks, to communicate with one another and with experts in the field, and to extend the range of their knowledge as they cooperate to solve the problems by which their success in learning will be assessed. The constructivist philosophy also encouraged reflection and consultation as learners review what they have achieved and what they hope to achieve at various stages of problem solving activity.

A constructivist teacher is especially interested in dialogues and consultations of this kind because they reflect more accurately than any written examination could do the kind of skills those learners have mastered as they achieve mastery over their environment.

A constructivist teacher is an interested but nondirective listener who ideally remains "invisible" even as he or she draws informed conclusions about the quality of group work, about levels of participation, and about the qualities that individual learners bring to the task in hand.

Lunenburg (1998) asserts that it is absolutely necessary for teachers to have a clear understanding of the pre-existing knowledge and skills that learners bring to bear in the learning activity. Brooks and Brooks (1993, p. viii), quoted by Lunenburg, (1998, p. 77), maintain that a constructivist teacher will:

i. Pose problems of known relevance to students
ii. Structure learning around primary concepts
iii. Seek and value the points of view of his or her learners
iv. Adapt the curriculum so that it supports the suppositions of learners at the stage of intellectual development at which they find themselves
v. Assess student learning in the context of teaching.

Lunenburg (1998, p. 78) asserts that constructivist teachers are comfortable with learner autonomy, independence and displays of initiative. This is one of the main differences between the traditional classroom and the constructivist classroom.

To a superficial or intimidated observer, the constructivist classroom may appear to be both chaotic and disordered. But an informed observer will detect characteristic signs of constructive learning in the apparent chaos, noise, excitement, contradiction and displays of personal energy and enthusiasm in the context of group work and teamwork. The traditional class, in contrast, assigns its greatest value to precisely the opposite qualities. The qualities most valued in traditional classrooms include silence, stillness, inaction, passivity, conformity, similarities rather than divergences in appearances and manner, self-effacement, self-abnegation and surrender of personal autonomy. In the constructivist classroom, the teacher encourages personal responsiveness, initiative and makes it clear that engagement rather than passivity is what is most valuable in group work. He or she also makes it clear that learners can expect to be assessed and evaluated for the contribution that they make rather than their silence, non-engagement and inactivity.

The constructivist teacher is not an impartial observer. The teacher remains very clear about what is most expected in learners as they engage with authentic learning tasks. The constructivist teachers' hopes and attitudes are determined by the implicit expectations of best-practice models of constructivist learning. Airasian and Walsh (1997) agree that constructivist teachers are responsible for creating the kind of sympathetic environment in which learners will not feel judged, exposed, criticised or humiliated as they take the initiative in group, personal or team learning situations. Taking the initiative implies self-disclosure. And self-disclosure is the basis of all creative activity.

Constructivist learning is, therefore categorically similar to other forms of creative activity and often indeed includes them. But self-disclosure is an inherently risky process. To disclose one means to open oneself to the potentially hostile scrutiny of one's peers and one's teachers. It follows therefore that the constructivist teacher is someone who is comfortable with the self-disclosure and initiatives of others. A constructivist teacher needs therefore to be expert in non-directive intervention. He or she would be someone who believes in the educational value of encouragement, enthusiasm, personal warmth, tact, challenge, and professional self-effacement for didactic purposes. Such personal qualities that would most certainly have condemned the constructivist teacher to professional oblivion in the traditional classroom.

The constructivist teacher is also someone who is comfortable with ambiguity, with the kind of tentativeness or "imperfection" that is characteristic of all learning processes, and with a great number of sometimes contradictory responses which is to say that there is often no one correct solution to many of life's problems.

The Role of Learners in a Constructivist Classroom

Brooks and Brooks (1993) have emphasised that learners are not "blank slates" (tabula rasa) upon which knowledge is imprinted. Learners approach each new situation in life with pre-existent knowledge and assumptions which, in turn, become "raw material" for the new epistemological syntheses that they will create.

Brooks and Brooks (1993, p.103- 118) are of the opinion that a constructivist teacher is someone who will:

i. Encourage and accept student autonomy and initiative
ii. Demonstrate to students the contradictions that may be embedded in initial understandings and formulations of situations or problems, and then encourage questions and discussion
iii. Provide time for students to construct relationships and create metaphors
iv. Assess student understanding by means of the application and performance of open-structured tasks
v. Encourage students to engage in dialogue with their teachers and with one another
vi. Assemble a wide variety of materials, including raw data, primary sources and interactive materials, and encourage students to use them
vii. Ask students what they understand by concepts before they share their own understanding of such concepts
viii. Encourage student inquiry by asking thoughtful, open-ended questions
ix. Encourage students to question one another
x. Encourage students to elaborate on their initial responses and formulations

Brooks and Brooks (1993) compare learners to detectives. They use this metaphor because detective is someone who solves problems by the intense application of his or her critical faculties to a particular problem. The detective is somebody who is constantly alert to inconsistency, incompatibility and incoherence in stories and in situations. He or she scrutinises human behaviour, asks questions, interviews witnesses, checks records and data banks, and follows promising lines of investigation. The activities of the detective are metaphorically parallel to those of the learner as he or she comes to grips with authentic problems, solves tricky problems, and creates higher syntheses of preexistent knowledge.

The metaphor of the learner as detective is especially apt because the learner is someone who learns to weigh and assess evidence as part of a process of creating a new synthesis of knowledge that explains facts that were inexplicable in terms of the old synthesis. Ideally, a learner, like a detective, becomes adept at scanning sources of information such as newspapers, telephone books, the Internet, and various public and private databases for information that is relevant to the problem that has to be solved. The constructivist learner is, like the detective, far more concerned to use his or her critical faculties to create a new synthesis rather than to memorise texts and some forthcoming ordeal (such as an examination or court appearance).

Empirical Studies Based on Constructivist Learning Theory

Although innumerable studies and a great deal of research have been based upon Constructivist learning theory, I shall, at this point, mention only two such studies. The first was undertaken by Richards of Winthrop University, South Carolina in 1998. The students whom Richards assembled to undertake constructivist literacy research were required to utilise only electronic technology to accomplish their goals. Each of the participants was asked to compile an electronically formatted portfolio from a list of topics relevant to literacy studies. These portfolios were expected to reflect how students had discriminated between relevant and irrelevant data, how they had assembled evidence to support the contention of the chosen theme or topic, how they had constructed arguments that supported their contentions, and how they had marshalled their data and arguments in a coherent and convincing electronic technological form. Participating students were then expected to share their conclusions with their fellow students and teachers.

The activities of the participants included "collaboration and cooperation in a group engaging in problem solving and constructing potential solutions to societal dilemmas, communicating the deeper processing of content and the critical development of literacy skills and strategies" (Richards, 1998).

Another study conducted by Walker (2000) from the Open University in the United Kingdom purports to demonstrate how constructivist forms of teaching and learning may be enriched and enhanced by the increasing integration of technology in the classroom. The institution concerned in Walker's research had developed a distance-learning course with the purpose of helping students to be able to learn more effectively and to become more active students while constructing their own understanding. The eleven subjects in the experimental group all felt that their learning skills had been significantly improved by their participation in the study. Walker (2000, p. 236) wrote: "The development of course modules that were based on constructivist practices and the integration of technology were also beneficial to the faculty. This resulted in changing the faculty plans by integrating technology for students to become more efficient by the use of application skills."

Computers and Teaching in the Classroom

The Role of Teachers in a Computer-Rich Environment

Means (1994, p. 18) and other researchers have confirmed that one of the most evident consequences of the introduction of technology into the classroom is that it changes the modes of interaction between learners and teachers. Because many learners are proficient in the manipulation of technologies such as personal computers, technology immediately creates a levelling effect on the classroom. It is pointless for a teacher even to attempt to maintain the kind of almost hieratic dignity and mystique that is characteristic of the behaviourist teacher in the face of the obvious superiority that many learners manifest when it comes to manipulating complex forms of technology such as the computer. To the behaviourist, this may be a disaster. But to the constructivist, the loosening of bonds of passivity and complacency and the learner's acceptance of personal responsibility for his or her education is an enormous dividend of a wholly constructive kind. It seems therefore that while technology in the classroom is inimical in many ways to the behaviourist agenda, it unintentionally promotes the purposes of constructivist teaching to an almost revolutionary extent. Nothing has quite undermined learner passivity and the customary vertical lines of authority of the traditional classroom more completely than active learner engagement within the classroom with highly prestigious forms of technology such as the computer.

Computer technology immediately creates a situation in the classroom in which the teacher is not the sole authority and in which learner initiative becomes not merely desirable, but indeed necessary. Navigation on a computer and successful manipulation of software require initiative rather than passivity, obedience, mindless respect for authority, and dependence on the superior knowledge of the teacher. But the teacher’s prestige and authority are not undermined by the introduction of technology into the classroom provided that the teacher is sufficiently flexible to adapt himself or herself to modes of interaction that learners are more democratic and self-effacing. This is both a challenge and an opportunity. While younger teachers tend to adapt themselves more easily to more democratic and centrifugal methods of instruction (usually because they themselves have often been exposed to this kind of educational method as learners), older teachers may understandably feel threatened because (ironically) their conditioning has not prepared them for the kind of radical doubt and confrontation that takes place in the fully active constructivist classroom.

Fontaine describes the dilemma in which older traditionalist teachers often find themselves in the following way: "Teachers may be forgiven if they cling to old models of teaching that have served them so well in the past. All of their formal instruction and role models were driven by traditional teaching practices. Breaking away from traditional approaches to instruction means taking risks and venturing in to the unknown. But this is precisely what is needed at the present time" (Fontaine, 2000, p. 53). In behaviourist classrooms of the traditional kind, teachers are at liberty (within reason) to dictate the kind of learning and classroom procedures that they prefer, and to enforce them with the authority conferred upon them by the institution and by society.

Siegel (1995) asserts that the introduction of technology and constructivist assumptions into the classroom compels teachers to change their custom modes of teaching and to adapt themselves to new necessities. Many traditional teachers are distressed by the need for such adaptations because their styles and modes of teaching and interaction with learners have (once again ironically) been conditioned by the rigours of a traditionalist teacher education. Teachers of this kind often find it extremely arduous to adapt to the more constructivist conditions that prevail in a classroom into which technology has been introduced (Burke, 1998).

The integration of technology into classrooms for learners has also revolutionised the classroom scene. Technology in a traditionalist classroom tended to be the preserve of the teacher an extension of the teacher's authority, control and prestige. A traditionalist teacher might accordingly use an overhead projector to project slides or transparencies imprinted with text or images. When used in this way, technology merely confirms the hegemony of traditionalist teacher modes of instruction because the teacher remains the centre of authority and the source of instruction. But as soon as technology becomes democratised (i.e. when each individual learner has equal access to a form of technology), the teacher is no longer the sole focus of attention, the approved purveyor of information, or the guardian of pedagogic protocols.

In a classroom in which technology is equally accessible to all learners, the teacher becomes a facilitator rather than an infallible authority. The dynamics of constructivism are metaphorically visible in the actual physical movements that the teacher undertakes in the constructivist classroom. In such a classroom, the teacher is no longer a "talking head" who dispenses information and instruction from a privileged position (literally spatially) above the learner. In the constructivist classroom, the teacher is no longer even able to talk down to learners because he or she has moved (in one sense at least) onto the same level as learners, the teacher has moved down and towards the learners in order to answer their questions, observe their progress, and suggest (rather than command) possible new lines of inquiry, activity and investigation.

As the teacher moves from one learner to another in situations like this, he or she responds to calls for help, comment or guidance by responding to the uniqueness of the learners' needs. Such a teacher no longer needs to embody the dignity and prestige of the institution or the power and authority of the society that finances, maintains and sanctions the institution. The tone that the teacher adopts when interacting with learners is thus correspondingly different in quality from that which a traditional behaviourist teacher might adopt. The behaviourist teacher is far more likely to offer suggestions, guidelines, support and even further questions, problems and complications rather than commands, solutions, definitions and obiter dicta (Stepich, 1996, quoted in Batane, 2004).

Dede (1998), quoted by Batane (2004, p. 390) approves of what happens when teachers use technology instead of didactic monologues. In a classroom supported by technology, teachers rotate about the room and observe learners from over their shoulders rather than from the prestigious position at the centre of the front of the room. The constructivist teacher is also far more likely to use the methods of Socratic dialogue by asking leading questions and by probing for a solution already implicit with the learner but to assemble the information that he or she already possesses. The constructivist teacher also suggests where resources might be found, but does not usually present them in a ready-made and pre-digested format. In every way, the learner in the constructivist classroom is encouraged to be responsible, to take initiative, to explore, to extend boundaries, and to discover solutions. In the behaviourist classroom, on the other hand, the learner is habituated to being a passive observer of how the teacher works through a problem and arrives at a situation which the learner is then invited to replicate. Reproduction, replication, centripetally, solitariness, memorisation and received dogma are all hallmarks of a behaviourist classroom. Experimentation, hypothesis, initiative, centrifugalise, trial and error, self-motivated inquiry, collaboration and teamwork are all hallmarks of the constructivist classroom.

As a teacher in the National Geographic Kids Network Project said:"I no longer spend most of my time standing in front of my class lecturing or having students reading from a textbook. I have become a facilitator, stage director, resource manager, master student, discussion leader, observer, and evaluator. For me this change has been refreshing and enlightening and long overdue. There are no longer textbooks or tests with right or wrong answers. They have become collaborators and teachers. They have become scientists, making predictions, developing hypothesis and analysing data. And they spend their money buying school pencils, folders, and banners to send home to their pen pals"

(Bracey, 1994, quoted by Batane, 2004, p. 391). Those who believe in the efficacy of technology as a means of educating children are of the opinion that every learner might well benefit from technology in the classroom provided that teachers use proven strategies for integrating technology into their classroom situations. While technology opens up all kinds of creative possibilities for teaching and learning, the incorrect use of technology in teaching situations will always prove disastrous.

Classroom technology needs to be carefully contextualized both in theory and in practice: it needs to be an integral part of a didactic philosophy that has been well researched and sensitively applied. No matter how promising a particular technology may be in itself, it will benefit neither teacher nor learner unless its advantages and limitations are clearly understood and taken into account in its classroom applications. The revolutionary technology such as the personal computer should be integrated in such a way into the classroom context that it will benefit each and every learner and not just a gifted learner (Fosnot, 1996, quoted in Batane, 2004).

The Office Technology Assessment (OTA) Report (1995), among other research studies, confirms that teachers are of the opinion that computer technology has revolutionised their teaching methods. If each of the learners in a classroom has access to a computer for educational purposes, that classroom immediately acquires most of the characteristics of constructivist learning situation. This does not happen for educational philosophical reasons, but rather because making a computer available to each learner automatically decentralises teaching and learning in a way that is consistent with the practical principles of constructivist teaching.

What happens in such a classroom, as I have noted before, is that teachers are “demoted” from their historical position as the sole repositories of knowledge.

Technologies such as computers place a corresponding onus on learners to become less passive, to take more responsibility for their learning, and become independent experts in their own right on the means of educational delivery (which, in this case, is the computer). It is the nature of the computer itself (rather than any kind of constructivist educational philosophy) that transforms a classroom in which computers are being used into a constructivist classroom. Since each computer is in itself an independent source of educational information, a classroom in which there are many computers is automatically one in which the locus of attention and authority becomes widely diffused rather than centralised.

The teacher does not lose dignity, authority or prestige in the computer-rich classroom. It is true that there is no place in such classrooms for teachers who cannot accept the decentralization of activity and responsibility that accompanies the widespread use of computers for education. It is true also that modern teachers need to be experts both in their subject specialties as well as in the software programs that their learners use. “Nowadays, the teachers must be specialist in rigorous subject matter and be adept with modern technologies” (Donley & Donley, 1996, p. 6). This new “burden” on teachers simply reflects changing patterns of imparting and processing information in the larger society in which we live.

The fact that modern teachers are expected to have a working knowledge of computers and widely used software hardly makes them unique. Applicants for even the most casual positions in the job market are routinely expected to be able to possess a working knowledge of computers. Most learners arrive in the classroom with far more advanced computer skills than many teachers. It is technology itself in the form of the computer that has dealt coup de grace to traditional authoritarian modes of teaching. The role of the teacher in the computer-rich classroom is not less important; it is simply different. Whether this new role is congenial or otherwise to the teacher depends entirely on temperament of the teacher himself or herself. Teachers who enjoy encouraging learner independence, creativity, initiative and self-actualisation will welcome the opportunities that the technological classroom provides. What is most certain is that teachers who are creative, pragmatic, imaginative and enthusiastic will find themselves very much at home in the modern technological classroom. The challenges presented by the computer-rich classroom are very great indeed, and they test the abilities of even the most gifted teachers. But the kind of teacher skills and aptitudes that ensure success in a classroom of this kind are very different from the skills, aptitudes and attitudes that maintained traditional behaviourist teaching. It is little wonder that many older teachers find it almost impossible to adapt creatively to the challenges of the computer classroom while younger teachers and recent graduates of education colleges find little to surprise them in such classrooms. This does not mean that teachers have become dispensable. They are just as necessary as ever they were. But the skills they need to make the teaching successful in the technological classroom are vastly different from the skills needed in traditional authoritarian teaching situations. The onus is on teachers to make technology-based educational a success. Without skilled choreography on the part of teachers, learners might easily lapse into old habits of futility and passivity technology or no technology (Hanson-Smith, 1997, quoted in Batane, 2004).

Cooperative Learning

One form of learning that is inimical to the traditional authoritarian classroom, but eminently suited to the technology-based classroom, is team or group learning. The presence of computers in the classroom makes it possible to divide learners into meaningful teams based on differences in ability, achievement and understanding. Teachers may, for example, use the more skilled and advanced learners in a class to coach their less advanced fellow learners. Arrangements such as this often make learning easier because learners frequently learn more easily from their fellow learners in group situations than from their teachers. In addition, learners who are entrusted with assisting their team members to master skills and solve problems are rewarded for the satisfaction that comes from having provided assistance to those in need.

Webb (1987, p.198) notes that half a century of research and a large number of research studies have confirmed that "there is a strong agreement among researchers that cooperative methods can and usually do have positive effects on students achievement". Webb's (1987) review of the literature dealing at that time with the interaction of learners among themselves and the efficacy of group learning that focuses on computers was undertaken in order to identify:

i. The pros and cons of learning in groups
ii. The kinds of verbal interactions that occur when small groups of learners work together at a computer.

The kinds of interactions that is beneficial or detrimental to learning

(Webb, 1987, p. 206)

This review led Webb to the conclusion that group work focused on computers leads to accelerated and more efficient kinds of learning. But this, according to Webb, was not the only advantage that accrued from group learning around computers. The flexibility afforded by the group learning format and by the peculiar advantages of computers also enables teachers to combine learners in groups that provide optimal learning opportunities for each team member. Hooper and Hannafin (1991), Rysavy and Sales (1991), and Simpson (1986) have reviewed the relevant literature and published articles about the value and efficacy of teamwork and cooperation in computer-assisted learning.

The Role of Teachers

In constructivist learning, teachers, as we have already noted above, become primarily facilitators, organisers, planners, liaison officers, coordinators, and the link between learners and the resources of institution and the authorities. Teachers also become referees in the computer-assisted classrooms because the responsibility for ensuring that all the necessary conditions for learning are present and ultimately resides with teachers. Yet although teachers in classrooms of this kind are "responsible" for maintaining proper working conditions and because they are "in control" in the sense of being responsible for what happens in the classroom, they do not exert the kind of centralised authoritarian control and responsibility that is the hallmark of the traditional behaviourist classroom.

The whole atmosphere in a constructivist computer-assisted classroom is more like a bazaar than the silent contemplative atmosphere that one encounters in some churches or traditional meditation rooms. The noise and bustle that is characteristic of classrooms of this kind is indicative of a specifically constructivist "working atmosphere".

The "working atmosphere" of the traditional authoritarian school is, on the other hand, a deep silence in which learners brood silently, passively and alone over their books or their written problems while making as little movement is possible. The noisy bustle that the teamwork of a constructivist classroom endangers would be regarded by authoritarian teachers as an indication of the kind of chaos in which no learning can take place. Constructivist teachers in charge of computer-assisted classrooms undertake the following kinds of activities:

i. They observe the work of learners (whether single or in teams) in an unassuming, non-directed and non-invasive manner
ii. They intervene in learner activities only if it is absolutely necessary to give proper direction and focus to the activities in which learners are engaged
iii. They have a clear idea of a kind of outcomes that learners need to be able to manifest as proof of their proficiency in certain predetermined skills and activities

iv. They are responsible for acquiring, servicing and maintaining all forms of technology, and for arranging for the maintenance of the fabric of classroom, its furniture, equipment and accoutrements

v. They encourage learners where and when necessary, and praise the achievements of groups and individuals

vi. They are responsible for creating and maintaining the kind of goodwill, fairness and satisfaction in a classroom without which constructivist computer-assisted learning cannot take place

vii. They organise and enunciate goals, deadlines, opportunities and limitations, and keep learners well-informed about what they are expected to achieve as proof of successful learning

viii. They assess and provide feedback where necessary on written or oral performances such as assignments, performance, portfolios and presentations

ix. They devise tailor-made activities and assignments for learners who find themselves out of their depth, and they themselves pay special attention to such learners or else refer them to those who can provide more systematic and remedial attention

x. They ensure each learner to take responsibility to the extent that he or she is able to manage it at their specific stage of development and maturation, and they make proper arrangements for learners to engage in self-evaluation

xi. They encourage the development of social and personal communication skills both in groups and in individual learners

xii. They encourage learners to become peer instructors who will take responsibility for the welfare and competence of individual learners and of the group itself (Joubert, 2000, online).

According to Joubert (2000), the following list describes some of the roles that learners may assume in groups or teams (what the learner would be responsible for these described in brackets after the title):

i. team leader or coordinator (responsible for the organisation and presentation of topics and individuals)

ii. recorder (responsible for the scheduling of meetings and the recording of research)

iii. data collector (responsible for being knowledgeable about resources; responsible also for extracting data from resources)

iv. media specialist or materials manager (responsible for collating data from different media)

v. checker (responsible for ensuring that all members have reached their goals)

vi. worrier or consensus taker (responsible for ensuring on-task participation)

vii. encourager or supporter (responsible for ensuring that all members make fair and realistic contributions)

viii. clarifier (responsible for providing examples or alternatives)

ix. reconciler or mediator (responsible for effecting reconciliation after disagreements)

x. group process monitor (responsible for observing the balance of group dynamics)

The advantages of cooperative learning

Joubert (2000, online) identified the following advantages that accrue from cooperative learning in the classroom situation:

i. Learners begin to value and appreciate the interdependence that arises out of cooperative learning
ii. Learners strengthen their social skills and develop useful peer relationships
iii. Learners become more favourably disposed towards the subjects that they study
iv. Learners' reflective and cognition abilities develop as they are required to clarify, explain and justify their points of view to other learners or to the group
v. The self-esteem of learners is strengthened, and they become more appreciative of their schools.
vi. The communication skills of learners improve
vii. Learners acquire the art of accommodating and tolerating points of view that are contrary or even the inimical to their own beliefs and conclusions
viii. The intrinsic motivation of learners improves.

The disadvantages of cooperative learning

Joubert (2000, online) identifies the following disadvantages that accrue from cooperative learning in the classroom situation:

i. Learners who are excessively shy suffer from having to cooperate actively with other learners and make verbal presentations in the group
ii. More talented students tend to play down or minimise the extent their achievements and abilities so that they will not be resented or envied by the group

iii. Learners who suffer from low self-confidence, a lack of initiative and a fear of rejection find group work frightening and anxiety-provoking. Because responsibilities are diffused throughout the group, some members may take it easy and rely on others to do work.

iv. More talented group members may appropriate leadership roles at the expense of others who are less obviously talented.

Individual learning

Sinitsa (2000) defines individual learning as:

"The capacity to build knowledge through individual reflection about external stimuli and sources, and through the personal re-elaboration of individual knowledge and experience in light of interaction with others and the environment. This capacity is demanded practically from everyone. All learning takes place within an individual, whether within a group or not."

The advantages of individual learning

Sinitsa (2000, p. 19) suggests that the following advantages accrue from individual learning:

i. Individual learning is more comfortable for introverts and shy students because it is relatively free from confrontation

ii. Individual learning may increase levels of self-confidence because it gives

iii. learners the opportunity to perform without outside interference

iv. It insulates learners from peer pressure

v. It increases intrinsic motivation

vi. It develop self-discipline

vii. It provides a format in which learners can work at their own pace

viii. This permits learners to repeat learning tasks as often as they need to requiring mastery of the subject in hand.

The disadvantages of individual learning

Sinitsa (2000) asserts that the social isolation that accompanies individual learning may create negative moods such as loneliness, boredom and frustration. Because of this, he suggests that the following disadvantages accrue from individual learning:

i. Individual learning requires a great deal of self-discipline. Not everyone possesses self-discipline to this degree

ii. Individual learning makes learners focus on their personal self-interest, success

iii. and achievements to the detriment of the successes, failures and difficulties of others

iv. The lack of stimulation from others may make individual learning boring and tedious

v. Individual learning is unsupported by the possibility of immediate peer input, support, feedback and interaction

vi. Since no other learners are present when individual learning takes place, the learner is not exposed to social models worthy of emulation

vii. In the individual learning format, there is no audience for verbal presentations, summaries and explanations of what has been learned.

The role of computers in the classroom

Jaber (1997) asserts that when learners use computers to study in classrooms, there are many more ready-made opportunities ;

i. For exploring variant solutions to problems,

ii. For obtaining more information and insights than might have been available to the solitary learner, and

iii. For collaborative problem-solving and peer stimulation.

This kind of radical reorganisation of the place in which learning occurs (the classroom) inevitably creates a great deal of alienation, resistance and opposition from educationists whose experience of teaching dates from a time before the advent of computers in the classroom. In cases where more conservative teachers are prepared to come to terms with the new didactic format created by computer-assisted learning, they often need to undergo intensive programmes of re-education and reorientation (Jaber, 1997, quoted in Muir-Herzog, 2004, p. 113).

Computers can transform education in the classroom. Computers and their peripherals might include any of the following: hardware and software, word processing programs, graphics capabilities, programmed instruction for problem-solving, spreadsheets, databases, dial-up connections or broadband, networked connections, and other forms of telecommunication and advanced technology. From a constructivist point of view, computers differentiate intrinsically between the roles played by learners and teachers and create a format in which constructivist educational methods may be applied and realized. We may therefore say that computers transform teacher-based instruction into student-centred instruction (Forcier, 1996).

Grabe and Grabe (1996) are in agreement with the opinion that computers and the conditions that accompany their implementation create teaching and learning that is both learner-centred and more obviously amenable to group work and peer support. Because of these enormous potential advantages, the main concern in classroom instruction today is to ascertain how technology and teacher instruction may be optimally integrated. While computer tools such as word processors, spreadsheets, databases and multi-media authoring programs may assist learners to learn more actively, they also encourage learners to become responsible for their own learning. Under these circumstances, technology of the kind we have indicated here provides an obvious format for the realisation of constructivist methods in the classroom (Grabe & Grabe 1996, p. 13).

Maddux, Johnson and Willis (1997) state that computers play well-defined roles in schools and in society. Because of rapid technological advances in computer technology in the past two decades, it has become possible in many educational institutions to provide each learner in the classroom with his or her own computer. Because of this, computers exert a fundamentally important influence on society and on education. The computer has revolutionised education more than any other single element in education since the invention of printing. Because computers are able to function with a speed, efficiency and power that far transcends human capabilities, they challenge human beings to adapt their educational methods to suit the new conditions in which learners find themselves.

Because computers so radically extend the ways in which learners can interact with one another and with the environment, one may confidently assert that "educational computing is an exciting new discipline whose effectiveness will depend on how today's teachers in training use computers in their own classrooms in the future" (Maddux, et al., 1997).

Pre-service teachers and technology

As we have noted in the section above, teachers who were educated and trained before computers became so ubiquitous in society, might well feel challenged, marginalised and alienated by the advent of technology of this kind. When teachers have already been teaching for many years without computers, the adaptation of their personal styles of interaction with learners and the notions they entertain about classroom discipline and order, often need radical revision.

Teachers who have not already computer-literate and familiar with routines occasioned by computers need to be radically re-educated in the new modes of computer-assisted education delivery. This kind of re-education, especially for teachers who are nearing retirement, may provoke a great deal of resistance, anxiety, distress, negativity, and even opposition.

While this is a painful experience for all concerned, it is hardly surprising.

Because computer technology creates such radically new methods of classroom interaction, it needs to be sensitively and carefully introduced to those (whether teachers or learners, whether young or old) who have no previous experience of computers. Studies supported the view that it is counter-productive to attempt to integrate teachers and learners in a computer-rich classroom environment by means of sporadic courses that are intended to familiarise course-goers with the technology or the software in hand.

Todd and Wetzel are of the opinion that it is far better to expose novices to a large number of courses in which the subject matter (the content) and the technology (delivery by means of computer) have already been well integrated (Todd, 1993; Wetzel, 1993).

Schacter (2001) reports that the most efficient way of helping teachers and learners to familiarize themselves with computer-assisted education is by providing the largest possible number of opportunities for hands-on work in courses where computers are already being used. Harel and Papert (1991) report that the most successful kind of integration occurs as a result of continuous practical high-volume exposure to real situations in which computers are used, and not from sporadic courses that offered piecemeal and disconnected instruction.

McKenzie (2001) and Scheffler and Logan (1999) noted that a properly trained learner needs not only to be thoroughly conversant with all computer-related skills: he or she also needs to have acquired the essential critical skills of analysis and evaluation. It is not enough for learners simply to know how to perform certain computer tasks. He or she also needs to be able to judge the quality of what is performed on and achieved by means of the computer.

In-depth computer-assisted education is therefore essential for pre-service teachers. These teachers need to have become so skilled in computer-related tasks and procedures, and so comfortable in an environment in which education is being delivered by means of computers, but they are able to pass their knowledge on to learners with maximum self-confidence, skill and efficiency. It goes without saying that the student teachers who arrive at college with a good deal of prior computer experience will find it far easier to learn what they need to know about using computers for educating learners within the classroom (Laffey et al., 1998; Hochman, Maurer, & Roebuck, 1993; Kearns, 1992). Dr. Lynda Roberts, a special adviser on technology to the United States Department of Education, wrote: “If you can get teachers to use technology effectively in their own lives, you have won 90 percent of the battle” (Rosenthal, 1999). Rosenthal describes how the National Council for Accreditation of Teacher Education (NACTE) requires all colleges and universities thoroughly to train pre-service teachers in the skills required for computer-assisted education in classrooms. He notes that this cannot be achieved merely by discrete and random “short courses” in technology. Student teachers can only be properly trained with the skills of this kind if they are trained in the context of a major programme that is didactically sound and based on sound research and content, and that extends from the first to the last year of student teacher training. Brush (1998) concurs with this opinion as he calls for integrated technology training throughout the teacher education programme. Computing instruction integrated throughout the teacher education program is, according to Moursund and Bielefeldt (1999), far superior to isolated and sporadic computer classes that are not part of a larger curriculum design. Student teachers who have received the kind of integrated computer instruction that we have described here should have skills far in advance of teachers who have been trained by means of in-service courses.

Wang (2000) believes that pre-service teachers who are placed in practical settings with teachers who view the efforts to integrate technology into the classroom as an unnecessary nuisance and hindrance to routine work, will never learn properly to appreciate the value and potential of computers in education. While a great deal of research has been undertaken on the topic of how pre-service teachers perceive and understand technology, Diegnueller (1992) points out that "some perceptions of good teaching practices may reflect an obsolete educational system" (Diegnueller, 1992, p. 512). As part of their research into the perceptions of pre-service teachers on how the roles of teacher have been changed by technology, Carr-Chellman and Dyer (2000) asked pre service teachers to respond to a reading about the future vision of education. The results showed that many respondents preferred traditional teacher roles that reflected the kind of teaching methods that they had experienced as learners. The researchers suggest that these responses are very much in line with the way in which human beings respond to change in general. Because teachers would prefer teacher roles to conform to what they personally experienced as learners and as students, they tend to be less than enthusiastic about any radical deviations from their expectations. Carr-Chellman and Dyer's (2000) results therefore probably reflect more accurately how teachers view the changes that are taking place in the education profession in general rather than how they view the role of technology in education.

Technology is also changing the way in which schools, colleges, universities and departments of education prepare teachers and measure their success, both in measurements used and in actual performance. Many teacher preparation programmes currently require that pre-service teachers are able to present well-prepared programmed lessons in their methodology and content courses. They have to give suitable evidence that they have conducted online research projects and that they have considered projects that are linked with learners in elementary or secondary classrooms and students in universities. They also need to be able to demonstrate their ability to integrate technology in appropriate ways into their lesson plans.

Hardy (1998), McNamara and Pedigo (1995), Siegel (1995), and Walters (1992) indicate that teachers must be able to use computers competently and efficiently in their classrooms, both as vehicles of pedagogically-sound instruction and for purposes of classroom management. They must also possess a working knowledge of hardware and various software applications. Siegel (1995), Schrum (1999), and Strudler and Wetzel (1999) agree that even if teachers are basically positive in their attitude toward the use of technology for educational purposes, they are unlikely to feel comfortable or competent about using technology in their classrooms if they are not given adequate support in the form of time, training, access and backup services.

Poole and Moran (1998) suggest that deficiencies in staff development prevent teachers from utilizing existing technology in their teaching. They expand on this by asserting that "one-shot workshops, added expense of training, lack of continued support, isolated knowledge, unawareness of school needs, lack of knowledge and support from leadership all contribute to the ineffectiveness of technology staff development". They feel that it is the teacher who is best able to judge when the time, situation and place are right for integrating technology creatively into the learning process. Also teachers on the job should be able to judge what kinds of technology are suitable for their teaching programmes.

The Michigan State Technology Plan has identified the kind of advances that have been affected by the transformation of education through technology. A technology that is appropriate and well-suited to specific educational purposes should allow:

i. Student-centered learning
ii. Mass-customization with accompanying instructions as to how individual student needs may be met
iii. Flexible pacing based on student abilities
iv. Distributed learning from any place and at any time
v. Critical thinking in real-world contexts
vi. Collaboration and dialogue among students, and between students and teachers
vii. Standards, strategies and statistics
viii. Up-to-date primary information resources and parent-teacher communication on a daily basis (The Michigan State Technology Plan, 2000).

These advances are in sharp contrast to the more traditional, non-technology-supported kind of education that emphasizes learning that is tied to a teacher, classroom and school building during school hours, that utilised textbooks that our often sadly out-of-date, and that schedules only one parent-teacher conference per semester.

Batane (2004) describes how teachers in Botswana are faced with daily challenges because of the far-reaching changes are taking place in schools and in society. One such change has been introduction of computers into schools. It is on the shoulders of teachers that the burden of understanding, maintaining and making proper use of these computers in the classroom falls.

Research, however, indicates that the teachers themselves need in-depth training in the use of computers and in techniques of integrating computers with classroom education. It is absurd to expect teachers to function in computer-endowed classrooms without proper training, guidance and orientation. In-service training, furthermore, is arranged and applied differently in each school. The main challenge is how to improve the quality of education by the successful integration of computers into classrooms (Stepich, 1996). If this is to happen, appropriate computer courses need to become an extensive part of the syllabus of student teachers, and in-service teachers need to be given more than the sometimes perfunctory training that they now receive. Whether teachers feel comfortable with computer-assisted teaching or not, teaching of this kind is obviously here to stay, and teachers need to do everything in their power to make themselves as proficient as possible in computer skills and in computer-assisted teaching techniques (Barnett, 2000, quoted in Batane, 2004).

Alden (2000) asserts that the most effective teacher training programmes are those that allow teachers first to learn how they themselves can benefit from technology. Teachers need to be shown the extent to which computers can make their lives easier, more productive, or pleasurable and more satisfying. There are computer programs that teachers can use to plan and develop lessons, to create learning materials, to perform tedious calculations, to create and distribute messages and information, and to prepare notices, letters and other documents (Batane, 2004, p. 389).

Technological preparedness on the part of teachers

A number of research studies describe how ill-prepared teachers are to use technology for instructional purposes in the classroom (Beaver, 1990; Brooks & Kopp 1989; Roblyer 1994). The results of the survey of 1100 student teachers indicated that more than 90% of them needed a great deal more hands-on training before they might be regarded as sufficiently knowledgeable and prepared to use computers for the own purposes and to teach computer-assisted education (Berger, Carlson & Novak, 1989).

Another survey conducted by Hurteau (1990) in New York State revealed that only 20% of respondents felt that they had been given an adequate amount of training in the use of computers for instructional purposes. The attitudes of elementary school teachers towards the use of computers in classrooms are bound to have crucial effect on the preparedness of their learners in primary and in high schools. This in turn will affect the computer skills of successive generations of school leavers and consequently of the workforce itself. By now it is well established that it is only teachers who are proficient and comfortable with technology who are able to assist their learners to use technology successfully and efficiently.

In a survey conducted in colleges, schools and departments of education in the United States to determine how well teachers had been trained to use computers and teach its uses to others, the Milliken Exchange and the ISTE found that there was very little difference between the teachers' levels of skill and those of their learners (Moursund & Bielefeldt, 1999, p. 28). The survey also concluded that the best way to improve teacher computer skills would be by more intensive exposure of student teachers to technological education and management throughout their years of vocational preparation (Moursund & Bielefeldt, 1999, p. 10).

The role of technology in pre-service education

The purpose of Batane's (2004) Botswana research into in-service training and technology integration into the teaching and learning process was to determine how well disposed the teachers of a particular high school in Botswana would be towards working with computers in their classrooms. The findings predictably showed that those teachers who had the best computer skills in the school were the teachers of technology, while teachers who had no professional technological training were dissatisfied with the kind of computer training that they had received. Unfortunately even those teachers with inadequate computer skills were expected to train learners in the whole range of computer skills that they needed to continue their studies and seek employment in the job market.

Eby (1997) has remarked that technological skills are a sine qua non of modern teaching, and that the instructional programs now being used in most schools cannot function without adequately trained teacher instructors. Teachers therefore need to be properly trained in technological management if the programs themselves are to function adequately. Inevitably, teachers who rated themselves as improperly trained lacked the confidence they needed to train learners. This lack of confidence also presumably affected their self-image and self-esteem adversely. As it is often the case with teachers, they had been thrown in at the deep end without being taught how to swim. It is perhaps are flection on the training they were given that even after being trained, a number of teachers still felt unable to meet the demands of computer-assisted education (Batane,2004).

As each year passes, technology is being used more and more intensively in every sector of society. In spite of this exponential increase in technology-related activities and skills in all walks of life, elementary school teachers are still not being properly trained to integrate technology with the teaching, and elementary school teachers themselves are not being given the opportunity to keep abreast of the latest developments in computer assisted education and accompanying forms of software. Even as more and more money is being made available by governments and corporations for the funding of computers in educational settings, there are misgivings about the quality and extent of the programmes that have been put in place to train student teachers to handle computers efficiently.

Gerald & Williams (1998) have indicated that K-12 schools will employ about two million new teachers by the year 2008. Because we live in a society in which computer technology is now well integrated into most aspects of life, there is a corresponding burden on universities and colleges of education properly to train these teachers before they leave universities and begin their careers. Student teachers need to be given as many opportunities as possible to observe how technology is already being used effectively in their universities and colleges.

They need to be exposed to these programmes and given opportunities to obtain first-hand experience of how computers are already effectively integrated in innumerable teaching situations (Hill & Somers 1996). In spite of these clearly understood needs, the Office of Technology Assessment (OTA, 1995) has reported that most graduates arriving in the teaching profession possess but an imperfect knowledge of how to incorporate technology into their classroom practice even though they could manipulate and navigate their way around a limited number of widely used programs. Only one in ten, however, possessed the skills to cope with more advanced forms of software and undertake fairly routine classroom tasks such as electronic presentations, and few were able to devise lesson outlines and support material for the teaching of technological skills in classrooms. The OTA study also reported that "overall teacher education programs in the United States do not prepare graduates to use technology as a teaching tool"; from

http://www.wws.princeton.edu.innopac.up.ac.za/ota/disk1/1995/9541.html

And while a study undertaken by the National Centre for Education Statistics (NCES) (2000), that reform of education cannot take place without the incorporation and integration of technology into educational structures, only 20% of teachers possessed the necessary skills to make technology central to their teaching.

Trotter (1999) reported on a study carried out by the International Society for Technology in Education (ISTE) in which 416 colleges of education were surveyed. The results of this study show that the student teachers in these colleges were not being adequately prepared to maximise the potential benefits of technology in the classroom and to pass on their skills and expertise to their future learners. Another important study by the NCES (2000) reached the following conclusions:

Only 50 % of the teachers surveyed who had computers (and Internet connection) in their classrooms actually used these computers for purposes of instructing learners of these, 61 % revealed that the most advanced usage to which they put the computers involved word-processing and spreadsheet operations

Only 33 % of all respondents were of the opinion that they possessed sufficiently adequate skills to benefit from the computers and the Internet connection in their classrooms

Another 33 % of the respondents believed that they were sufficiently skilled to obtain real benefits from their computers and from their Internet connections

93 % of the 33 % (referred to in the immediately previous item) revealed that they acquired their skills by themselves and not from colleges, in-service training

courses, or any other official source. These findings about in-service teachers, and others, suggest that it is vitally important for colleges of education and other teacher education institutions to devote far more time, energy and funds to the technological education of their student teachers (and, indeed, to the further education and training of in-service teachers).

The study conducted by Wentz and Wentz (1995, p. 49) concludes that the inclusion of technology in elementary school classrooms would compel elementary school teachers to use the technology to teach the syllabus. There is no point in spending vast amounts of money on expensive technology that is never used, and education administrators should be the first to appreciate this. The only reasonable way to compel teachers to use the technology at their disposal would be to design curricula and lesson plans in such a way that the teacher concerned would have to use the technology to teach the content. While the design of the curriculum may compel teachers to use technology, teachers cannot be blamed for using it ineffectually and incorrectly if they have never been exposed to practical hands-on work with technology over a long period of time. It is all very well to say that they should be an onus on the teacher to train him or herself in the use of classroom technologies at his or her own expense. The kind of technology that we are thinking about here is extremely expensive. In addition to this, much of the software that is used is anything but straightforward especially for those who have had minimal or zero exposure to computers outside the classroom and outside their normal line of duty. Self-coaching and self-training are indeed efficacious (especially when it comes to practising routines and manipulating software with which one is already partly familiar). But teachers especially elementary school teachers are notoriously badly paid, and once they begin teaching, they have very little disposable free time (except during school holidays).

It may sound reasonable to expect teachers to train themselves. But if this is to happen, then teachers need to be given incentives in the form of equipment, grants and time (leave), not to mention support and backup systems. This is a problem that admits of no easy solution, either in developed countries or in Africa where deficits in skills, time and money continue to be crucial components in the equations of deprivation. These problems should also be considered in the context of other difficulties that complicate the picture. It is generally agreed by all researchers that colleges of education need to provide the training and skills that future teachers will need (Handler & Strudler, 1997; Thomas, 1999; Wang & Holthaus, 1999).

The difficulty, however, is that there is seldom an integration between the computer skills that are being acquired and integration of computer technology in classroom teaching. There is obviously little point in having one without the other. The skills and training that a student teacher receives are ends in themselves. They are designed to prepare the teacher to use technological skills in classroom.

When student teachers are tested for competence in technological skills and in teaching method, they should be able to give convincing demonstrations of how they can use technology in a classroom to deliver subject content. Wang &

Holthaus (1999) have observed that most student teachers are unable to integrate technology effectively with their teaching in classrooms, and that computer training that they have received only allows them to use computers for purely personal (i.e. non-teaching) purposes. This seems to indicate what other research has already proved: that although student teachers are being trained to use computers, they are not being adequately train to teach learners in classrooms in which each learner has access to a computer. This then is the next major problem that faces those who are responsible for making future teachers competent practitioners of computer-assisted education.

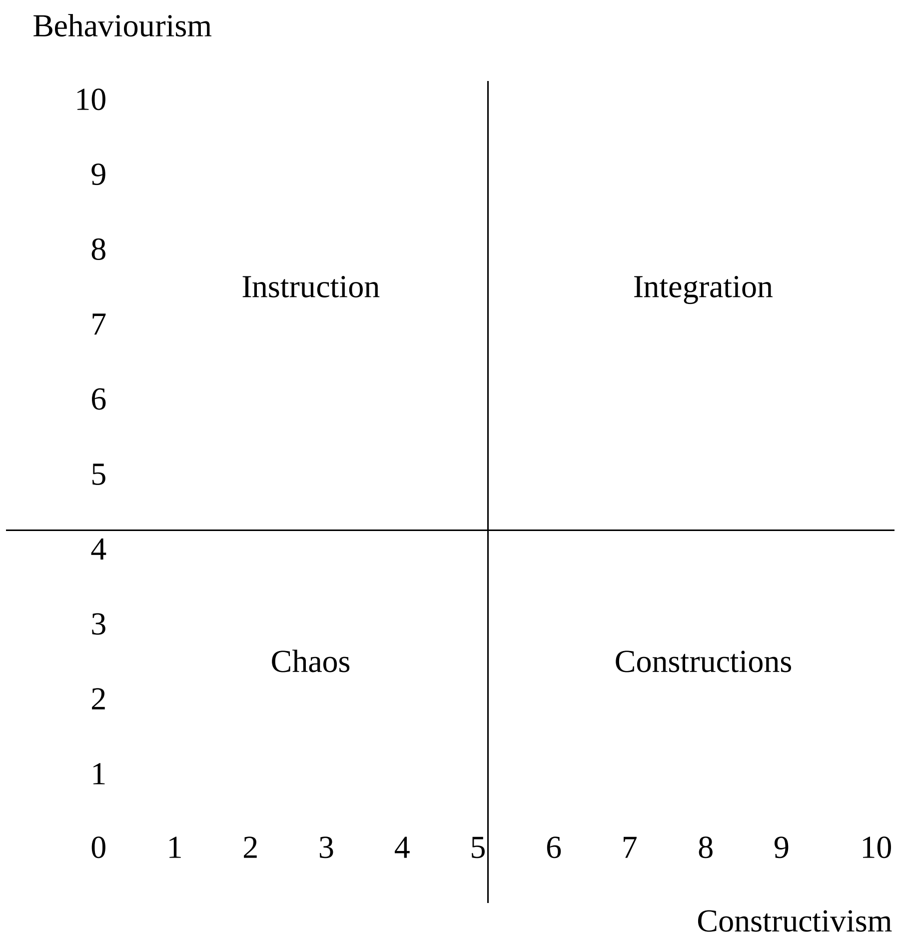
The theoretical framework of a constructivist theory of learning

The theoretical framework for this study is based on Bruner's (1996) description of constructivism. About this kind of constructivism, Bruner writes: "Learning is an active process in which students constructs new ideas or concepts based upon their current or past knowledge. The students select and transform information, construct hypotheses, make decisions, while relying on their cognitive structure" (Bruner, 1966). This objectivist approach is, according to Cronje (2000), the complementary opposite to the constructivist approach that Cronje describes in his two-dimensional, four-sector model (Cronje, 2000).

According to Cronje (2000), objectivism/behaviourism and constructivism are diametrically opposed to one another in methods, means, assumptions and purposes (as the model clearly shows). When the two approaches are kept at right angles, behaviourism and constructivism, they produce four conditions of learning. Cronje's four quadrants are labelled Instruction, Integration, Chaos, and

Construction respectively. The Figure below shows the four quadrants more clearly.

Figure 1; The Four Quadrants of Cronje's Model (2000)



The figure above shows how objectivism (behaviourism) is the complementary opposite of constructivism in Cronje's (2000) model that portrays the four possible quadrants of teaching and learning.

Cronje (2000) states that among the possible theoretical opposites portrayed by the model, objectivism/behaviourism and constructivism form one set of polar opposites. While the behaviourist approach assumes the presence of an existing reality outside learners, and consequently advocates behaviourist techniques such as conditioning as an appropriate method for training and educating learners, the constructivist approach, on the other hand, suggests that there is no objective reality exterior to learners, but that all learners (and all human beings) construct their own meanings, and that these meanings are their "ultimate reality". Although these two approaches are fundamentally different, they reside on the polar opposites of a continuum of the same model, and a researcher may, depending on the desired outcome, select and utilise techniques from opposite or adjacent quadrants in the pursuit of his or her research. In order to actualise a particular outcome in teaching and learning from the four quadrants, interaction is required. Each of the four quadrants depicted in the model is valid in itself, and each describes modalities of teaching and learning that have appropriate places in education.

The complementarity of objectivism and constructivism

The differences in teaching and learning in the four quadrants of the model are as follows:

Chaos

In this quadrant learning is opportunistic; this means that learning is low in objectivist and constructivist elements. While no proper learning should, in theory, take place in this quadrant, most learning seems to take place in this way. The learning environment does not need to be supportive for learning to occur.

The kind of learning depicted in this quadrant is therefore referred to as "incidental learning".

Instruction

This is the quadrant where we would situate programmed learning which makes use of tutorials, lectures, and drill-and-practice. It is high in intuitivist elements. This quadrant supports the behaviourist process of learning.

Construction

This quadrant reflects the constructivist paradigms of teaching and learning. The outcome of the "construction" is subjective and individual understanding and knowledge (the opposite of the "objective" knowledge posited by behaviourism).

Integration

In terms of this model, "integration" means combining instruction and construction in appropriate ways for the purposes of education. The kind of learning depicted in this quadrant requires a prior elucidation of goals and outcomes. The instructional designer would be categorised in this domain. The educationist selects appropriate behavioural instructions and constructivist learning events to achieve desired outcomes.

Teaching and learning theories

Bruner states that learning comprises "an active process in which students constructs new ideas or concepts based upon their current or past knowledge" (Bruner, 1966). Between the bare definition of constructivism and constructivist research, it is necessary to select the kind of research design and activities that conform to the definition of constructivism outlined above. While constructivist learning theory accommodates group learning, it is only in each individual student's mind that the authentic tasks with which they engage become meaningful. Each individual student, in other words, is personally responsible for the way in which he or she approaches and analyses the tasks, and assesses the competence of his or her performance while he or she is doing so. In addition, the role of the teacher or instructor in a constructivist classroom is, as we have already noted, drastically different from that of the behaviourist teacher.

Gergen (1995) regarded teachers as coordinators, facilitators, resource advisors, tutors or coaches. Such designations are obviously at odds with definitions of the teacher as “the prime actor” or “the sage on the stage”. This understanding of teaching also subverts the behaviourist characterisation of teaching as the transmission of knowledge from the enlightened (teacher) to the unenlightened (learner) in the process of education. Constructivism reinvents teaching is a process of facilitating student learning, with "the student as the prime actor and teachers as guides on the side or behind" (Brooks & Brooks, 1993).

Knowledge in a constructivist view, is not “out there” to be received or instilled. It is ultimately always “in here”, i.e. in the mind of the learner, and it needs to be constantly created and recreated by each individual (learner) for himself or herself. Bruner states that “learning is an active process in which students constructs new ideas or concepts based upon their current or past knowledge. The students select and transform information, construct hypothesis, makes decisions, relying on their cognitive structure” (Bruner, 1966).

Teachers need to rely on quality educational research for different pedagogical models and strategies; at the same time they have to practice the art and science of teaching themselves, refining it as they go according to their own needs and resources and particularly those of their students" (Lovat, 2003). According to Lipponen, (1990, p. 368) pedagogical practice in a constructivist learning situation needs to be meaningfully integrated into the culture and environment of those who are engaging in learning and teaching. That means that if technology is used, there is a need to "build social structures that encourage learning for supporting reflective discourse and for helping students build knowledge and deepen their understanding of their subject domain" (Lipponen, 1990).

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter explains the methodology used in carrying out the research. It gives a description of the research design, target population, sources of data. It further explains the study's sample size, sampling techniques used, research instruments and procedures followed in data collection, processing and analysis as well as data presentation**.**

Research Design

The design used for the study is a survey. Questionnaire was the main instrument used to collect quantitative data from the pre-service teachers in the survey. A survey is a structured set of questions given to a group of people in order to measure their attitudes, beliefs, values or tendencies to act.

Among the different methods of data gathering for research purposes, the survey method is preferred by many researchers due to its various advantages, strengths and benefits. Surveys provide a high level of general capability in representing_a large_population. Due to the usual huge number of people who answers survey, the data being gathered possess a better description of the relative characteristics of the general population involved in the study. As compared to other methods of data gathering, surveys are able to extract data that are near to the exact attributes of the larger population.

Because of the high representativeness brought about by the survey method, it is often easier to find statistically significant results than other data gathering methods. Multiple variables can also be effectively analyzed using surveys.

Surveys can be administered to the participants through a variety of ways. The questionnaire can simply be sent via e-mail or fax, or can be administered through the Internet. Nowadays, the online survey method is the most popular way of gathering data from target participants. Aside from the convenience of data gathering, researchers are able to collect data from people around the globe.

Surveys are ideal for scientific research studies because they provide all the participants with a standardized stimulus. With such high reliability obtained, the researcher's own biases are eliminated.

As questions in the survey should undergo careful scrutiny and standardization, they provide uniform definitions to all the subjects who are to answer the questionnaire. Thus, there is a greater precision in terms of measuring the data gathered.

However, surveys also have their disadvantages and weak points that must be considered.

The survey that was used by the researcher from the very beginning, as well as the method of administering it, cannot be changed all throughout the process of data gathering. Although this inflexibility can be viewed as a weakness of the survey method, this can also be a strength considering the fact that preciseness and fairness can both be exercised in the study.

Survey questions that bear controversies may not be precisely answered by the participants because of the probably difficulty of recalling the information related to them. The truth behind these controversies may not be relieved as accurately as when using alternative data gathering methods such as face-to-face interviews and focus_groups.

Another weakness is that questions in surveys are always standardized before administering them to the subjects. The researcher is therefore forced to create questions that are general enough to accommodate the general population. However, these general questions may not be as appropriate for all the participants as they should be. A good example of this situation is administering a survey which focuses on affective variables, or variables that deal with emotions.

These disadvantages not withstanding I am convinced that the survey design is the most appropriate for this study.

Population

Pre service science teachers in Colleges of Education in the central region were used for the study. The total population (sample size) of the pre-service science teachers from the colleges of education was 212. The study was limited to colleges that offer science as elective subjects. The names of the Colleges are

i. OLA College of Education.

ii. Komenda College of Education.

iii. Fosu College of Education.

Based on the time frame and financial constraints in covering all the Colleges of Education in the country, the study was also limited to pre service science teachers in the third year of their studies.

Sampling and Sampling Procedure

The techniques used for selecting respondents for the study are stratified random sampling, purposive and simple random sampling. First purposive sampling technique was used to select the third year group because they have gone through all the variables needed in the study. The simple random sample is the basic sampling method assumed in statistical methods and computations, it was also used to select 20 pre-service science teachers from each stratum in the various Colleges of Education. The main benefit of the simple random sample is that each member of the population has an equal chance of being chosen. This means that it guarantees that the sample chosen is representative of the population. In turn, the statistical conclusions drawn from analysis of the sample will be valid. The stratified random sampling was also used to select the colleges of education since the colleges were in strata.

A total of sixty (60) pre service science teachers were selected using simple random sampling technique. Twenty (20) pre service science teachers each were selected using stratified random sampling from the various Colleges of Education. This number is believed to represent a fair percentage of the total population of the pre service teachers in their various colleges of education which gave a total sample size of 212 pre-service teachers. The ages of the participants range between twenty one years to thirty five years and these students comprised male and female who did almost all the courses which qualify them to obtain Diploma in Basic Education to become professional teachers.

Research Instrument

The research instrument for this study was a self-constructed questionnaire with respect to the research questions in this study and some general practices of constructivism and the use of technology in constructive classroom settings. Questionnaire was the main instrument used to collect quantitative data. Questionnaire was used because it guaranteed easy data collection and also efficient for collecting statistically quantifiable data in social science research (Twumasi, 2001). Its usage ensures the independence and anonymity of respondents in the study.

The questionnaire, provided respondents with questions to complete independently. The demographic section of the survey included basic questions with categories based on the Teacher Quality Survey (TQS) from Marshall University and the WVSSAC classifications for the 2011- 2012 school year. The complete instrument is included as Appendix A. The second section of the quantitative survey solicited respondent information on the use of constructivist instructional practices in their science classrooms. This portion of the instrument was developed from a review of the literature and contained a list of research-based constructivist instructional practices with a type scale of 1-3 for participants to indicate their level of use for each practice (1= Never; 2= sometimes and 3= Frequently). The instrument produced a total score for level of use for constructivist practices and knowledge of use of technological tools.

Data Collection and Procedure

The questionnaire was distributed and answered in good and smooth conditions. Due permission was sought from the Principals of the colleges used for the study before data was collected. However, with the assistance of class and subject teachers, the questionnaires were distributed to the participants and they were answered, while some vital instructions were passed to the pre- service teachers with regard to the whole exercise. The questionnaire were collected after completion from the students and verified.

Data Analysis

The data was analyzed using descriptive statistics. Data analysis for the quantitative survey results was completed using the Statistical Package for the Social Sciences (SPSS) software. The data was cleansed coded and entered into the SPSS software, and frequencies, percentages, skewness, mean and standard deviations determined.

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

This chapter discusses and describes the results from the survey conducted on the topic Integrating Technology among Science Teachers using Constructivist Learning Events In Colleges of Education in Central Region of Ghana. Descriptive statistics such as frequencies, and percentages were used in analyzing the demographic data. Mean and standard deviations were also used as the measures of central tendency and dispersion respectively for the interpretation of the main data.

Demographic data

Table 1: Age Distribution of Pre Service Science Teachers

Age(years)	Frequency	Percent
21-25	46	76.6
26-30	14	23.3
31-35	0	0
36 and above	0	0
Total	60	100

Source: Field Data, 2014

As shown in Table 1, the frequency of the participants within the age distribution of 20-25 was 46 representing a percentage of 76.7 %. Those within the range of 26-30 had a frequency of 14 and recording 23.3 %. The age distribution between 31-36 and 36 and above recorded 0 % as shown in Table 1. The analysis with respect to age distribution therefore clearly shows that the majority of the pre service science teachers fell between the age distribution of 21-25 %.

Data was also collected in respect of gender distribution of respondents. The result is reflected in Table 2.

Table 2: Gender Distribution

Gender	Frequency	Percent
Male	28	46.7
Female	32	53.3
Total	60	100

Source: Field Data, 2014

Table 2, gives a description of gender distribution of the participants. From the table it was seen that, female were more than male with a frequency of 32 and a percentage of 53.3 % as compared to their male counterparts of frequency 28 and 46.7 %.

The data collected covered information on the state of schools used for the study. The result is tabulated in Table 3.

Table 3: School Status

School status	Frequency	percent
Public	60	100
Private	0	0
Total	60	100

Source: Field Data, 2014

Table 3, describes the school status of the pre service science teachers. From the table, it was seen clearly that all the schools that the participants were attending were public schools.

This gave a frequency of 60 which represents 100 %.

Analysis of main data.

Research Question 1.

To what extent do Tutors of pre service teachers use Technology in their classrooms?

The data collected and used to answer this research question are presented in Tables 4 to 10. The first, information was gathered about tutors' use of software. The result is presented in Table 4.

Table 4: Tutors' Use of Software

	N	M	SD	Skew.	N %	S %	F %
Microsoft Word	60	1.92	0.67	0.10	26.7	55.0	18.3
Microsoft Acc.	60	1.70	0.67	0.44	41.7	46.7	11.7
Microsoft Excel	60	1.92	0.72	0.13	30.0	48.3	21.7
Microsoft Ppt.	60	1.97	0.66	0.04	23.3	56.7	20.0
Animations	60	1.78	0.67	0.27	35.0	51.7	13.3

Source: Field Data, 2014

From the analysis in Table 4, it can be observed that 55.0 % sometimes use Microsoft word with a mean of 1.97 and a standard deviation of 0.67.

Only 11.7 % frequently use Microsoft access with a mean of 1.70 and a standard deviation of 0.67. Similarly, only 21.7 % use Microsoft excel to teach the Preservice Science Teachers with a mean of 1.9 and a standard deviation of 0.7. The analysis also shows that 20 % frequently use Microsoft power point in teaching with a mean of 2.0 and standard deviation of 0.7, while 13.0 % frequently use animations with a mean of 1.8 and standard deviation of 0.7.

From the analysis it can be observed that even tutors of preservice science teachers do not frequently use software. This confirmed the assertion of Mireku et al (2009), that lack of specialized computer software use was a problem. Also, Jones and Mercer (1993, p. 19), explained that modern teachers face a number of challenges as they undertake the often arduous process of integrating technology into their classroom teaching routines.

Many of these teachers, if not most of them have no clear idea on how to use computers in their classrooms or how to organise and manage technology integrated classrooms.

Table 5: Tutors' Use of Utilities

	N	M	SD	Skew.	N %	S %	F %
Backups	60	1.65	0.63	0.443	43.3	48.3	8.3
Trouble Shooting	60	1.58	0.59	0.431	46.7	48.3	5.0
Use Of Antivirus	60	1.87	0.68	0.166	30	53.3	16.7
Data Recovery	60	1.67	0.68	0.531	45	43.3	11.7
Disk Defragmentation	60	1.57	0.57	0.317	46.7	50	3.3

Source: Field Data, 2014

Table 5 also describes tutors' of pre service science teachers' use of utilities to teach. The analysis shows that greater percentage of the tutors sometimes have knowledge about utilities and they therefore integrate them in teaching their students. The corresponding means were 1.65 backups, 1.58 trouble shooting, 1.87 use of antivirus, 1.67 data recovery , 1.57 disk defragmentation and standard deviations of 0.63, 0.59, 0.68, 0.68, 0.57 respectively.

Very few percentages of tutors of preservice science teachers frequently know and use utilities in teaching and learning. This may be due to lack of formal and informal training for the tutors.

Table 6: Tutors' Use of Hardware

	N	M	SD	Skew.	N %	S %	F %
Monitors	60	2.6	0.5	-0.5	0	38.3	61.7
Keyboard Skills	60	2.5	0.5	-0.5	1.7	61.7	55
Systems Unit	60	2.6	0.5	-0.6	1.7	40	58.3
Mouse skills	60	2.6	0.5	-0.6	0	36.7	63.3

Source: Field Data, 2014

The analysis presented in Table 6 describes tutors' use of hardware. It revealed that 63.3 % of respondents exhibited frequent use of mouse skills while 61.7 % displayed the same level of use of monitors. Fifty-five percent also showed frequent use of keyboard skills and the use of systems unit. It was clear that some tutors of pre service teachers have knowledge of hardware and they frequently use it to teach in their classrooms. It was also observed that their use showed negative skewness.

This finding implies that tutors of pre service teachers have some knowledge about hardware but it looks like they are not ready to teach their pre service science teachers to use it in their teaching and learning. This confirms the study of OTA, that in spite of these clearly understood needs, most graduates arriving in the teaching profession possess but an imperfect knowledge of how to incorporate technology into their classroom practice even though they could manipulate and navigate their way around a limited number of widely used programs.

Table 7: Tutors' Use of Storage Devices

	N	M	SD	Skew.	N %	S %	F %
Floppy Disk	60	1.9	0.8	0.1	33.3	41.7	25.0
Hard Disk	60	2.1	0.7	-0.1	18.3	53.3	28.3
CD/DVD	60	2.1	0.6	-0.1	15.0	61.7	23.3
Pen drives	60	2.4	0.6	-0.5	8.3	46.7	45.0
Memory Cards	60	2.2	0.7	-0.3	13.3	50.0	36.7

Source: Field Data, 2014

Table 7 describes tutors of pre service teachers use of storage devices.

From the analysis, a good percentage of the tutors use storage devices in their daily activities. This gave a mean of 1.9 floppy disk, 2.1 hard disk, 2.1 CD/DVD, 2.4 pendrives, 2.2 memory cards with their corresponding standard deviations of 0.8, 0.7, 0.6, 0.6 and 0.7 respectively. From the analysis of data, tutors sometimes use some storage devices in teaching and learning.

Table 8: Tutors' use of Input Devices

	N	M	SD	Skew.	N %	S %	F %
Keyboards	60	2.4	0.5	0.3	0.0	56.7	43.3
Mouse	60	2.3	0.6	-0.2	6.7	55.0	38.3
Light pens	60	1.5	0.7	1.1	61.7	26.7	11.7
Touch Screens/Pads	60	1.8	0.8	0.3	40.0	38.3	21.7
Microphones	60	1.7	0.7	0.6	46.7	38.3	15.0
Scanners	60	1.8	0.7	0.3	36.7	43.3	20.0
Digital Cameras	60	1.8	0.7	0.4	41.7	40.0	18.3

Source: Field Data, 2014

Table 8 also describes Tutors' use of Input Devices. The results show that 56.7 % sometimes use keyboards, 55.0 % sometimes use mouse, 61.7 % never use light pens, 38.3 % sometimes use touch screen pads, 15 % frequently use microphones, 20 % frequently use scanners and 41.7 % never use digital cameras to teach.

This results gave a mean of 2.4, 2.3, 1.5, 1.8, 1.7 , 1.8 and 1.8 respectively and a corresponding standard deviation of 0.5, 0.6, 0.7, 0.8, 0.7, 0.7 and 0.7 respectively.

On the average tutors do not frequently use input devices to teach.

Table 9: Tutors' Use of Output Devices

	N	M	SD	Skew.	N %	S %	F %
Monitors	60	2.4	**0.7**	0.5	11.7	41.7	46.7
Printers	60	2.8	0.7	0.5	15	53.3	31.7
Photo Copiers	60	1.9	0.7	0.5	31.7	45	23.3
Plotters	60	1.5	0.7	0.5	56.7	33.3	10
Speaker/Headsets	60	1.9	0.8	0.6	28.3	45	26.7

Source: Field Data, 2014

Table 9 describes tutors of pre service teachers' use of output devices. From the SPSS analysis, it was observed that 46.7 % of tutors frequently use monitors, 53.3 % sometimes use printers, 45.0 % sometimes use photocopiers 56.7 % never use plotters and 45.0 % use speakers/head sets in their classroom settings. The mean and standard deviations obtained respectively were 2.4 against 0.7 (monitors), 2.8 against 0.7 (printers), 1.9 against 0.7 (photocopiers), 1.5 against 0.7 (plotters), 1.9 against 0.8 (speakers/headsets). An appreciable number of tutors of pre service teachers' use output devices in teaching from the data analysis.

Table 10: Tutors' use of Internet

	N	M	SD	Skew.	N %	S %	F %
Email Address	60	1.9	0.7	0.1	26.7	53.3	20
Research	60	2.1	0.7	-0.2	18.3	51.7	30
Correspond With Friends	60	2	0.7	0	26.7	48.3	25
Downloading Of Course Materials	60	1.8	0.7	0.3	36.7	45.0	18.3
Discussion Forum	60	1.9	0.7	0.1	30	46.7	23.3
Internet Conferencing	60	1.5	0.6	0.7	53.3	41.7	5
Send And Receive Messages	60	1.9	0.6	0	23.3	63.3	13.3
Intention to use Technology In the future?	60	2.8	0.5	-2.4	5.0	11.7	83.3

Source: Field Data, 2014

Table 10 describes tutors of pre service teachers use of the internet. The results reveal that above 50.0 % of Tutors sometimes use emails with a mean of 1.9 and standard deviation of 0.7, and sometimes use the internet for research purposes with a mean of 2.1 and deviation 0.7. Twenty-five percent use it frequently to correspond with friends with a mean of 2.0 and standard deviation 0.7, 18.3 % frequently use the internet to download course materials, mean 1.8 deviation 0.7, 23.3 % use the internet for discussion forum, with the mean of 1.8 and standard deviation 0.7. Below 10.0 % also frequently use the internet for conferencing with a mean of 1.5 and standard deviation of 0.6, 13.3 % use it frequently to send and receive messages with a mean 1.9 and standard deviation 0.6 and a large percentage 83.3 % of Tutors of pre device teachers wish to integrate technology in their future teachings with a mean of 2.8 and standard deviation of 0.5.

Tutors of preservice science teachers' incompetence in using the internet to do various works may be due to lack of staff training as asserted by Poole and Moran (1998). They suggested that deficiencies in staff development prevent teachers from utilizing existing technology in their teaching. They expand on this by asserting that "one-shot workshops, added expense of training, lack of continued support, isolated knowledge, unawareness of school needs, lack of knowledge and support from leadership all contribute to the ineffectiveness of technology staff development".

Research Question 2.

To what extent do Tutors of pre service teachers use constructivist teaching and learning events in the classrooms?

The data collected and used to answer this research question are presented in Tables 11 to 14.

Table 11: Tutors use of Shifting Roles

	N	M	SD	Skew.	N %	S %	F %
Put You In Small Groups	60	2.2	0.6	-0.1	8.5	59.3	32.2
Coach Instead of Lecturing	60	2.1	0.7	-0.1	20.3	52.5	27.1
Work With Weaker Students	60	2.2	0.7	-0.2	15.3	52.5	32.2
Engage Learners Actively	60	2.5	0.6	-0.8	3.4	39.0	57.6
Make Students More Cooperative	60	2.6	0.6	-1.0	5.1	33.9	61.0
Visual and verbal thinking	60	2.4	0.6	-0.5	6.8	47.5	45.8

Source: Field Data, 2014

Table 11 describes tutors' of pre service teachers shifting roles in the classroom settings.

From the information presented in Table 11, only 8.5 % never put students in small groups, with a mean 2.2 and standard deviation of 0.6, On the other hand, 52.5 % and 27.1 % sometimes and frequently respectively coach their students instead of lecturing with a mean and standard deviation of 2.1 and 0.7. Also only 15.3 % of them never work with weaker students, 3.4 % never engage learners actively, with mean of 2.5 and standard deviation 0.6, 61.0 % frequently and 33.9 % sometimes make students more cooperative, with a mean of 2.6 and standard deviation 0.6.finally, only 6.8 % of the Tutors help their learners in visual and verbal thinking with a mean of 2.4 and standard deviation of 0.6.

On the average tutors sometimes and frequently create shifting roles in their classroom to achieve constructivism in their classrooms.

This results confirm the assertion of Campoy (1992) that identify the kind of observable differences between a constructivist classroom and a traditional classroom.

Campoy notes that in a constructivist classroom, one might observe that:

i. There is a discernible shift away from whole-class instruction towards small group instruction
ii. The teacher, instead of lecturing, coaches, orientates, inspires and debates
iii. Teachers work more frequently with weaker students rather than focusing attention on brighter students (as is the case in traditional settings)
iv. Learners abandon their passivity and become more actively engaged
v. Students become more cooperative and less individually competitive
vi. Visual and verbal thinking rather than primary verbal thinking become more evident among learners (Campoy, 1992, p. 17).

Table 12: Tutors' Use of Assessment

	N	M	SD	Skew.	N %	S %	F %
Non Graded Options And Portfolio Assessment	60	1.8	0.6	0.2	30	56.7	13.3
Self - Evaluation	60	2.1	0.7	-0.1	5.0	56.7	28.3
Peer Evaluation	60	2.5	4.1	7.4	20.0	56.7	21.7
A Grading System That Provide Meaningful Feedback	60	2.3	0.7	-0.5	16.7	40	43.3
Assessment Is Context Dependent	60	2.2	0.7	-0.2	20	45	35
Assessment Based On Originality	60	2.2	0.6	-0.2	11.7	55	33.3

Source: Field Data, 2014

Table 12 describes tutors of pre service teachers' use of assessment in constructivist settings.

From the analysis in Table 12 only, it was seen that 13.3% of Tutors frequently use non-graded option with a mean of 1.8 and standard deviation of 0.6, less than 10.0 % never use self-evaluation with a mean of 2.1 and standard deviation of 0.7, 20.0 % never use peer evaluation with a mean of 2.5 and a standard deviation of 4.1, 16.7 % of them never provide a grading system that gave a meaningful feedback, with mean 2.3 and standard deviation of 0.7 and also 20 % of the tutors never gave assessment that is context dependent with a mean of 2.2 and a standard deviation of 0.7. Only 11.7 % of tutors never assess based on originality with mean 2.2 and standard deviation of 0.6. Generally on the average it can be observed that tutors have positive attitude towards assessment to achieve constructivism in their classroom settings.

This confirms Jonassen (1991a, p. 32) who made the following thirteen assertions about assessment and other matters in the constructivist classroom:

i. Technology can and will force the issue of constructivism
ii. Assessment will have to become outcome-based and student-centered
iii. Assessment techniques will have to reflect instructional outcomes
iv. "Grades" must be contracted wherever grades are required
v. There must be non-graded options and portfolio assessment
vi. Self-evaluation and peer-evaluation should be carefully and thoughtfully balanced with teacher assessment
vii. Performance standards that are easy to apply in practice need to be developed
viii. A grading system must be developed which provides meaningful feedback
ix. Technology can be used to facilitate communication with parents
x. Video Tapes of learners' working should be included as part of their portfolio
xi. The focus should be on originality and appropriate performance rather than on regurgitation
xii. It is important to evaluate how the learner goes about constructing his or her own knowledge rather than to focus exclusively on the end-product

Assessment is context dependent (Jonassen, 1991a, p. 32)

Table 13: Tutors Use of Students Engagement in the classroom

	N	M	SD	Skew.	N %	S %	F %
Teach Multiple Student Intelligences	60	2.1	0.6	-0.1	13.3	60	26.7
Art and Music Are Used in Class Activities	60	2.0	0.7	0.0	23.3	53.3	23.3
Hands On learning Activities	60	2.3	0.7	-0.4	11.7	46.7	41.7
Students Work In Cooperative Groups	60	2.3	0.6	-0.3	10.0	53.3	36.7
Students Make Interest Based Learning Choices	60	2.1	0.6	-0.1	16.7	58.3	25.0
Students Use Critical Thinking And Problem Solving Skills	60	2.4	0.6	-0.7	8.3	41.7	50.0
Students Use Multiple Resources In Class	60	2.0	0.7	0.0	23.3	53.3	23.3
I Serve As A Mentor And Motivator	60	2.4	0.7	-0.6	10.0	41.7	48.3

Source: Field Data, 2014

Table 13 describes tutors of pre service teachers' use of students' engagement to achieve constructivism in their classroom settings.

From the analysis in Table 13, it was obvious that only 13.3 % of tutors never teach to multiple students intelligences with a mean of 2.1 and standard deviation of 0.6, 23.3 % never use art and music in classroom activities with a mean of 2.0

and deviation of 0.7, 11.7 % never engage students in hands on learning activities with a mean of 2.3 and standard deviation of 0.7, 10.0 % never make students work in cooperative groups with a mean of 2.3 and standard deviation of 0.6, 16.7 % never make interest based learning choices with a mean of 2.1 and standard deviation 0.6. Below 10.0 % never made students think critically to solve problems with a mean of 2.4 and standard deviation of 0.6, 23.3 % never made students to use multiple resources in class with a mean of 2.0 and standard deviation of 0.7. Finally, only 10.0 % of tutors never serve as mentors and motivators with a mean of 2.4 and standard deviation 2.4.

On the average tutors engage their pre service science teachers positively in the classroom to achieve constructivism.

Table 14: Tutors use of Students Control

	N	M	SD	Skew.	N %	S %	F %
The physical arrangement of the classroom	60	1.8	0.6	0.1	32.0	60.0	8.0
Parents are included in the Learning activities	60	1.6	0.7	0.8	52.0	36.0	12.0
Students choose from multi option assignments	60	1.9	0.6	0.0	24.0	64.0	12.0
Students produce videotapes and simulations	60	1.8	0.8	0.4	40.0	40.0	20.0
Students produce video tapes							

simulations	60	2.2	0.6	0.1	8.0	68.0	24.0
Student investigate and solve Real world	60	2.1	0.7	-0.2	20.0	48.0	32.0
Social negotiation is part of the learning process	60	2.1	0.6	-0.1	16.0	60.0	24.0
Student monitor their own learning is active	60	2.0	0.6	0.0	20.0	64.0	16.0
Intention to use Constructivist event in the future?	60	2.6	0.6	-1.3	4.0	28.0	68.0

Source: Field Data, 2014

Table 14 describes tutors of preservice teachers use of students control to achieve constructivism in their classrooms.

From the analysis it was observe that, above 50.0 % of the tutors sometimes changes the physical arrangement of the classroom settings to achieve constructivism with a mean of 1.8 and standard deviation of 0.6, 36 % sometimes and 52 % of the tutors never include parents in the learning activities, the mean was 1.6 and standard deviation 0.7, 64 % of tutors allow their students to choose from multiple option assignments with a mean of 1.9 and standard deviation of 0.6. Also only 20.0 % frequently allow students to produce simulations, video tapes and role play in their classrooms with a mean of 1.8 and standard deviation of 0.8. In addition, above 50.0 % of tutors sometimes use social negotiations as part of the learning process with a mean of 2.1 and standard deviation of 0.6, 48.0 % of tutors also sometimes use social negotiations to solve real world problems as part of the learning process with a mean of 2.1 and standard deviation of 0.6 , 64.0 % of tutors sometimes allow their students to monitor their own learning activities with a mean of 2.0 and standard deviation of 0.6.

Finally, above 50.0 % of tutors frequently wish to use constructivist teaching approaches in their classroom settings in the future with a mean of 2.6 and a standard deviation of 0.6.

Research Question 3.

To what extent do pre service teachers use Technology in their classrooms?

The data collected and used to answer this research question are presented in Tables 15 to 21.

Table 15: Pre service Teachers' use of Software

	N	M	SD	Skew.	N %	S %	F %
Microsoft Word	60	1.7	0.8	0.7	51.7	30.0	18.3
Microsoft Access	60	1.4	0.6	1.3	66.7	25.0	8.3
Microsoft Excel	60	1.5	0.7	1.1	63.3	25.0	11.7
Microsoft PowerPoint	60	1.5	0.7	1.3	66.7	21.7	11.7
Animations	60	1.4	0.6	1.2	65	26.7	8.3

Source: Field Data, 2014

Table 15 describes pre service teachers' use of software.

From the analysis, above 51.7 % of pre service teachers never use Microsoft word to teach with a mean of 1.7 and a standard deviation of 0.8, also above 66.7

% of pre service teachers never use Microsoft access with a mean of 1.4 and a standard deviation of 0.6, 63.3 % never use Microsoft excel with a mean of 1.5 and a standard deviation of 0.7, 66 .7 % never use Microsoft power point with a mean of 1.5 and standard deviation of 0.7. On the average, pre service teachers never use software to teach in their classrooms. This confirms the assertion of Campoy (1992, p. 17) that: “Many educators, as well as members of the general community, are naive about the ramifications of technology implementation, and proceed without a clear understanding of both the role of technology in schools and what are reasonable expectations; (p. 17)

Table 16: Pre Service Teachers Use of Utilities

	N	M	SD	Skew.	N %	S %	F %
Backups	60	1.4	0.6	0.9	60.0	36.7	3.3
Trouble Shooting	60	1.4	0.5	1.0	66.7	31.7	1.7
Use Of Antivirus	60	1.4	0.5	0.5	0.0	61.7	38.3
Data Recovery	60	1.4	0.6	1.3	66.7	28.3	5.0
Disk Defragmentation	60	1.3	0.5	1.2	70.0	28.3	1.7

Source: Field Data, 2014

Table 16 describes pre service teachers’ use of utilities in their classrooms. From the Table 16 above, it was observed that 60.0 % of pre service teachers never use backups with a mean of 1.4 and standard deviation of 0.6, 66.7 % of teachers also never use trouble shootings with a mean of 1.4 and standard deviation of 0.5. 61.7 % sometimes and 38.3 % frequently use antivirus with a mean of 1.4 and standard deviation of 0.5, again 66.7 % never use data recovery methods with a mean of 1.4 and standard deviation of 0.6. Finally 70.0 % of pre service teachers never use disk defragmentation in their classrooms with a mean of 1.3 and standard deviation 0.5.

Even though tutors of pre service teachers sometimes use utilities to teach them, the pre service science teachers themselves hardly use utilities in their teachings.

This may be due to lack of training and confirms the assertion of Mann (1994) that many educators who were themselves educated in traditional classrooms have been slow to recognize the potential of various modes of technology use in the classroom.

Table17: Pre service teachers' use of hardware

	N	M	SD	Skew.	N %	S %	F %
Monitors	60	2.1	0.7	-0.1	15.0	56.7	28.3
Keyboard Skills	60	2.2	0.6	-0.1	10.0	60	30.0
Systems unit	60	2.2	0.6	-0.2	13.3	56.7	30.0
Mouse skills	60	2.2	0.6	0.0	10.0	65	25.0

Source: Field Data, 2014

Table 17 describes preservice teachers' use of hardware in teaching. From the analysis, above 56.7 % of pre service teachers sometimes use monitors with mean 2.1 and standard deviation of 0.7, 60.0% sometimes use keyboard skills with mean 2.2 and standard deviation of 0.6, 56.7% sometimes use system units in their teachings, 65.0% sometimes use mouse skills with a mean of 2.2 and a standard deviation of 0.6.

On the average 50.0% of pre service teachers sometimes use hardware in their classrooms to facilitate constructivism confirming the assertion of Hardy (1998), McNamara and Pedigo (1995), Siegel (1995) and Walters (1992), who indicated that, teachers must be able to use computers competently and efficiently in their classrooms, both as vehicles of pedagogically-sound instruction and for purposes of classroom management. They must also possess a working knowledge of hardware and various software applications.

Table 18: Pre Service teachers use of storage devices

	N	M	SD	Skew.	N %	S %	F %
Floppy Disk	60	1.6	0.7	0.8	55	31.7	13.3
Hard Disk	60	1.7	0.7	0.5	45	40	15
CD/DVD	60	1.8	0.7	0.3	36.7	50	13.3
Pendrives	60	1.9	0.7	0.2	31.7	50	18.3
Memory Cards	60	1.8	0.7	0.3	38.3	41.7	20

Source: Field Data, 2014

Table 18 describes pre service teachers use of storage devices. From the analysis, only 13.3 % frequently use floppy disks with a mean of 1.6 and a standard deviation of 0.7, 15.0 % frequently use hard disks with a mean of 1.7

anda standard deviation of 0.7 ; 13.3 % use CD/DVD with a mean of 1.8 and a standard deviation of 0.7; 18.3 % frequently use pendrives with a mean of 1.9 and a standard deviation of 0.7; 20.0 % frequently use memory cards with a mean of 1.8 and a standard deviation of 0.7. Pre service teachers sometimes use storage devices and this may be due to inadequate training as confirmed by Campoy (1992, p. 17) who writes that: "Many educators, as well as members of the general community, are naive about the ramifications of technology implementation, and proceed without a clear understanding of both the role of technology in schools and what are reasonable expectations." (p. 17)

Table 19: Pre Service teachers' use of input devices

	N	M	SD	Skew.	N %	S %	F %
Keyboards	60	2.2	0.6	-0.2	11.7	55.0	33.3
Mouse	60	2.2	0.7	-0.3	18.3	46.7	35.0
Light pens	60	1.4	0.6	1.5	70.0	23.3	6.7
Touch Screens/ Pads	60	1.6	0.7	0.8	53.3	31.7	15.0
Microphones	60	1.5	0.7	1.2	65.0	21.7	13.3
Scanners	60	1.4	0.7	1.3	66.7	23.3	10.0
Digital Cameras	60	1.6	0.7	0.8	55.0	31.7	13.3

Source: Field Data, 2014

Table 19 describes pre service teachers' use of input devices. From the analysis, it was observed that only 11.7 % never use keyboards with a mean of 2.2 and a standard deviation of 0.6, it is negatively skewed which showed that a greater number of the pre service teachers sometimes and frequently use keyboards. Also only 18.3% never use mouse with a mean of 2.2 and a standard deviation of 0.7. Seventy percent never use light pens, with a mean of 1.4 and a standard deviation of 0.6. Only 15.0% use touch/screen pads with a mean of 1.6 and a standard deviation of 0.7, 65.0 % never use microphones with a mean of 1.5 and a standard deviation of 0.7, 66.7.0 % never use scanners with a mean of 1.4 and standard deviation of 0.7, again, 55.0 % of pre service teachers never use Digital cameras in their teachings with a mean of 1.6 and standard deviation of 0.7.

Most of the pre service science teachers never use input devices and this is at a variance with the assertion of Siegel (1995) that the introduction of technology and constructivist assumptions into the classroom compels teachers to change their custom modes of teaching and to adapt themselves to new necessities.

Table 20: Pre service teachers use of output device

Source: Field Data, 2014

	N	M	SD	Skew.	N %	S %	F %
Monitors	60	2.1	0.7	-0.1	20.0	55.0	25.0
Printers	60	1.8	0.8	0.5	45.0	35.0	20.0
Photocopiers	60	1.6	0.7	0.8	53.3	36.7	10.0
Plotters	60	1.4	0.6	1.3	66.7	25.0	8.3
Speaker/ Headsets	60	1.9	0.8	0.2	36.7	38.3	25.0

Table 20 describes pre service teachers' use of output devices in instructional delivery. From the analysis of results only 25.0 % frequently use monitors, with a mean of 2.1 and standard deviation of 0.7, 20.0 % frequently use printers with mean of 1.8 and standard deviation of 0.8, very few of the teachers of about 10.0 % frequently use photocopiers with a mean of 1.6 and a standard deviation of 0.7, 8.3 % frequently use plotters with a mean of 1.4 and a standard deviation of 0.6, finally 25.0 % frequently use speakers/headset in the delivery of their lessons with a mean of 1.9 and a standard deviation of 0.8.

On the average most pre service teachers did not use output devices in teaching. Lack of technological training might be the reason for the pre service science teachers, this confirms the assertion that the revolutionary technology such as the personal computer should be integrated in such a way into the classroom context that it will benefit each and every learner and not just a gifted learner (Fosnot, 1996, quoted in Batane, 2004).

Table 21: Pre service teachers' use of the internet

	N	M	SD	Skew.	N %	S %	F %
Email Address	60	1.7	0.8	0.6	48.3	33.3	18.3
Research	60	1.8	0.7	0.4	41.7	40.0	18.3
Correspond With Friends	60	1.7	0.8	0.5	46.7	35.0	18.3
Down loading Of Course Materials	60	1.6	0.7	0.9	56.7	30.0	13.3
Discussion Forum	60	1.7	0.8	0.5	45.0	36.7	18.3
Internet Conferencing	60	1.4	0.6	1.2	65.0	28.3	6.7
Send And Receive Messages	60	1.7	0.7	0.6	48.3	38.3	13.3
Intention to use Technology in the future?	60	2.7	0.6	-2.1	6.7	13.3	80.0

Source: Field Data, 2014

Table 21 describes pre service teachers' use of the internet in lesson delivery. From the analysis, only 18.3 % frequently use e-mail address with a mean of 1.7 and standard deviation 0.8, 18.3 % use the internet for research purposes with a mean of 1.8 and standard deviation of 0.8, 18.3 % frequently use the internet to correspond with friends with a mean of 1.7 and standard deviation of 0.8, 13.3 % of the pre service teachers use the internet to download course materials with a mean of 1.6 and a standard deviation of 0.7, 18.3 % also use the internet as a discussion forum with a mean of 1.7 and standard deviation of 0.8, below 6.7 % use the internet for internet conferencing with a mean of 1.4 and standard deviation of 0.6, 13.3 % use the internet to send and receive messages with a mean of 1.7 and standard deviation of 0.7. Finally, 80.0 % of the pre service teachers wish to use technology in their future teachings with a mean of 2.7 and standard deviation of 0.6.

The preservice teachers lack of use of the internet to perform various tasks may be due to lack of staff training as asserted by Poole and Moran (1998), who suggested that, deficiencies in staff development prevent teachers from utilizing existing technology in their teaching. They expand on this by asserting that "one-shot workshops, added expense of training, lack of continued support, isolated knowledge, unawareness of school needs, lack of knowledge and support from leadership all contribute to the ineffectiveness of technology staff development".

Research Question 4.

To what extent do pre service teachers use constructivist teaching and learning events in the classrooms?

The data collected and used to answer this research question are presented in Tables 22 to 25.

Table 22: Pre service teachers use of shifting roles

	N	M	D	Skew.	N %	S %	F %
Put You In Small Groups	60	2.3	0.6	0.0	6.7	61.7	31.7
Coach Instead Of Lecturing	60	2.3	0.8	-0.5	18.3	38.3	43.3
Work With Weaker Students	60	2.4	0.7	-0.6	10.0	43.3	46.7
Engage Learners Actively	60	2.6	0.6	-1.1	3.3	31.7	65.0
Make Students More Co Operative	60	2.6	0.6	-1.1	5.0	31.7	63.3
Visual and verbal thinking	60	2.5	0.7	-0.9	10.0	33.3	56.7

Source: Field Data, 2014

Table 22 describes pre service teachers' use of constructivist roles in teaching. From the analysis, 6.7 % of the pre service teachers never put their students in small groups with a mean of 2.3 and a standard deviation of 0.6, 18.3 % of the pre service teachers never coach their students instead of lecturing with a mean of 2.8 and a standard deviation of 0.8, 10.0 % never work with weaker students with a mean of 2.4 and standard deviation of 0.7, again 3.3 % never engage learners actively with a mean of 2.6 and standard deviation of 0.6, also, 5.0 % never make students more cooperative with a mean of 2.6 and standard deviation of 0.6, 10.0 % never use visual and verbal thinking in lesson delivery with a mean of 2.5 and standard deviation of 0.7. Pre Service science teachers on the average have a positive attitude towards the use of shifting roles in other to achieve constructivism.

Table 23: Preservice Science Teachers use of Assessment

	N	M	SD	Skw.	N %	S %	F %
Non Graded Options /Portfolio assessment	60	1.8	0.7	0.2	33.3	53.3	13.3
Self - Evaluation	60	2.1	0.7	-0.2	18.3	51.7	30.0
Peer Evaluation	60	2	0.7	0.1	28.3	46.7	25.0
A Grading System That Provide Meaningful Feedback	60	2.1	0.7	-0.2	21.7	43.3	35.0
Assessment Is Context Dependent	60	2.0	0.8	-0.1	28.3	40.0	31.7
Assessment Based on originality	60	2.2	0.7	-0.2	16.7	50.0	33.3

Source: Field Data, 2014

Table 23 describes pre service teachers' use of assessment in the constructivist classroom. From the results only 13.3 % frequently use non graded options and portfolio assessment with a mean of 1.8 and standard deviation of 0.7, only 18.3 % never use self-evaluation with a mean of 2.1 and standard deviation of 0.7, 25.0 % frequently use peer evaluation with a mean of 2.0 and standard deviation of 0.7,

21.7 % never use a grading system based on meaningful feedback with a mean of 2.1 and standard deviation of 0.7, 28.3% never use assessment that is context dependent with a mean of 2.0 and standard deviation of 0.8.

Finally, only 16.7 % of the pre service teachers use assessment that based on originality with a mean of 2.2 and standard deviation of 0.7. On the average pre service science teachers sometimes have a positive attitude towards the use of assessment to achieve constructivism.

Table 24: Pre Service Teachers' use of Students Engagement

	N	M	SD	Skew.	N %	S %	F %
Teach To Multiple Student Intelligences	60	2.2	0.7	-0.3	16.7	45.0	38.3
Art and Music Are Used In Class Activities	60	2.2	0.7	-0.3	20.0	43.3	36.7
Hands On Learning Activities Are Provided	60	2.3	0.8	-0.6	20.0	30.0	50.0
Students Work In Cooperative Groups	60	2.4	0.7	-0.7	13.3	35.0	51.7
Students Make Interest Based Learning Choices	60	2.2	0.7	-0.2	13.3	55.0	31.7
Students use critical thinking	60	2.3	0.6	-0.2	8.3	55.0	36.7
Students Use Multiple Resources In Class	60	2.1	0.7	-0.1	18.3	55.0	26.7
I Serve As A Mentor And Motivator	60	2.6	0.6	-1.3	5.0	28.3	66.7

Source: Field Data, 2014

Table 24 describes pre service teachers' engagement of students in constructivist classroom. From the analysis, only 16.7 % never teach their students to multiple intelligence with a mean of 2.2 and standard deviation of 0.7, 20.0 % never use art and music in their activities with a mean of 2.2 and standard deviation 0.7, 20.0 % also never use hands on learning activities with a mean of 2.3 and standard deviation of 0.8, 13.3 % never let students work in cooperative groups with a mean of 2.4 and standard deviation of 0.7, 13.3 % never make students make interest based learning choices with a mean of 2.2 and standard deviation of 0.7. Less than 10.0 % never make students to think critically with a mean of 2.3 and standard deviation of 0.6, 18.3 % never make student use multiple resources in their classroom with a mean of 2.1 and standard deviation of 0.7. Finally 5.0 % of the preservice teachers again never serve as a mentors and motivators in their teachings.

On the average pre service teachers engage their students positively in their classrooms to achieve constructivism.

Table 25: Pre Service teachers' use of students' control.

	N	M	SD	Skew.	N %	S %	F %
The physical arrangement of the classroom	60	2.4	0.6	-0.5	8.3	46.7	45.0
Parents are included in the learning activities	60	1.8	0.7	0.3	36.7	48.3	15.0
Students choose from multi option assignments	60	1.9	0.7	0.1	28.3	50	21.7
Students produce video tapes simulations and or role play	60	1.9	0.7	0.2	30.0	53.3	16.7
Students investigate and solve real world problems	60	2.0	0.7	0.0	23.3	50.0	26.7
Students select topics for independent study	60	1.9	0.7	0.2	35.0	43.3	21.7
Social negotiation is a part of the learning process	60	2.1	0.7	-0.1	20.0	55.0	25.0
Students monitor their own learning	60	1.9	0.7	0.1	28.3	56.7	15.0
Intention to use constructivist events in the future.	60	2.6	0.7	-1.5	10.0	18.3	71.7

Source: Field Data, 2014

Table 25 describes preservice teachers' use of students control in constructivist classrooms. From the analysis, 8.3 % never change the physical arrangement of their classroom with a mean of 2.4 and a standard deviation of 0.6, only 15.0 % frequently include parents in the learning activities with a mean of 1.8 and standard deviation of 0.7, 28.3 % never allow students to choose from multi option assignments with a mean of 1.9 and standard deviation of 0.7, 16.7 % frequently produce video tapes/simulations and role play with a mean of 0.7 and standard deviation of 0.7. Furthermore, 23.3 % never allow students to investigate and solve real world problem with a mean of 2.0 and a standard deviation of 0.7, only 21.7 % allow students to select topics for independent study with a mean of 1.9 and standard deviation of 0.7, 20.0 % never allow social negotiations as part of the learning process with a mean of 2.1 and standard deviation of 0.7, 15.0 % frequently monitor their learning process with a mean of 1.9 and standard deviation of 0.7. Finally, 71.7 % frequently wish to use constructivist learning approaches in their future teachings with a mean of 2.6 and standard deviation of 0.7. Pre service teachers use students control to achieve constructivism.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The primary aim of this research is to investigate the integration of Technology among Science Teachers using constructivist learning events in selected colleges of education in Ghana.

A sample of 60 pre service teachers were selected randomly from three teacher training colleges of education in the central region, Ghana.

They answered the questionnaire based on their demographic data, use of software, use of utilities, use of hardware, use of input devices, use of output devices, use of storage devices, use of the internet, also their shifting roles in constructivist classrooms, assessment in constructivist classroom, students engagement in constructivist classrooms, students control in the constructivist classroom.

Summary of key findings

Use of computer software

From the analysis, it was observed that greater percentage of tutors of pre service teachers in the colleges of education were using various software in teaching their students as compared to the pre service teachers of which majority never use the software in teaching.

Use of Utilities

It was seen clearly from the analysis that a larger percentage of tutors of pre service teachers have knowledge about utilities and use them in their teachings.

On the contrary, greater number of the pre service teachers themselves never have knowledge of utilities and do not use them in their teaching activities.

Use of hardware

The data analysis showed that both the pre service teachers and their tutors have much knowledge of hardware devices and use them in their teachings.

Use of storage devices

Both pre service teachers and their tutors sometimes use storage devices to store data in their teachings this was shown by a large percentage responding positively to the use of storage devices.

Use of input devices

Pre service teachers never use most of the input devices in teaching, however their tutors sometimes use these input devices to teach them during lesson delivery in their classroom settings.

Use of output devices

Most of the pre service teachers do not use output devices in their teachings. Nevertheless, majority of their tutors use them to teach the pre service teachers themselves.

Use of the internet

A smaller percentage of the pre service teachers use the internet frequently to aid their teaching as compared to a larger percentage of tutors of pre service teachers' use the internet in their lesson delivery.

Shifting roles in constructivist classroom

Both tutors of pre service teachers and the pre service teachers themselves have a positive attitude towards shifting roles in their constructivist classrooms, they showed a greater percentage of frequently changes roles in their teaching.

Assessment in constructivist classroom

Tutors of pre service teachers and the pre service teachers themselves sometimes use constructivist assessments in their classrooms.

Students' engagement in constructivist classroom

Pre service teachers and their tutors engage their students positively in the classroom using constructivist approaches.

Students control in constructivist classroom

Finally, from the analysis it can be observed that pre service teachers and their tutors have a positive control of their students in the constructivist classrooms.

Conclusion

From the analysis of results using SPSS it can be concluded that most pre service science teachers do not frequently use technology to teach their students in the classroom.

A fewer percentage of the pre service teachers sometimes use constructivist approaches in their classrooms.

Recommendations

1. Technological training should not be the only means in which science teachers should be trained. However, courses which focus on methods of teaching science with technology should be integrated into the curriculum of pre service science teachers.
2. Technological and technical support unit should be provided in all schools so as to ease the problems of technological failures.
3. Finally, pre service science teachers should consults friends who have adequate knowledge of technology and website for science materials to help them teach effectively.
4. Software training should be introduced in teaching the pre- service science teachers.
5. Training on the use of input and output devices for effective teaching should be given to the pre-service science teachers periodically.
6. Internet orientations and training should be given to the pre- service teachers regularly.

Suggestions for Further Research

This study used a descriptive design with the questionnaire as the only instrument on how to achieve constructivist learning events by integrating technology among pre service science teachers, however, inferential statistics should also be used to ascertain how the various variables relate or affect each other.

Secondly, further separate research is needed on the various technologies needed in teaching science rather than putting all technologies together.

Finally, research should be conducted on how technology integration courses are taught in the curriculum of pre service science teachers.

REFERENCES

Airasian, P.W., & Walsh, M.E. (1997). Constructivist cautions. *Phi Delta Kappan, 78(6),*444 - 449.

Albion, P.R. (2000). *Interactive Multimedia Problem-Based Learning for enhancing preservice teacher's self-efficiency beliefs about teaching with computers: Design, development and evaluation.* Unpublished Doctoral Thesis: University of Southern Queensland.

Alden, S. (2000). *Effective programs for training teachers on the use of technology.* Retrieved 10 February 2001 from http://www.computerlearning.org/articles/Training.htm

Applefield, J.M., Huber, R., & Moallem, M. (2000/2001). Constructivism in theory and practice: Towards a better understanding. *The High School Journal, 84(2),* 35-53.

Barnett, H. (2000). Assessing the effects of technology in a standards-driven world. *Learning and Leading with Technology, 27,* 28-32.

Batane, T. (2004). In-service teacher training and technology: A case of Botswana. *Journal of Technology and Teacher Education, 12(3),* 387-410.

Beaver, J. (1990). *A profile of undergraduate educational technology (in) competence: Are we preparing today's education graduates for teaching in the 1990's?* Research Report. Buffalo, NY: SUNY at Buffalo. (ERIC Document Reproduction Service No. ED 332 985).

Berger, C., Carlson, E., & Novak, D. (Eds). (1989). *Handbook for pre-service technology training.* Ann Arbor, MI: The University of Michigan.

Bracey, B. (1994). *The digital classroom: World Net Television Program.* Washington DC: United States Information Agency.

Brennan, J.P. (2000). *The content and emphasis of the introductory technology course for the undergraduate pre-service teachers*. Unpublished Doctoral Thesis: IndianaUniversity.

Brooks, D.M., & Koop, T.W. (1989). Technology in teacher education. *Journal of Teacher Education, 40(4),* 2-8.

Brooks, J.G., & Brooks, M.G. (1993). *In search of understanding: the case for constructivist classrooms.* Alexandra, VA: Association for the Supervision and Curriculum Development.

Bruner, J. (1966). *Toward a theory of instruction*. Cambridge, MA: Harvard University Press.

Burke, J. (1998). Technology standards for teachers: SREB Educational Technology Cooperative. Retrieved 25 January 2002. Online: http://www.sreb.org/programs/EdTech/pubs/techstandards.asp

Brush, T.A. (1998). Teaching pre-service teachers to use technology in the classroom. *Journal of Technology and Teacher Education, 6(4),* 243-258.

Campoy, R. (1992). The role of computer technology in the school reform movement. *Educational Technology, 32(8),* 17-22.

Carr-Chellman, A.A., & Dyer, D. (2000). The pain and the ecstasy: Pre-service teacher perceptions on changing teacher roles and technology. *Educational Technology and Society, 3(2),* 96-105.

Cobb, P. (1994). Constructivism in mathematics and science education. *Educational Researcher, 23 (7),* 4.

Cooper, P.A. (1993). Paradigm shifts in designed instruction: From behaviourism to cognitivism to constructivism. *Educational Technology, 33(5),* 12-19.

Cronje, J.C. (2000). *Paradigms Lost: Ttowards Integrating behaviourism and Constructivism from* http://it.coe.uga.edu/itforum/paper48/paper48.htm

Dede, C. (1998). *Teaching and learning*. ASCD Yearbook. Alexandria, VA: Association of Supervision and Curriculum Development.

Dewey, J. (1938). *Experience and Education*. New York: Collier Books.

Diegnueller, K. (1992). Embracing technology as a tool in teacher training. *Education Week, 11(6),* 511-513.

Donley, J., & Donley, T. (1996). Teachers, technology and training perspectives on school reform and the developing role of the teacher: A new template. *International Journal of Instructional Media, 23*, 1-5.

Driscoll, M.P. (1994). *Psychology of learning for instruction.* Boston: MA. Allyn & Bacon.

Dunn, R. (2000). Capitalizing on college students learning styles: Theory, practice, and research. In R. Dunn & R. Griggs (Eds), *Practical* *approaches to using learning styles in higher education* (pp. 3-18). West Point, CT: Bergin & Garvey.

Duran, M. (2000). *Examination of technology integration into an elementary teacher education program: One university's experience.* PhD, Ohio University.

Eby, J. (1997). *Reflective planning, teaching and evaluation,* K-12. Upper Saddle River, NJ: Prentice Hall.

Ernest, P. (1995). The one and the many. In L. Steffe & J. Gale (Eds), *Constructivism in education* (pp. 459-486). Hillsdale, NJ: Lawrence Erlbaum.

Ferguson, D. (2001). Technology in constructivist classroom. *Information Technology in Childhood Education Annual,* 45-55.

Fontaine, M. (2000). *Teacher training with technology: Experience with five country programs.* The Learning Link Project, Academy for Educational Development.

Fosnot, C. (1996). *Constructivism: Theory, perspectives and practice.* New York: Teachers College Press.

Gazette of the Republic of Angola (2001). Series one, number 65 of 31 December 2001.

Gerald, D.E., & Williams, H. (1998). *Projections of educational statistics to 2008.*Washington, DC: US Department of Education National Center for Education Statistics.

Gergen, K.J. (1995). Social constructivism and the educational process. In L.P. Steffe & J. Gale (Eds.), *Constructivism in education* (pp. 17-39). Hillsdale, NJ: Erlbaum.

Grabe, M., & Grabe, C. (1996). *Integrating technology for meaningful learning*. Boston: Houghton Mifflin Company.

Handler, M. G., & Strudler, N. (1997). The ISTE Standards: Issues of Implementation. *Journal of Computing in Teacher Education, 13(2).* Retrieved 6 May 2002 from http://www.nevada.edu/~strudler/standards.html

Hanson-Smith, E. (1997). *Technology in the classroom practice and promise in the 21st century*. Teachers of English to Speakers of Other Languages, Inc. (TESOL).

Hardy, V.H. (1998). Teacher attitudes toward and knowledge of computer technology. *Computers in Schools, 14(3/4)*, 119-136.

Harel, I., & Papert, S. (1991). *Constructionism research reports and essays, 1985- 1990*. Norwood, NJ: Greenwood Publisher Group.

Hein, G.E. (1991). *Constructivist learning theory: The museum and the needs of people.* Paper presented at the CECA Conference in Jerusalem, Israel. Retrieved 10, May 2006 from http://0www.exploratorium.edu.innopac.up.ac.za/IFI/resources/research/constructivist learning.html

Hill, R.B., & Sommers, J.A. (1996). A process for initiating change: Developing technology goals for a college of education. *Journal of Teacher Education, 47(4),* 300-306.

Hochman, A., Maurer, M., & Roebuck, D. (1993). Buttons and cards and fields, oh my! *Tech Trends, 38(2),* 25-28.

Honebein, P. (1996). Seven goals for the design of constructivist learning environments. In B. Wilson (Ed.), *Constructivist learning environments* (pp. 17-24). NJ: Educational Technology.

Hooper, S., & Hannafin, M.J. (1991). The effects of group composition on achievement, interaction and learning efficiency during computer-based cooperative instruction. *Educational Technology, Research and Development, 39(3),* 27-40.

Hurteau, J. (1990). Perceived needs of computer training for educators in New York State. Unpublished Master's Thesis: State University of New York College, New York

Jaber, W. (1997). A survey of factors which influence teachers' use of computer based technology. Unpublished Dissertation Virginia Polytechnic Institute and State University, Virginia

Jonassen, D.H. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm? *Educational Technology, Research and Development, 39(3*), 5-14.

Jonassen, D.H. (1991a). Evaluating constructivist learning. *Educational Technology, 31*, 28-33.

Jonassen, D.H., Davidson, M., Collins, M., Campbell, J., & Hagg, B.B. (1995). Constructivism and computer-mediated communication in distance education. *The American Journal of Distance Education, 4 (2),*12-42.

Jones, A., & Mercer, N. (1993). Theories of learning and information technology. In P. Schrimshaw (Ed.), *Language Classrooms and Computers*. (pp.11- 26). London: Routledge.

Joubert, T. (2000). *Roles and social interaction*. Retrieved 18 June 2003 from http://hagar.up.ac.za/catts/learner/cooplrn/c1.html

Kearns, J. (1992). Does computer coursework transfer into teaching practice? *Journal of Computing in Teacher Education, 8(4),* 29-34.

Laffey, J., Tupper, T., Musser, D. & Wedman, J. (1998). A computer-mediated support system for project-based learning. *Educational Technology Research and Development,* 46, 1, 73–86.

Lindschitl, M. (1999). A vision educator can out into practice: Portraying the constructivist classroom as a cultural system. *School Science and Mathematics, 99(4),* 189-197.

Lipponen, L. (1990). *The challenges for computer supported collaborative learning in elementary and secondary level: Finnish perspectives*. Proceeding of the Computer Support for Collaborative Learning Conference.

Lovat, T.J. (2003). *The role of the teacher coming of age.* Australian Council Deans of Education, Discussion Paper. Retrived 10 May 2004 from http://activated.det.act.gov.au/learning/word/elt/1.0_Pedagogy.pdf

Lunenburg, F.C. (1998). Constructivism and technology: Instructional designs for successful education reform. *Journal of Instructional Technology, 25(2),* 75- 82.

Maddux, C.D., Johnson, D.L., & Willis, J.W. (1997). *Educational Computing: Learning with Tomorrow's Technologies (*2nd ed). *Boston: Allyn & Bacon*.

Mann, C. (1994). New technologies and gifted education. *Roeper Review, 16(3),* 172-176.

Matusevich, M. (1995) *School reform: What role can technology play in a constructivist setting?* Retrieved 10 May 2006 from http://0-pixel.cs.vt.edu.innopac.up.ac.za/edu/fis/techcons.html

McKenzie, J. (2001). *Designing staff development for the information age*. Retrieved 5 January 2002 from http://staffdevelop.org/adult.html

McNamara, S., & Pedigo, M.L. (1995). *Development of an individualized computer training model for classroom teachers.* (ERIC Document Reproduction Service No. ED384596).

Means, B. (1994). Introduction: Using technology to advance educational goals. In B. Means (Ed.), *Technology and education reform: The reality behind the promise* (pp.1-21). San Francisco: Jossey-Bass.

Moursund, D., & Bielefeldt, T. (1999). *Will new teachers be prepared to teach in a digital age? A national survey on information technology in teacher education.* Beverly Hills, CA: Milken Family Foundation.

Muir-Herzog, R.G. (2004). Technology and its impact in the classroom. *Computers & Education 42(2)*, 111– 131.

National Center for Education Statistics (2000). *Public school teachers' use of computers and the Internet.* Washington DC: US Department of Education.

National Council for the Accreditations of the Teacher Education's (NCATE) Task Force on Technology and Teacher Education (1998). Technology and the new professional teacher: Preparing for the 21st century classroom. NCATE NEWS. Retrieved 13 March 2000 from http://www.ncate.org/projects/tech/TECH.HTM

Office Technology Assessment (OTA), U.S. Congress. (1995). Teachers and technology: Making the connection. Washington, DC: U.S. Government Printing Office. Retrieved 16 January 2002 from http://0-www.wws.princeton.edu.innopac.up.ac.za:80/~ota/disk1/1995/9541.html

Pechman, E.M. (1992). Child as meaning maker: The organizing theme for professional practice schools. In Levine, M. (Ed.), *Professional practice schools* (pp. 25-62). New York: Teachers College Press.

Poole, J.J., & Moran, C. (1998). Schools have their computers, now what? *Technology Horizons in Education, 26(5)*, 60-61.

Richards, R.T. (1998). Infusion technology and literacy into the understanding teacher education curriculum through the use of electronic portfolios. *T.H. E. Journal, 25(9*), 46-50.

Roblyer, M.D. (1994). *Creating technology using teachers: A model for preservice technology training*. Report of a Florida DOE-funded project, Tallahassee, FL.

Rosenthal, I.G. (1999). New teachers and technology: Are they prepared? *Technology and Learning, 19(8),* 22.

Rysavy, S.D., & Sales, G.C. (1991). Cooperative learning in computer-based instruction. *Educational Technology, Research and Development*, *39(2)*, 70-79.

Sahin, T.Y. (2003). Student teachers' perceptions of instructional technology: Developing materials based on a constructivist approach. *British Journal of Educational Technology*, *34(1)*, 67-74.

Schacter, J. (2001). Teacher performance based accountability: Why, what, and how. Milken Family Foundation.

Scheffler, F.L., & Logan, J.P. (1999). Computer technology in schools: What teachers should know and be able to do. *Journal of Research on Computing in Education, 31(3),* 305-326.

Schrum, L. (1999). Technology professional development for teachers. *Educational Technology Research and Development, 47(4),* 83-90.

Shaw, T. (2003). Professional development potluck: Successful programs offer a dish for every taste. *Multimedia Schools*, *10(2),* 39-41.

Siegel, J. (1995). The state of teacher training: The results of the first national survey of technology staff development in schools. *Electronic Learning*, *14(8)*, 43-53.

Simpson, J. (1986). Computers and collaborative work among students. *Educational Technology, 26(10),* 37-43.

Sinitsa, K. (2000). Learning individually: a life-long perspective introduction to the special issue. *Educational Technology & Society, 3(1),* 17-23.

Southwest Educational Development Laboratory – SEDL (1995). *Constructing knowledge in the classroom.* Retrieved May 2005. Online: http://www.sedl.org/scimath/compass/ /1v01n03.html

Stepich, D. (1996). *Instructional technology for teaching*. Upper Saddle River, NJ: Prentice Hall.

Strommen, E.F., & Lincoln, B. (1992). Constructivism, technology and the future of classroom learning. *Education and Urban Society, 24*, 466-476.

Strudler, N., & Wetzel, K. (1999). Lessons from exemplary colleges of education: Factors affecting technology integration in preservice programs. *Educational Technology Research & Development, 47(4),* 63-81.

Tam, M. (2000). Constructivism, instructional design and technology: Implications for transforming distance learning. *Educational Technology & Society, 3(2),* 50-60.

The Michigan State Technology Plan (2000).

Thomas, L. H. (1999). A study of pre-service teachers' integration of technology applications into the elementary classroom. Unpublished Doctoral Dissertation: Mississippi State University, USA.

Todd, N. (1993). A curriculum model for integrating technology in teacher education courses. *Journal of Computing in Teacher Education*, *9(3)*, 5-11.

Trotter, A. (1999). *Preparing teachers for the digital age.* Education Week, *19(4).*

U.S. Department of Education, Office of Educational Research and Improvement (1998). *An educator's guide to evaluating the use of technology in schools and classrooms.* Washington, DC: U.S. Government Printing Office.

Walker, M. (2000). Educational multimedia and teachers needs for new competencies to use educational multimedia. *Education Media International, 37(4),* 235-241.

Walters, J.T. (1992). *Technology in the curriculum: The inclusion solution*. (ERIC Document Reproduction Service No. ED350281).

Wang, Y. & Holthaus, P. (1999). Facing the world: Student teachers' computer use during practicum. *Journal of Educational Technology Systems, 27(3)*, 207-223.

Wang, Y. (2000). Pre-service teachers' perception of the teachers' role in the classroom with computers. In C. Crawford, D. Willis, R. Carlsen, I. Gibson, K. McFerrin, J. Price, & R. Weber (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference* (pp. 1566-1573). Chesapeake, VA: AACE.

Webb, N.M. (1987). Peer interaction and learning with computers in small groups. *Computers in Human Behavior*, 3(3-4), 193-209.

Wentz, P, & Wentz, C. (1995). Technology education for pre-service teachers. *Journal of Instructional Psychology, 22(2)*, 146-151.

Wetzel, K. (1993). Teacher educators' uses of computers in teaching. *Journal of Technology and Teacher Education, 1(4)*, 22-27.

Wilson, B., & Cole, P. (1991). A review of cognitive teaching models. *Educational Technology Research and Development, 39(4),* 47-64.

Appendices

Appendix A

UNIVERSITY OF CAPECOAST

QUESTIONNAIRE FOR PRE- SERVICE TEACHERS

This questionnaire is meant to gather information on the integration of technology in teaching science using constructivist learning events in colleges of Education in the Central Region of Ghana.

Please tick (√) where applicable.

PART A: DEMOGRAPHIC DATA

AGE	21-25 [ ]	26-30 [ ]	31-35[ ]	Above 36 [ ]
GENDER	Male [ ]	Female [ ]		
SCHOOL STATUS	Private [ ]	Public [ ]		

PART B

1. To what extent do you and your tutors use technology in the classroom.

Likert Scale 1= Never, 2= Sometimes, 3= Frequently

	EXPECTED RESPONSES FROM PRE- SERVICE TEACHERS					
	Tutors			Pre-Service teachers		
ITEMS	1	2	3	1	2	3
USE OF COMPUTER SOFTWARE						
1. Microsoft Word						
2. Microsoft Access						
3. Microsoft Excel						
4. Microsoft PowerPoint						
UTILITIES						
5. Backups						
6. Trouble shooting						
7. Use of Antivirus						
8. Data Recovery						

9. Disk Defragmentation						
HARDWARE						
10. Monitors						
11. Keyboard skills						
12. Systems Units						
13. Mouse skills						
STORAGE DEVICES						
14. Floppy Disk						
15. Hard Disk						
16. CD/DVD						
17. Pen drives						
18. Memory Cards						
INPUT DEVICES						
19. Keyboard						
20. Mouse						
21. Light Pens						
22. Touch Screens/Pads						
23. Microphones						
24. Scanners						
25. Digital Cameras						

OUTPUT DEVICES						
26. monitors						
27. printers						
28. photocopiers						
29. plotters						
30. speaker/headsets						
INTERNET						
31. E-Mail Address						
32. Research						
33. Correspond With friends						
34. Downloading Of materials						
35. Discussion Forum						
36. Internet conferencing						
37. Send And Receive messages						
38. Wish to use technology in the future						

2. To what extent do you and your tutors use constructivist teaching and learning events in the classroom?

Likert scale 1=Never 2= Sometimes 3= Frequently

	EXPECTED RESPONSES FROM PRE- SERVICE TEACHERS					
ITEMS	Tutors			Pre-Service teachers		
SHIFTING ROLES IN CONSTRUCTIVIST CLASSROOMS	1	2	3	1	2	3
1. Put You In Small Groups						
2. Coach Instead Of Lecturing						
3. Work With Weaker Students						
4. Engage Learners actively						
5. Make Students More cooperative						
6. Visual And Verbal Thinking						
ASSESSMENT IN CONSTRUCTIVIST CLASSROOMS						
7. Non-Graded Options And portfolio Assessment						

8. Self- Evaluation						
9. Peer -Evaluation						
10. A Grading System That provide meaningful feedback						
11. Assessment Is Context dependent						
12. Assessment Based On originality and appropriate performance rather than regurgitation						
STUDENTS ENGAGEMENTIN CONSTRUCTIVIST CLASSROOMS						
13. Teach To Multiple Student Intelligences						
14. Art and Music Are Used In class activities						
15. Hands-On" Learning Activities are provided for the students						
16. Students Work In Cooperative groups						
17. Students Make Interest-Based Learning choices						
18. Students Use Critical Thinking And Solving Skills						

19. Students Use Multiple Resources In class						
20. I Serve As A Mentor And Motivator						
STUDENTS CONTROL IN CONSTRUCTIVIST CLASSROOMS						
21. The physical arrangement of the changes to facilitate learning activities						
22. Parents are included in the learning						
23. Students choose from multi-option assignment						
24. Students produce video-tapes, and/or role-play						
25. .Students investigate and solve problems						
26. Students select topics for independent						
27. Social negotiation is a part of the process.						
28. Students monitor their own						

learning active investigation						
29. Wish to use constructive learning events in the future						

APPENDIX B

UNIVERSITY OF CAPECOAST

Centre for Continuing Education

University post office

Cape Cost

Tel no: 03321-36947

Fax : 03321-36946

E - mail cce@ucc.edu.gh

Our Ref. No : CCE/MED/17/Vol. 1/065

9th April, 2014

Your Ref. No:

TO WHOM IT MAY CONCERN

This is to certify that **Mr. Godsway Believer Gbeze** with registration number ***ED/ITP/12/0024*** is pursuing a two year Master of Education Degree in Information Technology at the University of Cape Coast.

He is conducting a research on the topic **"Integrating Technology Among Science Teachers using Constructivist Learning Events in Colleges of Education in Central Region, Ghana".**

We will strongly appreciate any courtesy extended to him.

Thank you.

Emmanuel Arthur-Nyarko

for: **Director, CCE-UCC**