UNIVERSITY OF EDUCATION WINNEBA

INVESTIGATING THE LEARNING DIFFICULTIES OF CHEMISTRY STUDENTS IN ADA AND AKATSI SCIENCE COLLEGES OF EDUCATION

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Declaration

Candidate's Declaration

I, CHARLES LADZEKPO, declare that this dissertation, with the exception of quotations and references contained in published works which have all, to the best of my knowledge, been identified and acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

………………………………… ……………………………………

CHARLES LADZEKPO DATE

Supervisor's Declaration

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

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REV. BOATENG - ENNIMFUL DATE

(Supervisor)

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Dedication

Dedicated to my late mum, Lucy Aku Amekuedi.

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DEFINITION OF TERMS

1. **Learning difficulty** - A learning difficulty may exist in any situation where a student fails to grasp a concept or an idea.
2. **e-Chem** - A computer generated visualizing tool used to build molecular models and view multiple representations simultaneously.
3. **Constructivism** - It is a theory that says that learners construct their own understanding and knowledge of things they learn, through experiencing things and reflecting on those experiences.
4. **IEUCC** - Institute of Education University of Cape Coast.
5. **WAEC** - West African Examination Council
6. **NERIC** - New Educational Reform Implementation Committee
7. **Stoichiometry** - It is a branch of Chemistry that deals with the quantitative relationships that exist between the reactants and products in chemical reactions. In a balanced chemical reaction, the relations among quantities of reactants and products typically form a ratio of whole numbers.

ABSTRACT

This study explored some of the difficulties students face when learning Chemistry in the Science Colleges of Education. The study was prompted by the students" poor performance in their first and second semester examinations. The main purpose of the study therefore, was to identify some of the difficulties the students face when studying Chemistry and also look at the practices that would enhance their study of the subject. The study was also aimed at finding out whether the Science Colleges had adequate facilities and equipment that would help to promote effective learning of the subject. Another target was finding out whether e-chem had any impact on the study of molecular structure of compounds. Not only that but also the study sought to identify whether the use of practical activities by students to learn Chemistry assisted them to understand concepts which were complex.

The descriptive survey was used to conduct this study. Two sets of questionnaires were developed by the researcher. These instruments were used to collect data from both tutors and students to determine some of the difficulties students face when studying Chemistry. Data was collected from two (2) out of the fifteen (15) colleges designated to pursue the quasi-specialist science programme. The study involved one hundred (100) students made up of seventy (70) males and thirty (30) females, and four (4) of their male tutors.

The responses to the questions were coded and analyzed using Statistical Package for Social Sciences (SPSS) version 12. The findings were computed into percentages, categorized and used to describe some of the difficulties the students faced in the Colleges. The findings were also represented in bar charts for easy pictorial view. The study showed that students really perceived Chemistry to be difficult. They learnt and memorized concepts without understanding them even though their tutors used practical activities to teach them. The study also found out that the students were hardly motivated and their prior knowledge was not considered when a new lesson was to be taught.

The study also showed that tutors were not familiar with the technological tool, e-chem, and this made its usage non-beneficial to the students. The study also found out that lack of adequate facilities like Chemistry laboratories, equipment and reagents in the colleges made the study of Chemistry much more difficult to the learner.

It was however recommended that students be involved in more practical activities to enable them teach effectively after College. Also, students should be encouraged and motivated to learn Chemistry. Moreover, it was recommended that government should, as matter of urgency, complete all infrastructure projects in the colleges. Finally, students selected to offer elective science should be those who offered elective science at the Senior High School and have good grades at WASSCE level.

CHAPTER ONE

INTRODUCTION

Overview

This chapter discuses the background to the study which includes students" learning difficulties in Chemistry, statement of the problem, purpose of the study, objectives and research questions of the study. The rest are the limitations, delimitations, and definitions of terms.

Background of the Study

Chemistry is a subject filled with interesting phenomena, appealing experimental activities, and fruitful knowledge for understanding the natural and industrial world.

However, it is perceived by students to be difficult. It is, therefore, important to appreciate the various areas of difficulties as expressed by students. The subject by its very nature is highly conceptual, and so while much can be acquired by rote learning (this often being reflected by efficient recall during examinations), real understanding demands the bringing together of conceptual understanding in a meaningful way. Thus, while students show some evidence of learning and understanding in examinations, researchers find evidence of misconceptions and rote learning (Johnstone, 1984; Bodner, 1991): What is taught is not always what is learnt.

Chemistry curricular commonly incorporates many abstract concepts, which are central to further learning in both Chemistry and other sciences (Taber, 2002). Therefore, it is very important for the students to sufficiently grasp these abstract concepts to enable them understand chemistry easily. (Zoller, 1990; Nakleh, 1992; Ayas and Demirbas, 1997; Coll and Treagust, 2001).

According to Krishman and Howe (1994), students‟ difficulties to understand concepts in Chemistry are because some teachers are not able to harness students‟ prior knowledge in the classroom.

Since the establishment of teacher training colleges to train teachers in Ghana, Chemistry was studied as a core area in Science. In 1987 Education Reform programme, it was indicated that the Certificate „A‟ 3-year Curriculum could not equip trainees with the needed skills to teach Science effectively at the basic level.

This has called for the implementation of the 2004 New Educational Reform Implementation Committee (NERIC) report. This led to the upgrading of the 38 Teacher Training Colleges (now Colleges of Education) to Diploma awarding institutions. Out of the 38 colleges of Education, 15 colleges were set aside to pursue special programmes in Science and Mathematics Education. This was done in order to improve the teaching and learning of science in our basic schools.

Unfortunately, since the inception of the programme, most colleges designated to pursue the science programme have been facing various kinds of problems like inadequate laboratory equipment and necessary facilities which have resulted in the use of inappropriate teaching methods of Chemistry. It is in view of this that I have been prompted to consider the appropriate methods of teaching Chemistry and use the visualizing tool, e-chem, that allows students to build molecular modules to improve teaching and learning of Chemistry in the colleges.

Statement of the Problem

Chief Examiner‟s report (West African Examination Council, WAEC 2009; 2010 and Institute of Education – University of Cape Coast, IEUCC, 2009; 2010) indicated that Science students had difficulty in learning the subject. This has reflected in the low grades obtained by students during the end of semester examinations. It was also indicated that students found it difficult to write and balance simple chemical equations, draw structures of organic compounds, perform simple practical experiments and solve problems involving mole concepts (WAEC and IEUCC 2009;2010)

It is also evident that most students admitted into the Colleges of Education to pursue elective science programme obtained weak grades in the West African Senior Secondary Certificate Examination.

Considering the evidence outlined above on students difficulties in Chemistry, it is clear to note that Chemistry students in the Science Colleges find it difficult to write and balance simple chemical equation. This study therefore sought to investigate the causes of students‟ difficulties in learning chemistry in the selected science colleges. The study further sought to investigate the way chemistry was taught and learned in these colleges in Ghana.

Purpose of the Study

The purpose of the study is to investigate the causes of students‟ learning difficulties in Chemistry. The study looked at the facilities available to the students for use and the methods used in the teaching and learning of Chemistry. It also looked at the constructivist model and how it will help learners use active process to develop their own meaning and knowledge. This study will enable students grasp concepts which are difficult to understand when the lecture method is used.

Finally, many students have difficulty learning chemical symbols and molecular chemical representations. It is, therefore, necessary to use a technological tool, e-chem, that would enable students to view and draw structures of compounds correctly.

Objectives of the Study

The objectives of the study are to:

i. identify students‟ problems in learning Chemistry.
ii. use activity and practical/laboratory methods of teaching Chemistry effectively.
iii. use the technological tool, e-chem in teaching chemical symbols and molecular structures of compounds.
iv. determine whether the facilities available for teaching and learning Chemistry are adequate and in good condition.
v. examine the alternative methods for solving stoichiometric problems.

Research Questions

1. What problems do students encounter in learning Chemistry?
2. How can students be helped to use practical activities to learn Chemistry?
3. What technological tools can be used to support learning chemical symbols and molecular structures of compounds?
4. Are the facilities available adequate and effective in learning Chemistry?
5. How do alternative concepts in stoichiometry help in solving mole concept questions?

Significance of the Study

The outcome of the study will be very important in the teaching and learning of Chemistry in the Science Colleges of Education.

First of all, it will identify the problems associated with lack of understanding the pre-requisite concepts of students which make it difficult for them to study Chemistry at higher levels.

It will also assist teachers and students to take appropriate steps that will enable them teach and learn Chemistry effectively. The study will also inform the teachers to use the technological, visualizing tool, e-chem, to make teaching and learning of Chemistry easy.

It is hoped that the findings of the study will be of value to stakeholders in education such as teacher trainees, tutors of Science Colleges of Education (SCOE), Education Officers, the Teacher Education unit of the Ministry of Education and other higher institutions in Ghana, which train teachers to teach science in general and Chemistry in particular. It will also help future researchers to investigate more into the topic in finding out some other learning difficulties in Chemistry that might not be captured under this study.

Limitations

The Science Colleges of Education were far from each other and this made accessibility difficult. The resources and time frame for the study conducted could not permit the researcher to involve all the science colleges.

Delimitations

The researcher, due to insufficient time, could not use other parameters to determine their low grades in Chemistry but depended solely on results from their first and second semester examinations. Also, only two out of the fifteen Science Colleges of Education were involved in the research and the results of the study may not be considered as the findings from all the 15 Science Colleges of Education.

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CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter reviews and discusses issues in the literature relating to learning difficulties in Chemistry. The review has looked briefly at the conceptual understanding of chemical representations using technology, the role of constructivism in teaching and learning of Chemistry and the role of practical activities in Chemistry lesson delivery and concept formation.

Further, the development of tools for stoichiometry problems has also been reviewed. This review seeks to bring together some of the main findings from research over the past few decades, attempting to establish some key general principles which may be of value in curriculum development and for policy makers, teachers, teaching strategies as well as in generation of more research work. An examination of the aims of each study will reveal the motive of the researchers who undertook the study.

Learning Difficulties in Chemistry

At the beginning of any course, students start their study with a set of beliefs about the nature of learning and what they intend to achieve (Biggs & Moore, 1993). These beliefs are derived from earlier school and learning experiences as well as their current goals and motives. An understanding of how students learn can help teachers to devise effective strategies for teaching. This requires that research into the learning process is made accessible (Clow, 1998). To facilitate the development of students" views of knowledge, students need to be supported at the appropriate level. A student, who strongly believes that there is only one correct answer, will find an exercise, which shows a multiplicity of possible interpretations confusing and unhelpful. According to Taber (2002), Chemistry topics are generally related to or based on the structure of matter and it proves a difficult subject for many students.

Chemistry curricula commonly incorporate many abstract concepts, which are central to further learning in both Chemistry and other sciences. These abstract concepts are important because further Chemistry concepts or theories cannot be easily understood if these underpinning concepts are not sufficiently grasped by the students (Zoller, 1990; Nakhleh, 1992; Ayas & Demirbas, 1997; Coll & Treagust, 2001a; Nicoll, 2001). The seemingly abstract nature of Chemistry along with other content learning difficulties (for example the mathematical nature of some Chemistry topics) means that Chemistry classes require a high level skill set (Fensham, 1988; Zoller, 1990; Taber 2002). Chemistry is often regarded as a difficult subject, an observation that sometimes repels learners from continuing with studies in Chemistry. This was established in the last decade with new Chemistry syllabuses for senior secondary schools in different countries (Sirhan, 2000).

One of the essential characteristics of Chemistry is the constant interplay between the macroscopic and microscopic levels of thought, and it is this aspect of Chemistry learning that represents a significant challenge to novices (Bradly &Brand, 1985). In his early study, Johnstone (1974) reported that the problem areas in the subject from the students‟ point of view persisted well into university education, the most difficult topics being the mole, chemical formulae and equations, and inorganic chemistry‟s condensation and hydrolysis.

Over a number of years, many of the above difficulty areas were subjected to systematic study to try to identify the point of difficulty and to seek common factors among the nature of these difficulties (Johnstone et al., 1977; Ducan & Johnstone, 1973; Kellett & Johnstone, 1974; Garforth et al., 1976). Johnstone and El-Banna (1986) suggested a predictive model that enabled them to raise and test an important hypothesis, which was then applied to Chemistry learning as well as to learning in other science disciplines. The focus questions for this overview of literature are:

- What are the main areas of learning difficulty?
- What are the main aspects of reducing obstacles to learning?

The following areas have been identified:

Curriculum Content

The advent of revised school syllabuses in Chemistry in the 1960s and 1970s in many countries saw a move towards the presentation of school Chemistry in a logical order, the logic usually being that of the experienced academic chemist. Similarly, early chapters in almost all textbooks for first level higher education courses start with topics like atomic theory, line spectra, Schrodinger equations, orbital hybridization, bonding, formulae, balancing ionic equations and Stoichiometry. This is the grammar and syntax of Chemistry but is daunting for the student (Jenkins, 1992).

Johnstone (2000) has made arguments against this „logical" presentation cogently: The logical order may well not be psychologically accessible to the learner.

Much school Chemistry, taught before 1960 laid great emphasis on descriptive Chemistry, memorization being an important skill to achieve examination success. The sub-microscopic interpretation and symbolic representation were left until later.

Today, the descriptive is taught alongside both the „micro" and „representational".

Johnstone (1982) has argued that the learner cannot cope with all three levels being taught and Gabel (1999) supports this argument. Indeed, today, there is a danger that chemistry depends too much on the representational, with inadequate emphasis on the descriptive.

Chemical knowledge is learned at three levels: „sub-microscopic," „macroscopic" and „symbolic", and the link between these levels should be explicitly taught (Johnstone, 1991; Gabel, 1992; Harrison and Treagust, 2000; Ebenezer, 2001; Rivialo, 2001; Treagust et al., 2003). Also, the interactions and distinctions between them are important characteristics of Chemistry learning and necessary for achievement in comprehending chemical concepts. Therefore, if students possess difficulties at one of the levels, it may influence the other. Thus, determining and overcoming these difficulties should be our primary goals.

Johnstone (1984, 1991) indicated that the nature of chemistry concepts and the way the concepts are represented (macroscopic, microscopic, or representational) makes Chemistry difficult to learn. The methods by which students learn are potentially in conflict with the abstract nature of chemistry, which in turn, influences the methods by which teachers have traditionally taught (Johnstone, 1980).

In order to determine whether students" understanding of Chemistry would increase if the particulate nature of matter (sub-microscopic level) was emphasized, Gabel (1993) conducted a study involving students in an introductory Chemistry course. Introducing extra instruction to the experimental group that required students to link the particulate nature of matter to other levels (macroscopic and symbolic level); Gabel(1993) found that the experimental group performed higher in all levels than the control group. It seems that this kind of additional instruction is effective in helping students make connections between the three levels on which Chemistry can be both taught and understood.

Sawrey (1990) found that in an introductory Chemistry course; significantly more students were able to solve the problems that used symbols and numbers that could solve those depicting particles. Bunce et al. (1991) interviewed students who had solved problems out loud. This study indicated that students rarely thought about the phenomenon itself but they searched in their minds until they came upon something that fitted the conditions of the problem.

Osborne and Cosgrove (1983) showed how students (at several school age levels) understood little about the particulate nature of matter or about chemical phenomena in their everyday lives. Surprisingly, some of the incorrect explanations that students gave to common phenomena were concepts that they developed after formal school instruction. Bonder (1991) then used the same questions developed by Osborne and Cosgrove (1983) to determine how prevalent these ideas were among the students. His findings indicated that non-scientific explanations persisted for some students even after they had graduated with a major in Chemistry. He concluded that students had difficulty in applying their knowledge and they did not extend their knowledge into the real world.

This last aspect has been discussed (Reid 1999, 2000) where it was suggested that the Chemistry syllabus to be taught should not be defined by the logic of the subject but by the needs of the learner.

Overload of Students' Working Memory Space

The working memory space is of limited capacity (Baddeley, 1999). This limited shared space is a link between what has to be held in conscious memory, and the processing activities required to handle it, transform it, manipulate it, and get it ready for storage in long-term memory.

When students are faced with learning situations where there is too much to handle in the limited working space, they have difficulty selecting the important information from the other less important information. The latter has been described as “noise”, the student having difficulty in separating the signal from the noise (Johnstone & Letton, 1991).

Faced with new and often conceptually complex material, the Chemistry student needs to develop skills to organize the ideas so that the working space is not overloaded. Without the organizing structures available to the experienced teacher, the student frequently has to resort to rote learning, which does not guarantee understanding. To solve this type of problem, Johnstone (1999) has argued that teachers have to look more closely at what is known about human learning and also look at the nature of the discipline of Chemistry and its intellectual structure in an effort to harmonize them.

The ability to develop strategies to cope with information overload depends heavily on the conceptual framework already established in the long-term memory. Working space cannot be expanded but it can be used more efficiently. However, this depends upon some recognizable conceptual framework that enables student to draw on old material only. Miller (1956) suggested the idea of “chunking” (the ability to use some strategy to bring together several items into one meaningful unit, thus reducing working space demands).

Language and Communication

Language has been shown to be another contributor to information overload (Johnstone, 1984). Language problems include unfamiliar or misleading vocabulary, familiar vocabulary which changes its meaning as it moves into chemistry, use of high-sounding language, and the use of double or triple negatives (Cassels & Johnstone, 1985). An interesting example of the effect of language on working memory space overload is the work carried out to measure working memory space, using the second language of the pupils. They found that, where the learner was operating in a second language, the usable working memory space dropped by about one unit. It was suggested that this unit was being "used" to handle the language transfer (Johnstone & Selepeng, 2001).

In USA, Gabel (1999) has noted that difficulties students have with Chemistry may not necessarily be related to the subject matter itself but to the way of talking about it. In Australia, Gardner (1972) made a study of the vocabulary skills of pupils in secondary schools. He drew up word lists to show which non-technical words were inaccessible to pupils at various stages. He also examined the words and phrases which connect parts of a sentence and which give logical coherence to it (development of logical arguments are impossible without these logical connectives). He found that many words used frequently by science teachers were just not accessible to their pupils.

In Scotland, similar investigations were conducted and extended into higher education. The study by Cassels and Johnstone (1980) has shown that the non-technical words associated with science were a cause of misunderstanding for pupils and students. Words, which were understandable in normal English usage, changed their meaning (sometimes quite subtly) when transferred into, or out of, a science situation. For example, the word "volatile" was assumed by students to mean "unstable", "explosive" or "flammable". Its scientific meaning of "easily vaporized" was unknown. The reason for the confusion was that "volatile", applied to a person, does imply instability or excitability and this meaning was naturally carried over into the science context with consequent confusion.

White (1977) argues that learning involves the interaction of the information that the learner receives through his sensory system and the information that he or she already has available in his or her long-term memory. This enables the learner to recognize and organize the incoming information and make sense of it. Unfamiliar or confusing words and constructions come into conflict with the organizational process. White (1977) also emphasizes that the cognitive processes may be considered to involve the interaction of the components of memory: Working memory and long-term memory.

Language influences the thinking processes necessary to tackle any task. This is supported by the observations made by Cassels and Johnstone (1984). They note that memory span is not determined by the number of words but by the grammatical structures (for example, embedded clauses) that may themselves load the memory. They stress that the important factor in the sentence is its meaning while sentences with a negative implication require more of working memory capacity than do otherwise identical sentences lacking the negative.

The whole area of language, including the use of representational symbolisms, needs careful thought. Previous work has established the reality and nature of the problem. Language helps or hinders interactions with long-term memory but it also can be a source of significant information overload. Perhaps, this suggests that there has to be more opportunity for the learner to verbalize and discuss ideas as they are being presented. This would give opportunities for misunderstandings and confusions to become more apparent, allowing the learner to adjust thinking and clarify ideas (Cassels and Johnstone 1984).

Concept Formation

Chemistry learning requires much intellectual thought and discernment because the content is replete with many abstract concepts. Concepts such as dissolution, particulate nature of matter, and chemical bonding are fundamental to learning Chemistry (Abraham et al., 1992, 1994; Nakhleh, 1992).

Unless these fundamentals are understood, topics including reaction rate, acids and bases, electrochemistry, chemical equilibrium, and solution Chemistry become arduous. Therefore, inquiring into students‟ conceptions of the fundamental concepts in Chemistry has been a research focus of several researchers in many countries for the last two decades (Stavy, 1988; Peterson & Treagust, 1989; Quiles-Pardo & Solaz-Portoles, 1995; Ayas & Demirbas, 1997; Ayas & Costu, 2002; Calik et al., 2005).

Real understanding requires not only the grasp of key concepts but also the establishment of meaningful links to bring the concepts into a coherent whole. Ausubel‟s important work (1968) has laid the basis for understanding how meaningful learning can occur in terms of the importance of being able to link new knowledge on to the network of concepts, which already exist in the learner‟s mind. Concepts develop as new ideas are linked together and the learner does not always correctly make such links. This may well lead to misconceptions.

Conceptions or pieces of intellectual thoughts either reinforce each other or act as barrier for further learning. To overcome obstacles in students‟ conception, researchers have been focusing on identifying and assessing students‟ „misconceptions‟ (Helm, 1980), „alternative frameworks‟ (Driver, 1981), „children‟s science‟ (Gilbert et al., 1982), or „preconceptions‟ (Novak, 1977). These labels are attached when students‟ conceptions are different from the scientific ideas and explanations (Nakhleh, 1992; Taber, 2000; Nicoll, 2001; Ayas, Kose and Tas, 2002).

There have been enormous number of studies on misconceptions in Chemistry and there are several reviews of this area (Anderson, 1990; Stavy, 1991, 1995; Nakhleh, 1992; Gabel & Bunce, 1994; Wandersee et al., 1994). In addition, various studies indicate that student‟s difficulties in learning Science concepts may be due to the teachers‟ lack of knowledge regarding students‟ prior understanding of concepts (Driver & Easley, 1978; McDermott, 1984). Bodner (1986) makes a salutary point when he notes that, "We can teach-and teach well-without having the students learn".

Alternative conceptions may not be just students‟ fault. Chemical knowledge structures, for example, in "combustion", "physical and chemical change", and "dissolving and solutions" by their very nature lead to alternative conceptions argued Griffiths (1994). Students‟ conceptions are constrained both by the perceiver (learner) and the perceived (chemical phenomena). Thus, learning involves knowledge that needs to be restructured, adapted, rejected, and even discarded (Duschl &Osborne, 2002).

Various other studies have focused on students‟ concepts and their inter-connections. Fensham and George (1973) investigated problems arising from the learning of organic chemistry while Kellett and Johnstone (1974) indicated that students had little conceptual understanding of functional groups and their role. This caused difficulties with for example, esterification, condensation, and hydrolysis. Kempa and Nicholls (1983) found that problem-solving ability, above the algorithm level, depends on the strength of concept interlinking in a student‟s mind. They also found that a student‟s ability was dependent on context, such that individual students could do well in some areas and badly in others.

Bodner (1991) has listed several factors that may lead to misconceptions in the minds of learners. He notes the problems of rote learning where students possess knowledge without understanding. When the teacher first introduces an idea, the learner may already possess previous experience (derived from the world around, including the media), which leads to confusion. In addition, there is also the problem where the scientific language remains constant while the meanings of the terms change until they become misleading. Many research tools appear in the literature to identify students‟ misconceptions. Examples include the diagnostic tests developed by Treagust (1988) and Krishnan and Howe (1994).

While the literature is replete with papers, which provide evidence of misconceptions, fewer papers suggest potential remedies. It is worth recognizing that misconceptions will occur – learner does not come to the Chemistry lessons with empty minds. The process of learning Chemistry will involve the modification or alteration of previously held ideas and this is a natural process. It is individual in nature and there is no way by which the teacher has the time or capacity to approach each learner on an individual basis. However, in practice, if concepts are developed with care, building on the language and thought forms already present, while allowing concepts to be approached from several directions, the learner will be enabled to develop ideas more meaningfully. In addition, learners need the opportunity to "play with ideas‟, share ideas, verbalize concepts so that, in a natural step-wise fashion concepts steadily move forward on a secure base. This will allow alternative conceptions to be modified in an acceptable way. Nonetheless, misconceptions will always occur, even among those highly experienced in Chemistry (Bodner, 1991).

The whole area of misconceptions (including alternative frameworks and the ideas in constructivism) probably needs some re-thinking. It appears to be a natural part of the developmental process and it appears to be individually idiosyncratic. However, strategies can be adopted to take advantage of this natural process in the development of more secure concept understandings. A useful future line of research might be to explore the effects of strategies, which teachers might use to take advantage of this natural process in order to give the learners an enriched understanding of important concepts. Group work, dialogue and the exchange of ideas may all be very important in allowing misconceptions to be corrected effectively.

Motivation

There is no doubt that motivation to learn is an important factor controlling the success of learning and teachers face problems when their students do not all have the motivation to seek to understand. However, the difficulty of a topic, as perceived by students, will be a major factor in their ability and willingness to learn it (Johnstone & Kellett, 1980).

Students‟ motivation to learn is important but does not necessarily determine whether they employ a deep or a surface approach: Aspects of students‟ motivation to learn can be classified as either intrinsic (e.g. wanting to know for its own sake) or extrinsic (for example wanting to learn what is on an exam syllabus) (Entwistle et al., 1974). There is also a third class, called „a motivational‟ learning, which covers the situation where students do things (like attending lectures) without any conscious belief that this will help them learn anything (Vallerand & Bissonnette, 1992).

Resnick (1987) founds that students will engage more easily with problems that are embedded in challenging real-world contexts that have apparent relevance to their lives. If the problems are interesting, meaningful, challenging, and engaging, they tend to be intrinsically motivating for students. However, Song and Black (1991) indicate that students may need help in recognizing that school-based scientific knowledge is useful in real-world contexts.

White (1988) argues that the issue of long-term and short-term goals is relevant to the learning of science. The student who goes to lectures with short-term goals of passing examinations often has a specific approach to learning. Scientific laws and potentially meaningful facts are learned as propositions unrelated to experience. On the contrary, the students who have a stronger sense of achievement, or who want to learn about science, may attend the lectures with a long-term goal of a deeper understanding and appreciation of science. They may approach it involving advanced learning strategies of reflection and interlinking of knowledge. With the pace of normal lectures, there is unfortunately little opportunity for this to occur during the lectures. Ames and Ames (1984) have pointed out that students‟ motivations for learning from lectures have important consequences for what they are attending to, how they are processing information, and how they are reacting to the lectures.

In treating the existence of four motivational traits that are attributable to students‟ needs (Trumper, 1995), she introduced the notion of motivational pattern and implied that learners differ with respect to their preference for and responsiveness to different instructional features. She was also able to identify empirically the four major motivational patterns in her students sampled, and, accordingly, she classified students into four types: the achievers, the curious, the conscientious, and the sociable. Hofstein and Kempa (1985) followed this line of research and found that students of different motivational patterns have their preferred modes of learning as well.

Kempa and Diaz (1990) found that a high proportion of the total student population could be clearly assigned to one of the four motivational patterns. They went on to suggest that students with the conscientious or achievers type of motivational pattern would exhibit a strong preference for formal modes of teaching. Numerous other studies have sought to probe motivational features of learning (such as Ward & Bodner, 1993; Nakhleh & Mitchell, 1993). Together, they gave an insight into the vital importance of considering motivational features in a learning situation.

Reducing Obstacles to Learning

It is the aim of Chemistry teachers at all levels to make the subject accessible in such a way that maximum meaningful learning can take place. Salvaratnam (1993) has listed a number of important aspects to aid such learning.

These are consistent with two broad principles:

- the need to avoid working memory space overload which have been discussed in 2.1.2
- the importance of taking into account concepts already held. These ideas are explored now in some detail.

Paying Attention to Incoming Information

Learners have to focus on a specific task within a „noisy" environment (irrelevant material), but also, within the task, they have to select specific information that is relevant (meaningful) for them. Teachers can only really find out whether learners are paying attention to what they are learning (Ausubel, 1968). Learners need to know when and where to pay attention, and to what to pay attention.

Fox (1993) claims that attention is affected by the complexity of the task and the motivation of the individual. The focus of the learners" attention determines what information is processed. Learners can attend to only a very limited number of the demands that compete for their attention. Johnstone and Percival (1976) find that attention breaks do appear to exist and occur generally throughout lectures. The observer can detect such breaks relatively easily and those attention breaks appear as genuine loss of learning in subsequent diagnostic tests. A learners" ability to select the important information to attend to is a key strategy for effective learning. Selective or discriminatory attention has been shown to underlie learners" rates of learning.

Preparing the mind of the learner is one way to help students to focus their attention on the new information by linking it to their previous knowledge (the knowledge they already have and understand). This is discussed in more detail in Sirhan et al. (1999) where the use of pre-lectures is shown to be powerfully effective as a way to prepare the minds of learners, with special emphasis on those whose background knowledge and experience is less than adequate. Students who know more about a topic find it easier to identify and focus on important information. For this reason, carefully choosing the delivered material may greatly facilitate learning. This has been explored in detail in Sirhan (2000) and is outlined in Sirhan and Reid (2001, 2002).

Recalling Previous Knowledge Easily

To make the material easier for recall, learners actively need to construct, organize, and structure internal connections that hold the information together. The systematic organization of knowledge, which may be considered to be the ordering of the component knowledge items in a logical, coherent, concise, and principle-based manner, is of fundamental importance for effective learning, recall, manipulation, and use of knowledge.

Salvaratnam (1993) asserts that effectiveness of knowledge organization is increased if the:

(i) knowledge stored in memory is principle/concept based, coherent, systematic and concise.

(ii) organization is around the minimum amount of essential knowledge (number of principles and concepts).

This latter point is one that has been confirmed in very recent work (Otis, 2001). It has been found that the concept maps generated by medical students at various stages in their learning shows that many students move from a simple, but inadequate, concept maps at early stages of learning through increasingly complex maps until they move back to much simpler but more adequate maps when concepts have been grasped much more fully. It is, therefore, important that unnecessary principles, concepts, definitions, and terms being excluded as concepts are built up in the minds of learners.

Salvaratnam (1993) also listed five aspects, which would aid the learning, understanding, recalling, and application of knowledge.

The steps are provided below:

- use the underlying principles and concepts as the sole basis for knowledge organization;
- exclude unnecessary laws, concepts, definitions, and terms;
- use systematic and meaningful terms and definitions ;
- link the component items of knowledge sharply and coherently; and
- store knowledge concisely.

These steps could help to reduce memory overload, aid learning and understanding, and avoid mistakes. In this complexity, and because knowledge construction is not easy, students often are tempted to engage in rote learning rather than meaningful learning. Learners need to decide on the level of complexity at which they will process new information. For example, a student can take notes and either writes them as key words or makes connections between this information and the previous knowledge (Su, 1991). The more elaborative or complex the learner"s processing of the information, and the more he tries to make meaningful the new information, the more likely he is to remember it. This could be done by giving different examples on the same problem and making interconnections between it and the learners‟ knowledge to facilitate memorization.

Conceptual Understanding of Chemical Representations Using Technology

Many students have difficulty learning symbolic and molecular chemical representations. This review brings out how students develop their understanding of chemical representations with the aid of a visualizing tool, e-chem, that allows them to build molecular models and view multiple representations simultaneously.

According to Gabel, Samuel and Hunn (1987) there are three levels of understanding in Chemistry: macroscopic, microscopic and symbolic. Complimentary research to Gabel et al‟s work (for example. Ben-Zui, Eylon & Silberstein 1986) has shown that learning of microscopic and symbolic representations is especially difficult for students, since these representations are invisible and abstract while students‟ understanding of Chemistry relies heavily on sensory information. Visualizing with e-chem refers to the ability beyond the perception of seeing. When students visualize a molecular structure, they can generate its chemical meanings beyond the lines, dots and symbols shown on paper.

Chemical representations are the elements of chemistry language (Hoffman & Laszlo, 1991); chemists use them to communicate with colleagues and to do science inquiry (Chin, Russell & Marx 1997). However, the literature indicated that most students are unable to visualize the microscopic and symbolic representations as experts to do and are incapable of completing the model – to – formula translations (Keig & Rubba, 1993).

Research supports the advantages of manipulating physical models that include helping students to visualize invisible atoms and molecules, and promoting long term understanding (Copolo & Hounshell, 1995; Gabel & Sherwood, 1980).

Technological tools that integrate multiple representations provide students with opportunities to visualize chemistry and promote conceptual understanding. The use of multiple, linked representations help students understand equilibrium and its related concepts. The e-chem guides students to carry out three main actions: that is to construct, visualize and analyse structure. The construct function allows students to create organic molecular structures, view them from all possible angles and manipulate them more easily than physical ball – and – stick models (Copolo & Hounshell).

The Constructivist View of Learning

Constructivist view of learning is developed based on personal construct and learning based on what the learner knows (Grasbowski, 2004 as cited in Jonassen, 2005). Furthermore, one of the earliest psychologists who focused on children‟s thinking process is Jean Piaget. According to Piaget (1970), knowledge is constructed in learners‟ mind through their interaction with the environment. According to Heron (2000), Piaget believes that there is a biological inevitability to how children develop. Furthermore, according to Bodner (1986), there are three concepts of Piaget‟s work which are related to constructivist theory of knowledge. These are assimilation, accommodation, and equilibration. Therefore, Piaget‟s work had some insight (Heron, 2000). These are:

- children think differently related to their stage of development.
- learning requires active involvement between children and their environment.

- children construct their own cognitive structures.

Therefore, Piaget‟s work is important in the constructivist theory of learning.

Constructivist view of learning is different from the traditional view. The traditional view is focused on instructional goals such as recalling facts, generalization, defining concepts and performing procedures" (Scerri, 2003). Therefore, this view ignores the existing prior knowledge of the individual. On the other hand, constructivists view learning as the product of interaction between existing understanding and new knowledge (Christie, 2005). Furthermore, according to Prawat (1996), there are three types of constructivism which are personal constructivism, radical constructivism and social constructivism. Personal constructivism focuses on the prior knowledge of individual which can be constructed by individual. On the other hand, radical constructivism focuses on students‟ knowledge based on their experiences which recognize students‟ freedom to have their own ideas. Social constructivism focuses on the way the individual construct knowledge through interaction with the environment. However, in general, constructivists "emphasize reasoning, critical thinking, social negotiation, self regulation and mindful reflection" (Barrow, 2005). Furthermore, constructivists view learning as an active process in which the learners actively construct knowledge as they try to comprehend their reality world. According to Duit and Treagust (2003), there are six characteristics of the constructivist theory of learning which are:

- learning is not only dependent on the learning environment, but also the knowledge of the learners.
- learning involves the construction of meaning.
- construction of meaning is a continuous and active process.
- meaning, once constructed, is evaluated and can be accepted or rejected.

- learners have the final responsibility for their learning.
- students construct meaning between the experiences with the physical world through natural language.

Constructivism as a theory of learning is very useful to apply in the classroom. One important aspect that can be developed through the constructivist approach is that learners use the Active process to develop their own meaning and knowledge (Jonassen, Mayes & McAleese, (1993). As a result, the learning process will be the meaningful experiences for the students. However, according to Prawat (1996) as cited in Treagus & Duit (2003), there are four beliefs which are challenges and debates on constructivism, which are:

- learner and content are separated,
- tendency to equate activity with learning,
- limited research evidence,
- fixed curriculum.

Moreover, there are several challenges using the constructivist theory. Firstly, it is time consuming, because it needs more time to use the strategies which can monitor the construction of each student"s knowledge. Secondly, some students could have difficulty to take responsibility for their own learning. For example, if the learners do not take responsibility for learning such as self management, they will find this approach difficult. Therefore, it is important for teachers to be motivated and also be creative to apply this approach in the classroom. Moreover, applying the constructivist learning in the classroom also encourages teachers to shift their paradigm from replicating knowledge into the construction of individual knowledge.

The Role of Practical Activities in Lesson delivery and Concept Formation

Practical activities play various kinds of indispensable roles in translating most abstract ideas into simple and concrete forms. Advocates of Chemistry practical activities contend that it is advantageous for students' acquisition of scientific knowledge and methods of science teaching as well as students' acquisition of scientific skills and motivation. The literature pertaining to each of these reasons is extensive and conflicting as there are arguments supporting and refuting each of the rationale that has been stated. This is because Chemistry Practical has been accepted as part of the science curriculum for the Ghanaian Colleges of Education by the MOE and IEUCC. As indicated in the 2006 New Educational Reform Implementation Document, it is expected that practical work should promote cognitive and social competencies as well as affective dispositions (Ministry of Education, 2006). A key issue in the reform efforts of the Ministry of Education (MOE) and the Ghana Education Service (GES) aims at promoting the learning of science in all schools and colleges including teacher training institutions by providing students with equal opportunity to engage in Science Practical work. It is, therefore, expected that allowing students to experience the process of scientific enquiry can develop understanding of science and its nature. Practical work is, therefore, an integral part of the science curriculum in the selected colleges of education for science study in Ghana. Literature from earlier studies, however, shows that the use of experiments as a means for verification of previously studied facts, and the use of laboratory as the focus of the learning process where experiments are presented as problems to which answers are to be sought characterized most of the practical works in the past. This situation was considered as not helpful to both teachers and students, hence the need for a total review. Presently, there seems to be a growing concern that although faced with many challenges, the laboratory cannot be disposed of entirely; its role in science education should be reassessed. As already noted, analysts differ in their opinions about the role of practical activities because of their different views about learning theory (Ross & Lewin, 1992). According to Woolnough (1998), one way of looking at science practical activities is to categorize them broadly into those related to developing practical skills and those related to discovering or explaining theory. The latter makes use of structured experiments linked to theory.

It seems that much of what is said about practical work stems from the view about the use of the enquiry approach to teach science. In reality, what practical work does is simply to reproduce a phenomenon, which has already been established (Millar, 1998). Essentially then, according to Millar (1998), whatever teachers may say about why they conduct practical work, the real purpose of practical work done in schools is to try to "encourage students to make links between things they can see and handle, and ideas they may entertain which might account for their observation" (p.34). Practical work that is intended to support the teaching and learning of scientific knowledge has to be understood, and judged, as a communicating strategy. Science practical work may therefore involve illustrations of a phenomenon; providing experiences or getting a feel for phenomenon by students.

Learning Difficulties in Stoichiometry and Proposals for Alternative Concepts for Teaching

Many studies on stoichiometry deal with students" misconceptions (for example Mitchell and Gunstone, 1984; Schmidt, 1990; Huddle and Pillary, 1996; BouJaoude and Barakat, 2000). The main findings are that students:

- equate the mass ratio of atoms in a molecule with the ratio of the number of these atoms, and the mass ratio with the molar mass ratio (Schmidt, 1990),

- calculate the molar mass of a given substance by summing up the atomic masses and then multiplying or dividing this sum by the coefficient of the substance in the chemical equation; others do not understand the significance of the coefficients in a chemical equation at all (BouJaoude and Barakat, 2000),
- confuse the concepts of conservation of atoms and possible non-conservation of molecules or do not take into account the conservation of atoms or mass at all (Mitchell and Gunstone, 1984),
- cannot determine the „limiting reagent" in a given problem, when one substance is added in excess (Huddle and Pillay, 1996),
- confuse or do not know the definitions of and relationships between stoichiometric entities in general (Furio, et al., 2002).

Other studies took closer look at students" approaches to solving stoichiometric problems. In a large scale study in the 1990s, Schmidt (1994) found out that German students mostly used three different strategies to solve stoichiometric questions that can be solved without arithmetical calculations and without a calculator:

a. strategy using explicit calculation of the amounts of substance („mole method"),

b. strategy avoiding explicit calculation of the amounts of substance and instead using the ratio of molar masses („proportional method") and

c. strategy using mere logical reasoning („logical method").

Interestingly, the large majority of the students used the „logical method" (c) and (b) Schmidt concluded that this was due to the fact that the given problems were easy to calculate. This was collaborated by a more recent interview study with a small sample of Swedish students, Schmidt and Jigneus (2003). They found that, for easy-to-calculate problems, the participating students also used the „logical method‟ but switched to a mathematical strategy, for example (a) or (b), when confronted with a more complicated task. However, a study conducted in Hungary produced totally different results (Toth and Kiss, 2005). The Hungarian Secondary School students participating in this study almost never used the logical method but the mole method (most often), or the proportional method. According to the authors, this might be due to the fact that the mole method is the one taught in Hungarian schools most prominently. On the other hand, the German students participating in Schmidt‟s study had more chemistry lessons than the Hungarian students and were older in general. So they can be seen as relative experts compared to the Hungarian students and thus develop a logical method more easily.

In another study, BouJaoude and Barakat (2003) investigated the relationships of students‟ problem solving strategies in stoichiometry to their conceptual understanding and to their learning approaches as defined by (Entwistle & Ramsden, 1983). Based on the results that indicated a connection between sound conceptual and procedural knowledge and successful problem solving, they administered a learning approach questionnaire and a stoichiometry test, partially followed by unstructured interviews, to forty Lebanese students. Through the stoichiometry tests and the unstructured interviews, they found many of the misconceptions described in earlier studies. They derived three main strategy types from the tests and the interviews.

a. Correct strategies, which were subdivided into „algorithmic‟, „efficient‟ and „messy‟ strategies,

b. Incorrect strategies, subdivided into „incorrect strategies-incorrect answer‟ and „incorrect strategies-correct answer‟ and

c. „Incomplete‟ strategies.

As the authors stated, the majority of students participating in this study used algorithmic problem solving "even when they did not have adequate understanding of the relevant concepts" (pp. 24-25). In contrast to results in the literature, they did not find a correlation between the factors „learning approach‟ and „conceptual understanding‟. Furthermore, they did not find any patterns in the problem solving strategies used by students with different learning approaches.

In another study conducted by Frazer and Servant (1986, 1987) on titration calculations, the authors investigated which one of four possible expert methods were used by students solving two titration calculation problems. Three of the four methods were similar to those reported by Schmidt (1994) if one transfers the methods to this kind of problem:

- a method deriving the reaction stoichiometry from the balanced chemical equation and using direct calculation of amounts of substance.
- a method avoiding calculation of amounts of substance and instead using proportion equations.
- a method immediately converting the reaction stoichiometry into the quantities given in the text and continuing by using the „unitary method‟ (see also Williams, 1980).
- a method using the „quantity calculus‟ and selecting and rearranging equations (see also Packer, 1980).

In the same study of a sample of 244 students, only 79 written answers given to the two titration problems were correct. Most of the students used methods (1) to solve the problems, but less than a quarter of these responses were correct. Method (2) was the second most popular, but with poorest success. Method (3) was only used by a few students on the first problem. Method (4) was not used by any of the students. Although the results were poor in general, the authors came to the conclusion that using the second strategy was least recommendable since students only had to “fill in the blanks”. In contrast, using method (1) may lead to an interlinked understanding of the chemical concepts.

The authors of all these studies give general advice on how to overcome the learning difficulties in the field of stoichiometry. Furthermore, some authors have developed alternative approaches on how to introduce subjects of stoichiometry in school. In Germany, Rossa (1998) for example, suggested visualization of the complex and the abstract entity of „mole". Kaminski et al. (1994) developed a unit for introducing the chemical formula, setting aside the whole mole-concept and providing students with a table listing how many atoms one milligram of an element contains instead of giving them the molar masses. According to the authors, introduction of the mole-concept should be postponed. In other countries, similar proposals were made. These can be classified into those which focus attention on conceptual prerequisites; those which use new analogies; and those which emphasize applications (Furio, et al., 2002).

CHAPTER THREE

METHODOLOGY

Overview

In this chapter, the methodology of the study is discussed. The research design, which is in two phases, describes how the researcher intended to conduct the research. The initial phase involved collection of data on the learning difficulties of Chemistry students in the Science Colleges of Education through survey questionnaires from the students. This was followed by collection of data on tutors. The population of the study was made up of 15 science colleges of education in Ghana but two were sampled for the study. The questionnaires surveyed both tutors‟ and students‟ opinions about the leaning difficulties of chemistry students. This was pilot tested and later fine tuned to establish its reliability. Finally, the data collected were analyzed qualitatively to establish the learning difficulties of Chemistry students in the science colleges.

Research Design

The design of a study gives accurate picture of events and assists in explaining people‟s opinion and behaviour on the basis of data gathered at a point in time (Polit & Hungler, 1995). This study is a descriptive survey and is in two fold. It followed a single method design using qualitative technique.

Creswell (1994) and Hogan (1999) indicate that survey involves collection of data by means of tests, questionnaires, observations, interviews and examination of documents. In this study, questionnaires were administered to both tutors and students. The researcher established a rapport with the authorities in order to obtain permission to arrange for a convenient day to sample out respondents.

Hundred (100) students and four (4) tutors were sampled for the study; Fifty (50) students and two (2) tutors were sampled from the two science colleges of education for the study. These selections were done using simple random sampling procedure. This was followed by administration of questionnaires to both tutors and students, there after, students‟ responses were collected and analyzed. Tutors‟ responses to the questionnaires were also collected and analyzed.

As earlier on indicated by Polit and Hungler (1995) that the design gives accurate picture of events and assists in explaining people‟s opinion and behaviour on the basis of data gathered at a point, students‟ and tutors‟ responses were analyzed using SPSS (statistical package for social sciences). The qualitative component of this methodology also made it possible to identify the variables and appropriate statistics to be used for data analysis (Creswell, 1994; Hogan, 1999). The descriptive survey design was employed by the researcher in the study because it helps in analyzing research questions more effectively, and also has the advantage of gathering information from a large number of sources, relatively cheaper and at relative short time. It may be broad or narrow in scope, encompassing several countries or be confined to only one national, local education authority or school (Norman, 2000). In addition, descriptive survey helps to generalize from a sample to a population so that inferences could be made about some characteristics or behaviours of the population (Osuala, 1991). Osuala (1991) again noted that descriptive surveys are “versatile and practical, especially to the researcher in that they identify present needs” (p. 181). According to Best & Kahn (1995), descriptive survey is concerned with the conditions of relationships that exist, such as determining the nature of prevailing situations, practices opinions that are held, processes that are going on or trends that are developed. Descriptive research is highly regarded by policy makers since data gathered by way of descriptive survey represents field conditions (Osuala, 1991). However, there are some problems that face descriptive survey. These include, ensuring the questions to be answered are clear and not misleading; getting respondents to answer questions thoughtfully and honestly and getting sufficient number of questionnaires completed and returned so that meaningful analysis can be made (Wallen & Frankel, 1998). Despite the short comings identified, the descriptive survey design was used because it has the potential for providing a lot of information from sample of individuals. The design was considered useful in generating data that facilitated the determination of the visions learning difficulties students‟ faced in chemistry in the science colleges of education.

Population

The population was made up of the number of science students in 2 colleges of education out of the 15 designated to pursue quasi-specialist science programme in Ghana. Science students in their first and second year were used for the study.

A total of one-hundred and forty-nine (149) students and twelve (12) tutors in two (2) science colleges of education formed the population for the study. Out of this, a total number of one-hundred (100) science students made up of thirty (30) females and seventy (70) males and their four (4) chemistry tutors made up of only males were sampled.

For the purpose of this study, the science colleges were assigned code names for anonymity and convenience during data collection. This further helped to eschew the practice of using names of colleges which are sometimes too long to use in tables. In addition, it was also considered as a contradiction of ethical issues on treating respondents and their participating colleges with some level of anonymity.

Sampling

A sample is a smaller group which is drawn from a larger population and studied. The two main types of sample are probability and non probability samples (Dunn 1999). Probability sample is the type where every member of the population has equal opportunity to be selected into the sample. The types of probability samples are; simple random, systematic and stratified samples. Non- probability sample is the type that deliberately represents a particular group in the wider population. Cohen & Manion, (1994) noted that non-probability samples are less complicated to set up.

He type of sample chosen for this study was purposive sample which was a non-probability sample. Non-probability sample was used because the sample deliberately represented first and second year chemistry students (elective science students) of the two science colleges of education under study. This sample type focused on selecting participant whose study would illuminate the questions under study (Patton, 2002). It was also considerably less expensive to use and was perfectly adequate since the findings would not be generalized beyond the sample.

According to Cohen, Manion and Morrison (2003), purposive sampling is the selection of sample on the basis of their judgment of their typicality or possession of the particular characteristics being sought.

A sample of one-hundred (100) first and second year students were used for the study. Also, four (4) Chemistry tutors were selected for the study. The researcher spent a substantial amount of time in the natural setting of the study to have intense contact with the participants to enable easy data collection.

Reasons for choosing first and second year elective science students for the study were that, at the time of data collection, the third year students were on internship. The first and second year students offering elective science had little expertise or knowledge in Chemistry, since they had studied elective Chemistry for only one semester or more at the time of the data collection.

Data Collection Techniques

Various techniques were employed in this study to improve the quality of the outcome of the study, and these have been explained below. The science laboratory classroom environment inventory developed by Fraser, Mc Rabbie and Giddings (1993) served as a guide for the researcher to develop the questionnaires on learning difficulties in Chemistry. The instrument developed by Frazer et al. (1993) was itself based on the individualized classroom Environment Questionnaire and the classroom Environment Scales.

Among the various instruments, the researcher decided to use questionnaire to elicit responses from the respondents. This the researcher did with the view that the students would give adequate information about their learning difficulty. Other aspects of the questionnaires had been self-designed by the researcher after a small-scale investigation carried out earlier in some science colleges of education. This approach was easier for the researcher due to his experience as a science tutor in one of the Science Colleges of Education. This was also to ensure that major areas of concern to teachers about students" learning difficulties in chemistry were addressed in the formulation of the questions by the researcher.

The respondents could complete the questionnaires at their own convenience which might avoid biases caused by the presence of the researcher.

Two sets of questionnaires were used; one for tutors and the other set for the students. The questionnaires were designed using both open and close ended methods. The closed-ended aspects were mostly based on verbal frequency scale types (Alfred & Settle, 1985). The format for this is fairly similar to Likert scale which has words that indicate how an action has taken place (for example from Strongly Disagree to Strongly Agree"). Other parts of the questionnaire also included biographical and academic information on all categories of respondents at the college of education.

Reliability

The reliability of a research instrument is the consistency of the instrument producing similar results given the same conditions on different occasions. Yin (1994) views reliability as the extent to which data are consistent, accurate and precise.

Two questionnaires were used to collect the data, one for chemistry tutors, and the other for the elective science students. The questionnaires were piloted on a sample of the population to be investigated before its final use. The piloting of the questionnaires was pre-tested in one college of education. This was to enable the researcher test how long it would require respondents to complete the questionnaire. The purpose of piloting was to ensure that loose knots were tightened to ensure that the respondents did not have difficulties in completing the questionnaire.

Validity

A questionnaire can be reliable if it can be a valid measure. Researchers are, therefore, concerned with the extent to which the research instrument measures what it is expected to measure.

The expertise of my supervisor and some science education lecturers as well as some of my colleagues in the Science Department, University of Education Winneba, were drawn on to validate the questionnaires and to ascertain both content, face and construct validity of the questionnaires. The responses of the tutors, in particular, were to improve on the questions. These processes led to a refinement and fine tuning of the questionnaires.

Ethical Issues

To ensure proactive participation of the selected respondents and their respective institutions, the researcher ensured confidentiality of their information and opportunities that were offered to them in this study. Official permission with an introductory letter from my Head of Science Department at University of Education, Winneba, was also used as evidence to win their trust. In order to maintain privacy, names were not used in connection with the responses. Instead, code numbers and code names were assigned to each participant and their respective participating colleges for easy analysis of data. After collection of the data and analyses, the researcher rounded off activities by expressing gratitude to all respondents and college authorities for their commitment in all activities.

Data Collection Procedure

Research questions were answered through separate questionnaires for students and their chemistry tutors. Each questionnaire had items on the following: Biographic data, learning difficulties faced by Chemistry students, chemical representation using technology, students‟ alternative conceptions in Chemistry, acquisition of students‟ practical skills, organization of Chemistry practical activities, availability of facilities and communication problems arising from language.

The recovery rate was 100% in both cases. This was because the questionnaires were handed over personally by the researcher and collected after students had finished responding to them the same day. Tutors were also given similar treatment.

Data Analysis Technique

A descriptive analysis using simple percentages was used to address the five (5) research questions. Data were analyzed by making use of the research questions. This was done systematically by selecting research questions using the responses from the questionnaires. This continued until all the research questions and responses for both questionnaires were exhaustively dealt with.

Each questionnaire was given a code name or number to facilitate easy identification. For example students‟ questions were coded from S_1 – S_{100} and tutors‟ from T_1 – T_4. The questionnaires were subjected to quantitative analysis using SPSS. The information obtained from the responses was put into the package for easy analysis.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

Introduction

In this chapter, the analysis of data from questionnaires administered to both tutors and students have been presented. Data presentation and analysis are in two major parts; the first part comprises presentation and analyses of students‟ academic qualifications and the courses offered at the Senior High School level. This was followed by analyses of tutors‟ academic qualifications and subjects taught at the College of Education level. The second part also comprises the analyses of both students‟ and tutors‟ responses based on the test items in the questionnaires in line with the research questions.

Part 1

In this part, five items have been analyzed for students and three for tutors. These items include the analysis of students‟ academic qualification. Items analyzed include science subjects offered at Senior High School, reason for offering chemistry, grade obtained in Chemistry, best science subject and reasons for choosing the best science subject. This was followed by analysis of tutors‟ academic qualification, area of specialization in science and challenging topics encountered during teaching.

Academic Information on Students

The sample of the students comprised 70 males and 30 females whose academic information are presented and analyzed in this part of the study. Item 1 of part 1 of questionnaires administered to students are analyzed and information obtained is presented in Table 1. This item was designed to find out the number of students who offered elective science in the Senior High School.

Table 1. Science subject offered by students at the senior high school.

Category	Number of responses	Percent (%)
Chemistry only	7	7.0
Chemistry, Biology, Physics	62	62.0
General agric, horticulture & crop, chemistry	7	7.0
Chemistry, Biology, agric science	4	4.0
Chemistry, agriculture science, animal husbandry	1	1.0
Agric Science only	11	11.0
Integrated Science only	3	3.0
Chemistry, biology, mathematics	2	2.0
Chemistry, physics, mathematics	3	3.0
Total	100	100.0

Source: Field Data

From table 1, it is observed that 62% of the students indicated they offered Chemistry, Biology and Physics in the Senior High School. It was also realized that 11% took only Agricultural Science.

Those students who offered only Chemistry are 7%. Another 7% offered General Agriculture, Horticulture and Crop and Chemistry. It was also noted that 4% of the students took

Chemistry, Biology and Agricultural Science. Those who offered Integrated Science only are 3% while another 3% offered Chemistry, Physics and Mathematics. The students who offered Chemistry, Agricultural & Animal Husbandry are 1% whiles another 1% took Chemistry, Biology and Mathematics. It was also observed that 4% of the students offered Chemistry, Physics & Mathematics. Based on the responses given, it could be noted that majority of the students representing 62% offered all the three elective science subjects which is a basic qualification to offer elective science in the Colleges of Education.

Item 2 requested the students who offered chemistry at the Senior High School to give their reason for offering Chemistry.

Table 2. Reasons for offering Chemistry

Category	Number of responses	Percent (%)
It forms major part of the science course	26	26.0
In order to become a medical doctor, chemist or biologist.	11	11.0
It is a subject of interest to me	14	14.0
It was made compulsory in their school	18	18.0
It is a practical course	23	23.0
No reason for offering the subject	8	8.0
Total	100	100.0

Source: Field Data

From table 2, 26% of the students took Chemistry because it forms major part of the science course. Those who offered Chemistry because it is a practical subject formed 23% of the respondents. The students who took Chemistry because it was made compulsory are 18%. Also 14% of the students offered Chemistry because of their interest in the subject. Those who took Chemistry because of its career related jobs formed 11% whiles those with no reason for offering Chemistry at the senior high level were 8%. It became obvious that about 48% of the students who offered Chemistry had some motivation to do so.

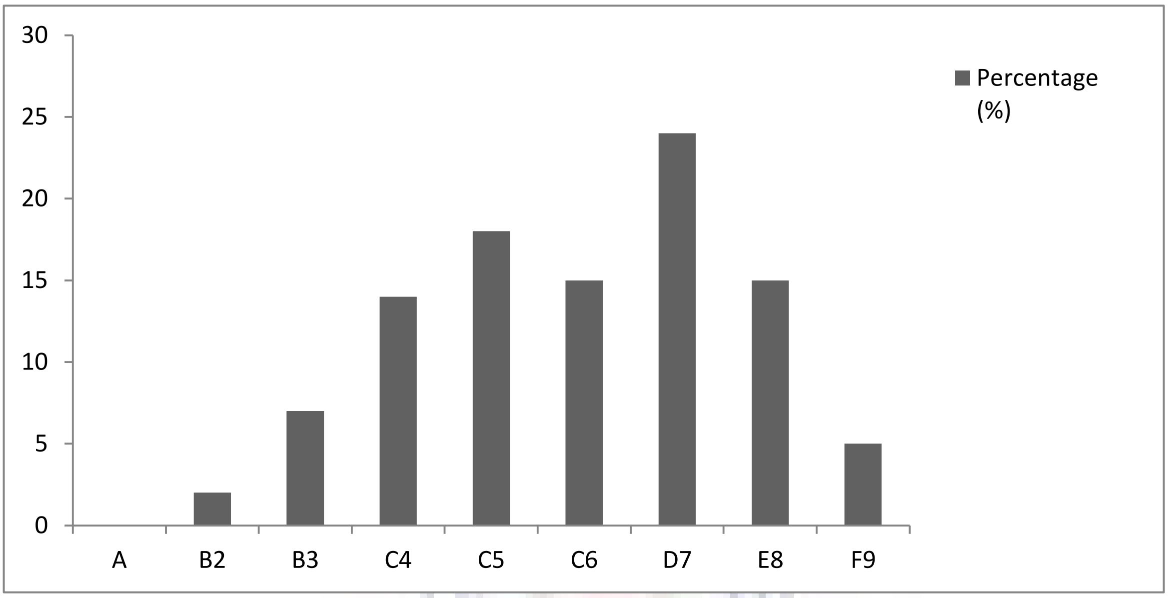
The grades obtained in Chemistry at the Senior High level were also considered in the study. The responses are presented in Table 3 below.

Table 3. Grades obtained in Chemistry at WASSCE

Category	Number of responses	Percent (%)
A	0	0.0
B2	2	2.0
B3	7	7.0
C4	14	14.0
C5	18	18.0
C6	15	15.0
D7	24	24.0
E8	15	15.0
F	5	5.0
Total	100	100.0

Source: Field Data

Figure 1. Pictorial View of Grade Obtained in Chemistry at WASSCE



Source: Researcher's Own Construct

The responses from the students indicate that none of them had grade A in Chemistry at the senior high level. Those who had grades B2 and B3 formed only 7% of the students. Those that had grades C4, C5 and C6 are 47%. The responses from the students also indicate that 24% of the respondents had grades D7. Fifteen percent (15%) and 5% of the students had the least grades E8 and F respectively. Generally, on the grades obtained in chemistry by students at the senior high school level which was used to gain admission into the Colleges of Education was average. This formed about 47% of the students. Also 38% of the students had weak grades in chemistry, and 5% failed completely.

It is likely those who had weak grades or failed may not have interest in chemistry and this is likely to influence their study of chemistry at the college level.

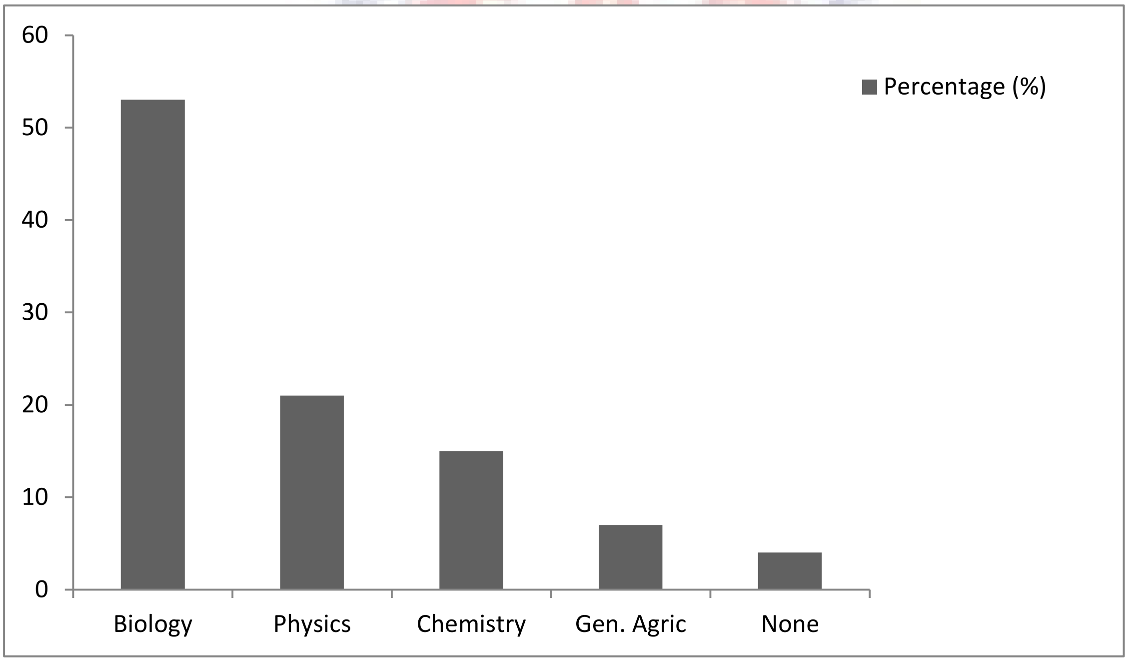
Item 4 requested students to identify their best science subject at the senior high school. Responses given by students are represented in Table 4.

Table 4. The best science subject at the senior high school

Category	Number of responses	Percent (%)
Biology	53	53.0
Physics	21	21.0
Chemistry	15	15.0
General agric	7	7.0
No best subject	4	4.0
Total	100	100.0

Source: Field Data

Figure 2. Graphical View of Best Science Subject at the Senior High School



Source: Researcher's Own Construct

From Table 4, 53% of the students indicated Biology as their best science subject. Those who indicated Physics as their best science subject are 21%. Also 15% of the students indicated Chemistry as their best science subject, whilst only 7% of the students chose Agricultural Science as their best subject. However, 4% of the students had no best subject. It became obvious that Chemistry is not the students‟ best science subject and this may also affect their interest in the study of Chemistry.

Academic Background of Tutors

Under this subheading, three items were presented and analyzed. In items 1 and 2 tutors were asked to indicate their academic qualifications and area of specialization in science. In item 3, the tutors were asked to indicate the challenging topics encountered during teaching.

In item 1, three tutors indicated that they had Bachelor of Education (B. Ed) in science whilst one had Master of Philosophy (M.Phil) in science. It could be generally observed that currently only one tutor had the basic qualification to teach in the College of Education. However, in the near future those with first degrees would be required to acquire their master‟s degrees to enable them continue to teach in the Colleges of Education.

In item 2, 1 tutor specialized in physics, 2 in Chemistry and 1 in Biology. It is therefore, clear that though 4 tutors teach Chemistry, 2 of the tutors did not specialize in Chemistry.

In item 3, four (4) tutors indicated the following topics as their challenging topics:

- the mole concept
- titrimetric analysis
- coordinate bonding
- writing and balancing of chemical equation
- rates of reaction
- bond polarity.

Part II

In this part, responses to students‟ questionnaire were presented followed by the responses given by their tutors. The responses are dealt with in different sections based on the five research questions.

Responses of Students

Responses of the students are presented based on the items in the questionnaire under the five research questions.

What problems do students encounter in learning Chemistry?

The above question was designed to find out problems students encounter in learning Chemistry and if possible give suggestions to address the problems.

Eight items were grouped to enable the above research question to be answered. Each item had four options to be chosen from.

The first item under this question demanded students to indicate whether Chemistry is perceived to be difficult. The responses are represented in Table 5 below.

Table 5. Students' perception of Chemistry as a difficult Subject

Option	Frequency	Percentage (%)
Strongly Disagree	8	8.0
Disagree	12	12.0
Strongly Agree	36	36.0
Agree	44	44.0
Total	100	100

Source: Field Data

From Table 5, Majority of the students representing 44% agreed Chemistry to be a difficult subject. Also, 36% of the students strongly agreed to the statement. It is clear from the table that 20% disagreed that student‟s perceived Chemistry to be a difficult subject. It shows from the table that majority of the students representing 80% perceived Chemistry to be difficult. The perception of the majority of the students that Chemistry is difficult may have negatively affected the way the subject was studied, since their interest may not be there.

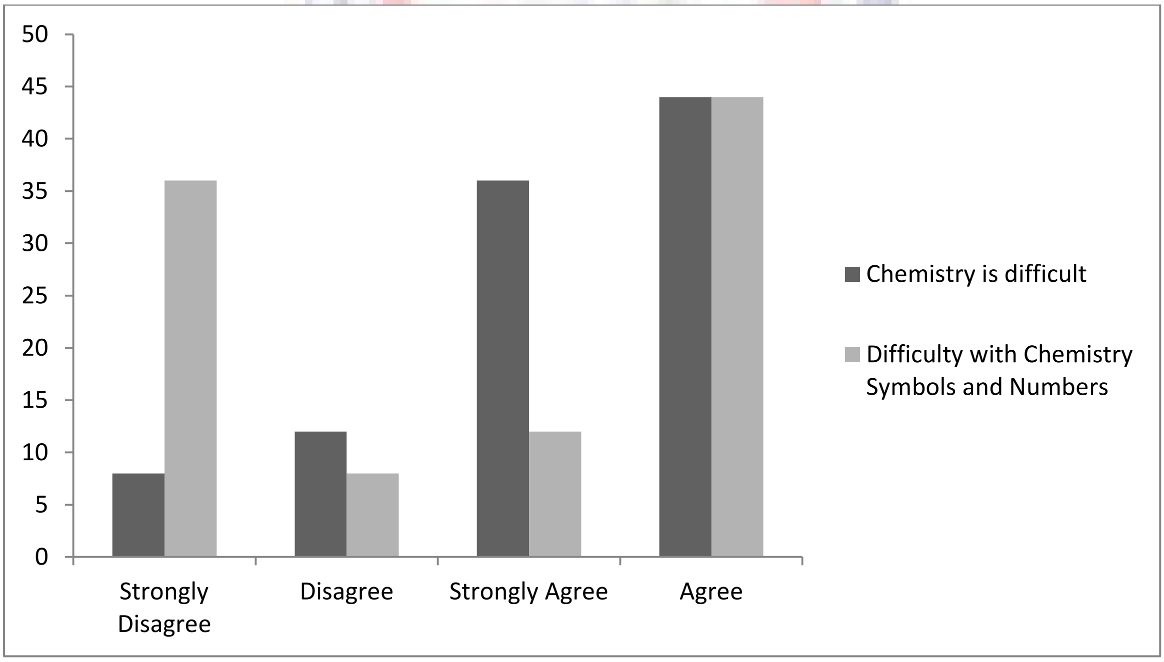
Item 2 was to find out whether students find it difficult solving questions involving symbols and numbers in Chemistry. The results of this are presented in Table 6.

Table 6. Students' find it difficult solving questions that involve symbols and numbers in Chemistry

Option	Frequency	Percentage (%)
Strongly Disagree	36	36.0
Disagree	8	8.0
Strongly Agree	12	12.0
Agree	44	44.0
Total	100	100.0

Source: Field Data

Figure 3. View of Students who see chemistry as well as chemistry Symbols and numbers as Difficult



Source: Researcher's Own Construct

From Table 6, Almost 56% of the respondents agreed that it is difficult solving questions involving symbols and numbers in Chemistry. However, 44% of the students disagreed to the statement. It is clear from the table that more than half of the student, representing 56% find it difficult solving questions involving symbols and numbers in chemistry. Probably their background in Mathematics may be weak and this could have accounted for their difficulty.

Item 3 intends to find out whether students memorize concepts in Chemistry without understanding them. The responses are presented in table 7

Table 7. Students memorize concepts in chemistry without understanding them

Option	Frequency	Percentage (%)
Strongly Disagree	16	16.0
Disagree	8	8.0
Strongly Agree	8	8.0
Agree	68	68.0
Total	100	100.0

Source: Field Data

From Table 7, 76% of the respondents agreed that they memorize concepts without understanding them whilst 32% disagreed with the statement. It is, however, clear from the table that majority of the students accept that they often memorize concepts without understanding them. This may also account for one of their difficulty in studying Chemistry.

In item 4, students were required to indicate whether topics treated in a semester are too loaded. Responses given on this item are presented in Table 8.

Table 8. Load of work in chemistry in a semester

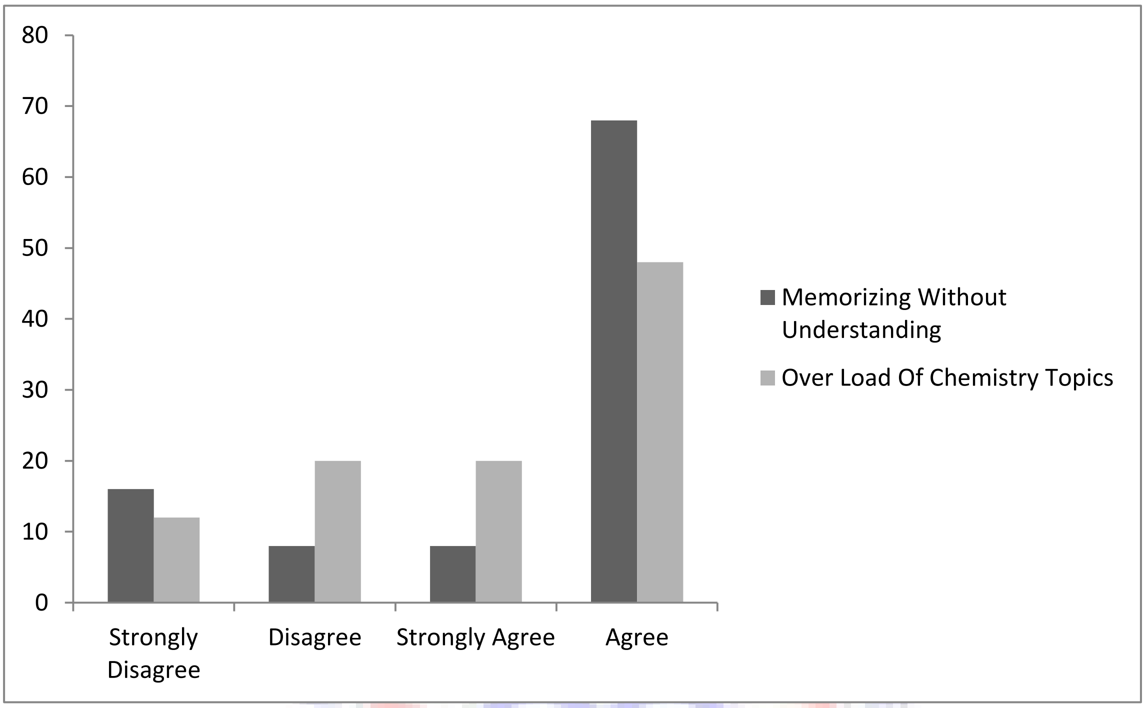
Option	Frequency	Percentage (%)
Strongly Disagree	12	12.0
Disagree	20	20.0
Strongly Agree	20	20.0
Agree	48	48.0
Total	100	100.0

Source: Field Data

From Table 8, it could be observed that 68% of the students agreed that topics to be treated are too loaded. However, 32% of the students disagreed to the statement. Majority of the students (68%) claimed that the Chemistry syllabus is too loaded.

Students were asked in item 5 whether they had difficulty in understanding the meaning of vocabularies and terms used in teaching Chemistry. Responses on this item are presented in Table 9.

Figure 4. Pictorial View of Students who Memorize without understanding as well as Work Over Load in Chemistry



Source: Researcher's Own Construct

Table 9. Difficulty in understanding the meaning of vocabularies and terms used in teaching chemistry

Option	Frequency	Percentage (%)
Strongly Disagree	0	0.0
Disagree	16	16.0
Strongly Agree	32	32.0
Agree	52	52.0
Total	100	100.0

Source: Field Data

From Table 9, 84% of the respondent agreed they had difficulty in understanding the meaning of vocabularies and terms used in teaching Chemistry whilst 16% disagreed having difficulty in understanding the meaning of vocabularies and terms used during instruction.

Item 6 required students to indicate how often Chemistry was taught in abstract at the Colleges of Education. Responses to item 6 under the first research question are presented in Table 10.

Table 10.The abstract teaching of Chemistry at the Colleges of Education

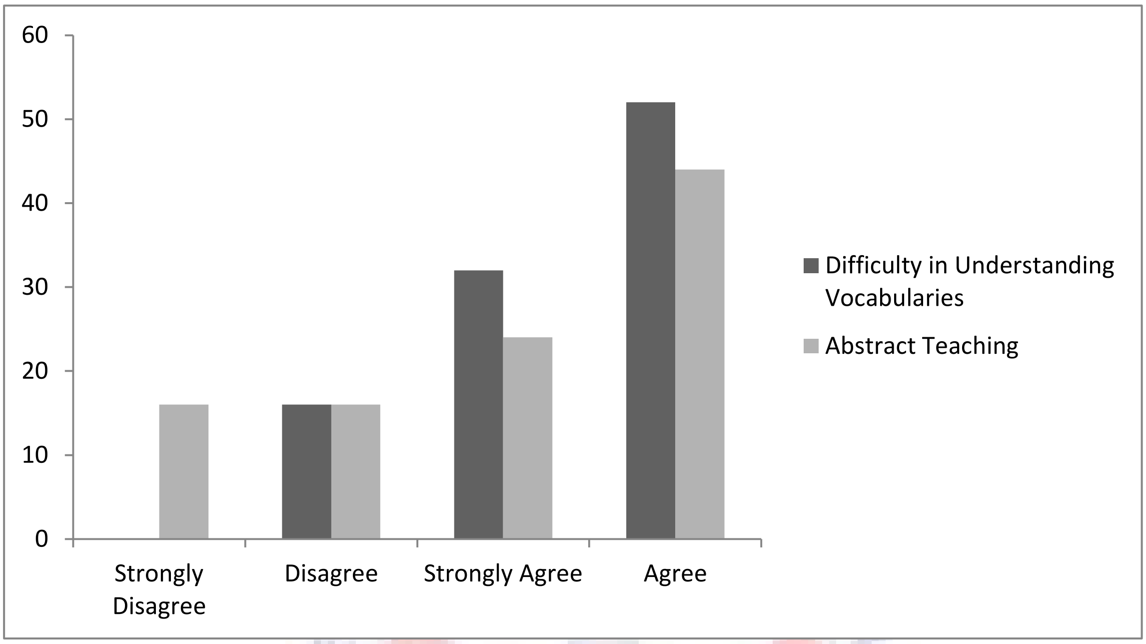
Option	Frequency	Percentage (%)
Strongly Disagree	16	16.0
Disagree	16	16.0
Strongly Agree	24	24.0
Agree	44	44.0
Total	100	100.0

Source: Field Data

From Table 10, it could be observed that 68 % of the respondents agreed that Chemistry was taught in abstract whilst 32% disagreed to the statement. It is clear from the table that majority of the students indicated tutors taught them in abstract. This would make the study of Chemistry difficult to the students since basic concepts would not be easily understood.

Students were asked in item 7 to indicate whether their tutors did not motivate them to study chemistry. Responses to this item are presented in Table 11.

Figure 5. Graphical View of Students' Difficulty in Understanding Vocabularies, Terms and Abstract Teaching



Source: Researcher's Own Construct

Table 11. Motivation of Student to Study Chemistry

Option	Frequency	Percentage (%)
Strongly Disagree	44	44.0
Disagree	32	32.0
Strongly Agree	12	12.0
Agree	12	12.0
Total	100	100.0

Source: Field Data

From Table 11, 76% of the respondent disagreed that their teachers motivated them to study Chemistry. However, 24% agreed that their teachers motivated them to learn Chemistry. It is clear from the table that majority of the students (76%) agreed that their tutors did not motivate them enough to study Chemistry.

The students were required in item 8 to express their views on whether their prior knowledge was often not considered when a new concept was to be learnt. The responses given on item 8 are presented in Table 12.

Table 12. The use of students' prior knowledge to teach new concept

Option	Frequency	Percentage (%)
Strongly Disagree	16	16.0
Disagree	60	60.0
Strongly Agree	16	16.0
Agree	8	8.0
Total	100	100.0

Source: Field Data

From Table 12, responses given by students" show that 76% disagreed that the prior knowledge of the students was considered when a new concept wass to be learnt. However, 24% of the students agreed to the statement. It is known that the use of student"s prior knowledge prepares a good foundation for new concepts to be grasped. This eases the difficulties in understanding Chemistry.

How can students be helped to use practical activities to learn Chemistry?

The second research question was designed to find out whether the use of practical activities in the laboratory would help students to study and understand Chemistry.

Four different test items were grouped to answer this research question. In item 1, it was demanded from respondents to indicate whether Chemistry concepts could easily be understood when the activity method is used to teach it. The responses are presented in Table 13.

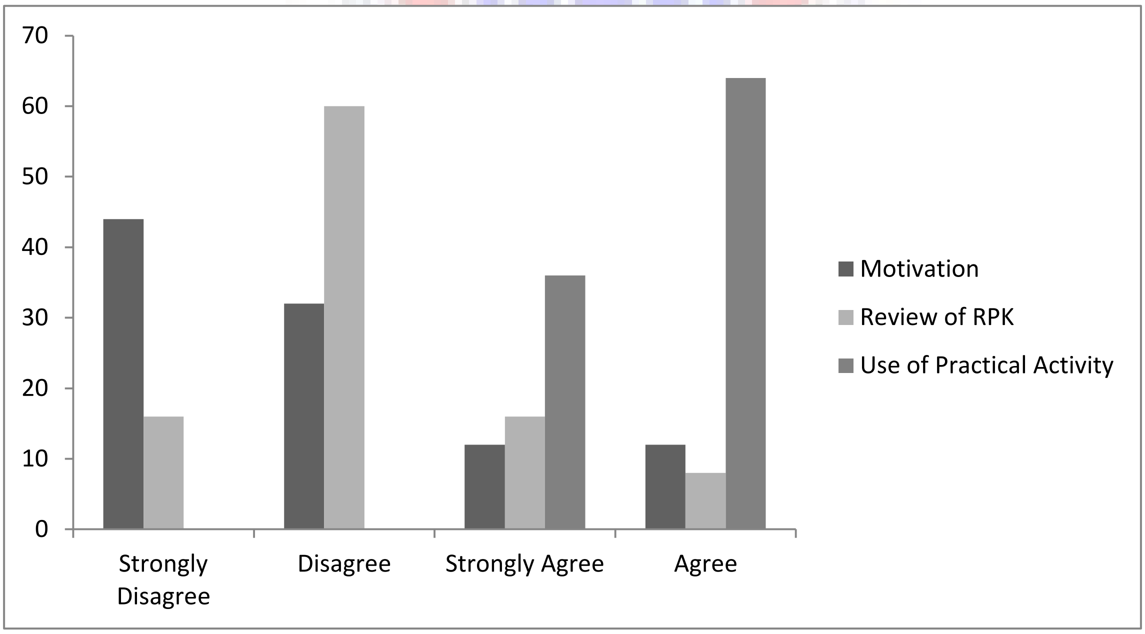
Table 13. Understanding of Chemistry concept by the use of practical activities

Option	Frequency	Percentage (%)
Strongly Disagree	0	0.0
Disagree	0	0.0
Strongly Agree	36	36.0
Agree	64	64.0
Total	100	100.0

Source: Field Data

From Table 13, 64% of the responses agree that Chemistry concepts can easily be understood when practical activities are used to teach them. Also, 36% of the students strongly agree to the statement. It is clear from the table that all the students (100%) agree that Chemistry concepts can easily be understood if practical activities are used to teach it.

Figure 6. Pictorial View of Ways at Improving Students' Interest in Science



Source: Researcher's Own Construct

Under item 2, students were asked to indicate whether they were often involved in practical activities. The responses are presented in Table 14

Table 14. Involving students in practical activities in the Chemistry laboratory

Option	Frequency	Percentage (%)
Strongly Disagree	12	12.0
Disagree	16	16.0
Strongly Agree	36	36.0
Agree	36	36.0
Total	100	100.0

From Table 14, it could be noted that 72% of the respondents agreed that they were often involved in practical activities. However, 28% of the respondents disagreed to the statement. It can be seen from the table that majority of the students (72%) indicated that they were often involved in practical activities. Regular involvement in practical activities by the students would enable them to relate and apply the theory learnt.

In item 3, students were asked to indicate whether practical activities enabled them to develop practical skills which helped in the understanding of Chemistry. The responses are presented in Table 15.

Table 15. Performing practical activities will enable students to develop process skills

Option	Frequency	Percentage (%)
Strongly Disagree	8	8.0
Disagree	20	20.0
Strongly Agree	28	28.0
Agree	44	44.0
Total	100	100.0

Source: Field Data

From Table 15, 72% of the students agreed that practical activities enabled them to develop process skills which helped them in understanding concepts in Chemistry. However, 28% of the students disagreed to the statement. This means, therefore, that majority of the students (72%) agreed that practical activities enabled them to develop process skills which helped them in understanding Chemistry. The acquisition of the process skills will place the students at a better position to learn chemistry with ease.

In item 4, under the research question 2, it was found out from the students whether their tutors discussed practical activities with them before performing the activities. Responses given on this item are presented in Table 16.

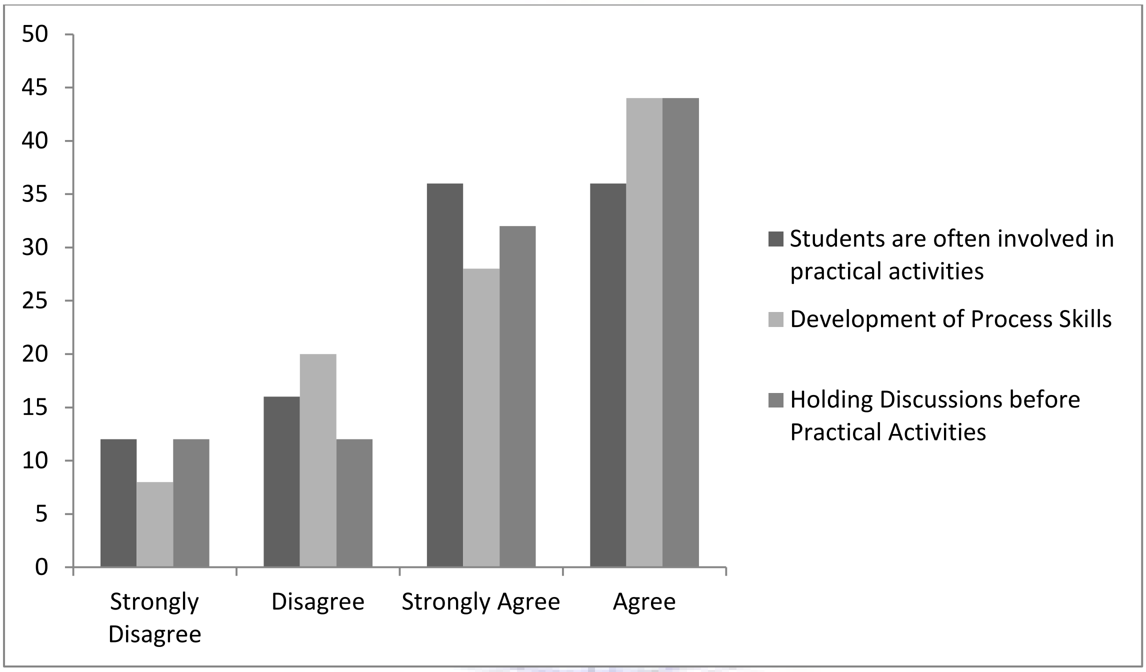
Table 16. Discussing practical activities with students before they are performed

Option	Frequency	Percentage (%)
Strongly Disagree	12	12.0
Disagree	12	12.0
Strongly Agree	32	32.0
Agree	44	44.0
Total	100	100.0

Source: Field Data

From Table 16, 76% of the students agreed tutors discussed practical questions with them before they were performed, while 24 % of the students disagreed that tutors discussed practical questions with them before they were carried out. It can be seen that majority of the students (76%) have indicated that their tutors take them through practical activities before they are performed. This enables them to get the right procedures to obtain accurate results.

Figure 7. Graphical Representation of how Student could be helped to Improve Performance in Chemistry



Source: Researcher's Own Construct

What technological tools can be used to support learning symbolic and molecular structures of compound?

This research question was meant to find out what technological tools could be used by the students and how the use of these tools could support them in the study of molecular and symbolic structures of compounds. Three test items were grouped to answer this research question.

In item 1, students were required to indicate whether their teachers used e-chem when teaching symbolic and molecular structures of compounds. The responses to this item are presented in Table 17.

Table 17. The use of e-chem by tutors in teaching symbolic and molecular structure of compounds

Option	Frequency	Percentage (%)
Strongly Disagree	32	32.0
Disagree	52	52.0
Strongly Agree	12	12.0
Agree	4	4.0
Total	100	100.0

Source: Field Data

From Table 17, it could be seen that 84% of the students agreed to the fact that teachers did not use e-chem when teaching symbolic and molecular structures of compounds whiles 16% agreed that their teachers used e-chem when teaching symbolic and molecular structure of compounds. It is clear from the table that majority of the tutors did not use the technological tool, e- chem.

In item 2, students were further asked to find out whether e-chem motivated them to picture and understand the structures of chemical compounds. Responses to item 2 are presented in Table 18.

Table 18. Using e-chem motivates and enables the drawing of structures of chemical compounds

Option	Frequency	Percentage (%)
Strongly Disagree	36	36.0
Disagree	32	32.0
Strongly Agree	20	20.0
Agree	12	12.0
Total	100	100.0

Source: Field Data

From Table 18, it was realised that 68% of the students disagreed to the statement that the use of e-chem motivated them to grasp the way the structures of compounds were drawn. However, 32% of the students agreed with the statement that e-chem motivated them to draw structures of compounds. It is clear from the table that majority (68%) of the students were not motivated by the use of e-chem, since most of their tutors did not use it to facilitate the teaching of symbolic and molecular structures of compounds.

Item 3 was to determine whether the use of e-chem by the students enabled them to construct, visualize and analyse structures of chemical compounds. Responses are presented in Table 19.

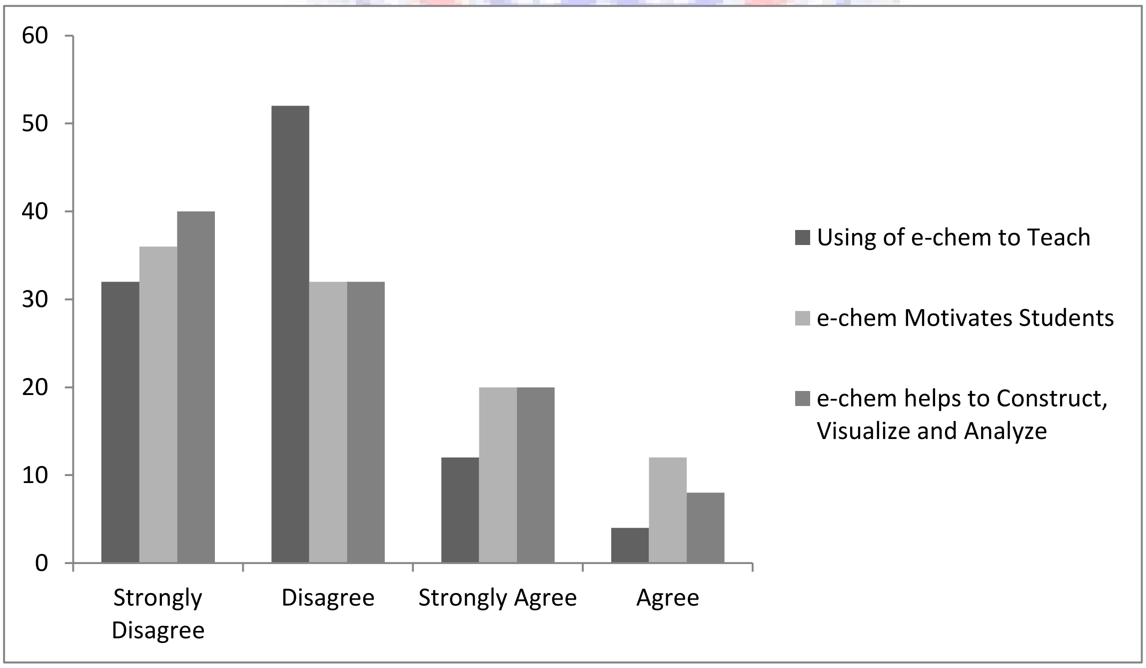
Table 19. E-chem helps students to construct, visualize and analyze structures of chemical compounds

Option	Frequency	Percentage (%)
Strongly Disagree	40	40.0
Disagree	32	32.0
Strongly Agree	20	20.0
Agree	8	8.0
Total	100	100.0

Source: Field Data

From Table 19 above, 72% of the students disagreed to the statement whiles 28% agreed that e-chem enabled students to construct visualize and analyse structures of chemical compounds. It is clear that majority of the students do not use e-chem, hence it will be difficult to agree or disagree.

Figure 8. Role of the Tool, e-Chem in Leaning Chemistry



What facilities are available for the effective teaching and learning of Chemistry?

The fourth research question was designed to find out the facilities that were available for effective teaching and learning of Chemistry in the science colleges of education. This was to enable the researcher to find out whether or not the facilities available had any influence on studying Chemistry.

Five items were selected to enable the above research question to be answered.

The first item under this research question was to find out how often students had access to Chemistry laboratory to perform practical"s. Responses given are presented in Table 20.

Table 20. Students often have enough access to Chemistry laboratory

Option	Frequency	Percentage (%)
Strongly Disagree	52	52.0
Disagree	20	20.0
Strongly Agree	20	20.0
Agree	8	8.0
Total	100	100.0

Source: Field Data

From table 20, it could be observed that, 72% of the students disagreed they often had access to their Chemistry laboratory. However, 28% of the students agreed that they often had access to their Chemistry laboratory. It became obvious that majority of the students representing 72% did not have access to their Chemistry laboratory. It implies that majority of the students may not be performing enough practical activities in the laboratory and this can adversely affect their performance in Chemistry.

In item 2, it was requested from the students to indicate how well their Chemistry laboratory was equipped with teaching and learning materials. The responses to this item are presented in Table 21.

Table 21. Equipping Chemistry laboratories adequately in the Colleges of Education

Option	Frequency	Percentage (%)
Strongly Disagree	20	20.0
Disagree	52	52.0
Strongly Agree	0	0.0
Agree	28	28.0
Total	100	100.0

Source: Field Data

From Table 21, 72% of the students disagreed to the fact that their Chemistry laboratory was well equipped with the necessary teaching and learning materials. However, 28% of the students agreed to the statement that their Chemistry laboratory was well equipped with teaching and learning materials. It is clear from the table that, to the students, their Chemistry laboratory is not adequately equipped for effective teaching and learning of Chemistry.

In item 3, students were asked to state whether facilities in the Chemistry laboratory motivated them to study Chemistry. The responses are presented in Table 22.

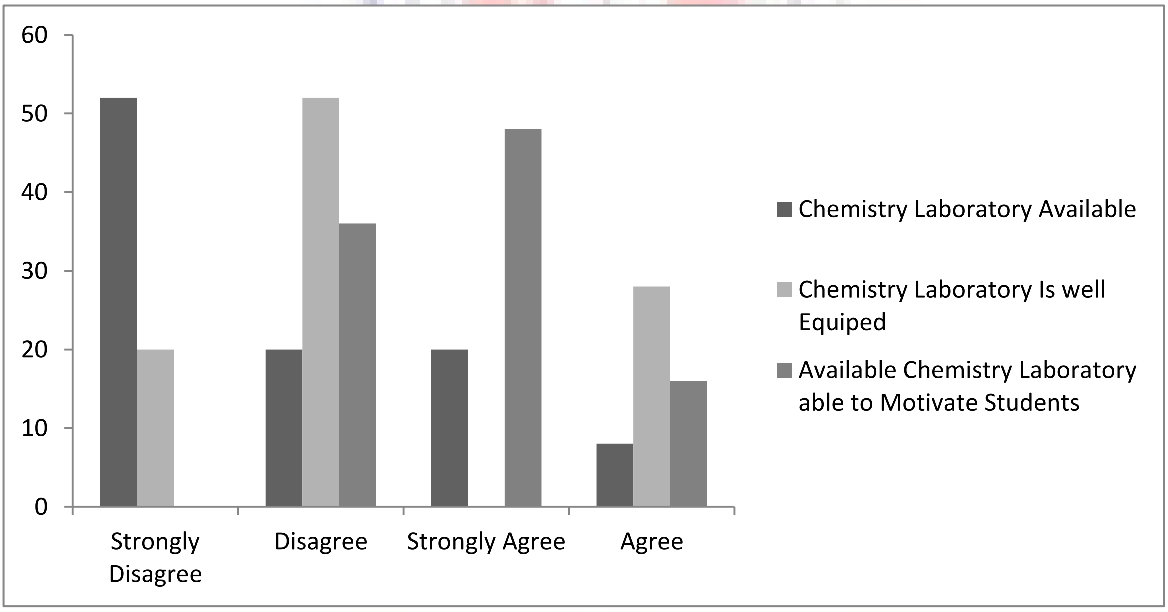
Table 22. Facilities in the chemistry laboratory motivate students to study Chemistry

Option	Frequency	Percentage (%)
Strongly Disagree	0	0.0
Disagree	36	36.0
Strongly Agree	48	48.0
Agree	16	16.0
Total	100	100.0

From Table 22, it was indicated that 64% of the students agreed that facilities in the Chemistry laboratory motivated them to study chemistry. However, 36% of the students disagree to the statement. It is observed from the table that majority of the students agreed to the fact that availability of facilities in the laboratory motivate them to study Chemistry.

In item 4, students were asked to indicate whether adequate use of facilities motivated and sustained their interest in learning chemistry. Responses to this item are presented in Table 23.

Figure 9. Availability and Condition of Chemistry Laboratory as well as its Effect on Students



Source: Researcher's Own Construct

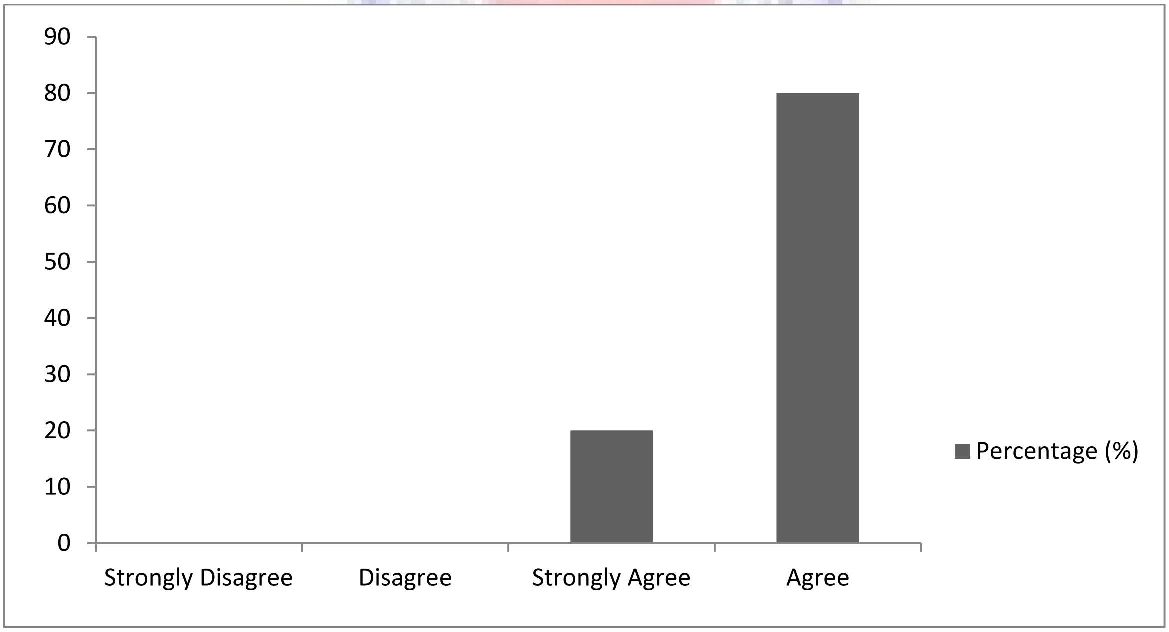
Table 23. Regular use of facilities by students motivates and sustains their interest in learning Chemistry

Option	Frequency	Percentage (%)
Strongly Disagree	0	0.0
Disagree	0	0.0
Strongly Agree	20	20.0
Agree	80	80.0
Total	100	100.0

Source: Field Data

From Table 23 above, all the students (100%) agreed to the fact that the regular use of facilities motivated and sustained their interest in learning Chemistry. It is clear from the table that the regular use of facilities in the laboratory will facilitate the way they learn Chemistry.

Figure 10. Graphical Representation of Students' Views on the Regular Use of Chemistry Laboratory



Do tutors use alternative concepts in stoichiometry to help solve problems on mole concept?

The last research question was designed to find out whether alternative concepts in stoichiometry could help in solving mole concept problems. Four items were selected under this question to enable the above research question to be answered.

In item 1, respondents were asked whether problems involving calculation on mole concept were difficult to solve. The responses to this item are presented in Table 24.

Table 24. Students find it difficult to solve problems involving calculations on mole concept

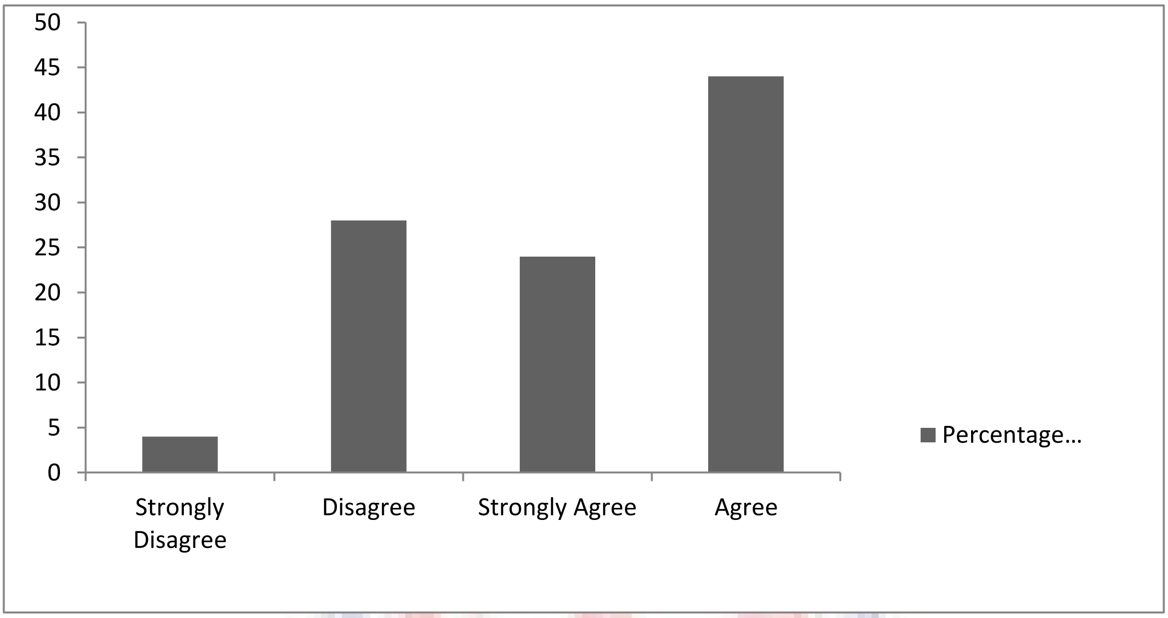
Option	Frequency	Percentage (%)
Strongly Disagree	4	4.0
Disagree	28	28.0
Strongly Agree	24	24.0
Agree	44	44.0
Total	100	100.0

Source: Field Data

From Table 24, it could be observed that 68% of the students agreed they found it difficult solving problems involving calculation on mole concept. However, 32% disagreed to the statement. This indicates that majority of the students have difficulty in solving problems on mole concept which may be due to the method used.

In item 2, it was demanded from the respondents to indicate whether their teachers often used algorithm method to teach them mole concept. Responses given on this item are presented in Table 25.

Figure 11. Pictorial Representation of Existing Problems Relating to Calculations on Mole Concept



Source: Researcher's Own Construct

Table 25. The use of algorithm method to teach the mole concept in the same class

Option	Frequency	Percentage (%)
Strongly Disagree	4	4.0
Disagree	20	20.0
Strongly Agree	32	32.0
Agree	44	44.0
Total	100	100.0

Source: Field Data

From Table 25, 76% of the students agreed their teachers used algorithm method to teach the mole concept whiles 24% disagreed to the statement. It is clear that majority of the students indicated their tutors used algorithm method to solve problems on mole concept.

The next item, 3 considered whether teachers used proportional method to solve problems on the mole concept. The responses are presented in Table 26.

Table 26. Tutors use proportional method to solve problems on mole concept in the same class

Option	Frequency	Percentage (%)
Strongly Disagree	36	36.0
Disagree	50	50.0
Strongly Agree	10	10.0
Agree	4	4.0
Total	100	100.0

Source: Field Data

From Table 26, 86% of the students disagreed that their teachers taught them how to use proportional method to solve problems on mole concept. However, only 14% agreed that their teachers used proportional method in solving mole concept problems. It is clear from the table that majority of the students (84%) were not taught how to use proportional method to solve problems on mole concept.

Item 4 under the last research question requested to find out whether teachers used logical reasoning to solve problems on mole concept. The responses are presented in Table 27.

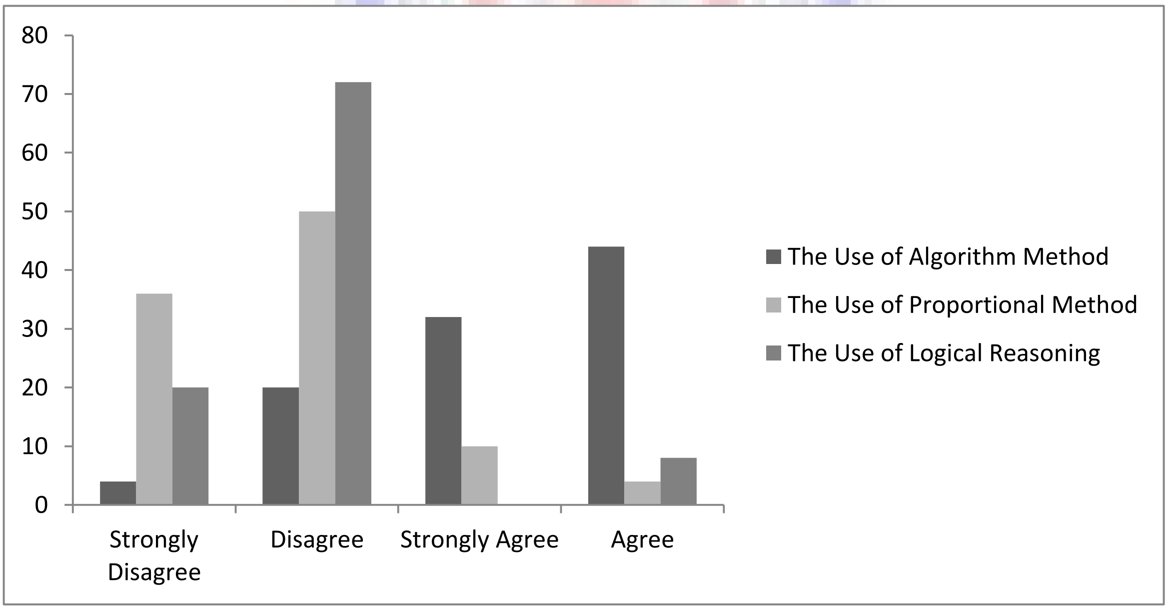
Table 27. Teachers teach students to use logical reasoning to solve problems on the mole concept

Option	Frequency	Percentage (%)
Strongly Disagree	20	20.0
Disagree	72	72.0
Strongly Agree	0	0.0
Agree	8	8.0
Total	100	100.0

Source: Field Data

From Table 27 above, 92% of the students disagreed that their teachers used logical reasoning to solve problems on mole concepts. However, only 8% of the students agreed that teachers used logical reasoning to solve problems on mole concept. It is also clear from the table that majority of the students were not taught the use of logical reasoning to solve problems on mole concept.

Figure 12. Diagram Representing Suitable Method for Solving the Mole Concept Related Problem



Source: Researcher's Own Construct

Responses of Tutors

Responses of tutors are also presented based on similar items in the questionnaire under the five research questions. Analyses were done using the number of responses given by the tutors, since they were only 4 Chemistry tutors involved in this research.

Students' Difficulty in Learning Chemistry

The above item was also designed to find out problems students encountered in the study of Chemistry and if possible address the issues raised.

In item 1, tutors were asked to indicate whether Chemistry was perceived by students to be difficult. Two tutors strongly agreed to the statement whiles another two agreed that students perceived Chemistry to be a difficult subject. It means that all the tutors agreed students perceived Chemistry to be a difficult subject.

In item 2, tutors were asked whether challenging topics in Chemistry were difficult to teach. Three tutors agreed that teaching some challenging topics was difficult. However, only one tutor disagreed to the statement. This means majority of the tutors indicated it was difficult teaching some challenging topics.

Item 3, requested from tutors to indicate whether the topics in Chemistry were too loaded in a semester. Responses showed that three tutors agreed the topics were too loaded. However, one tutor disagreed to the statement. It shows that three out of four tutors agreed the topics to be treated in a semester were too loaded.

In item 4, tutors were asked to state whether students found it difficult to understand basic fundamental concepts in Chemistry. Three tutors agreed to the statement. However, one disagreed that their students found it difficult understanding basic fundamental concepts in chemistry.

In item 5, tutors were asked whether students found it difficult to understand the meaning of terms used during instructional period. In this item, three tutors agreed to the statement whiles one disagreed they found it difficult understanding the meaning of some terms used by their tutors.

Item 6 was aimed at seeking from the tutors whether Chemistry was perceived as an abstract subject. Responses gathered indicated that three tutors strongly agreed whiles one tutor disagreed with the statement that Chemistry was perceived as an abstract subject. Since Chemistry was regarded as an abstract subject by their tutors it means that they have to demystify the teaching of Chemistry.

In item 7, tutors were asked whether their students lacked self motivation. Responses from the tutors showed that all the four tutors agreed their students lacked self motivation.

In the last item, tutors were asked to indicate whether the prior knowledge of students was often related to new concepts to be learnt. Responses from tutors showed three tutors strongly agreed they related students" prior knowledge to new concepts to be learnt. However, one disagreed with the statement. It is clear from the responses that majority of the tutors relate prior knowledge of students to new concepts to be learnt.

Using practical activities to learn Chemistry

This group of items was aimed at finding out whether tutors used practical activities in teaching Chemistry in their colleges.

In item 1, tutors were requested to indicate whether they used practical activities to teach Chemistry or not. Responses show that all the four tutors agreed they involved their students in practical activities when teaching Chemistry.

In item 2, tutors were asked whether practical work was always linked to the theory to be learnt. From the responses gathered, three tutors agreed that practical work was normally linked to the theory to be learnt. However, one tutor disagreed that practical work was normally linked to the theory to be learnt. It is clear from the responses that majority of the tutors agree they link practical activities to the theory to be learnt.

In Item 3, tutors were asked whether practical activities helped develop process skills of students. Three tutors agreed to the statement. However, one tutor disagreed that practical activities helped students to develop their process skills. It is clear from the responses that majority of the tutors agree involving students in practical activities help to develop their process skills.

In item 4, it was requested from tutors to further indicate whether practical activities helped to sustain students" interest in learning Chemistry. Responses given on this item showed that all the four tutors strongly agreed to the statement. This means that practical activities of students sustain their interest in learning Chemistry and also help to develop their process skills.

Availability of facilities for teaching and learning Chemistry

The above item was designed to identify whether there were facilities available for teaching and learning of Chemistry in the Colleges Education. Five items were also grouped to answer the research question.

In item 1, it was requested from the tutors to indicate whether their colleges had adequate and relevant equipment for laboratory work. From the responses, all the 4 tutors indicated that their colleges did not have adequate and relevant equipment for laboratory work.

In item 2, tutors were asked whether their chemistry laboratory was well equipped with teaching and learning materials in their college. Responses given were that all the four tutors indicated that their Chemistry laboratory was not well equipped with teaching and learning materials. It means that both students and tutors face lot of challenges whenever they want to perform practical activities in the laboratory.

In item 3, tutors were asked to state whether adequate use of facilities motivated and sustained the interest of their students in learning Chemistry. Responses from the tutors indicated three tutors agreed with the statement. However, one tutor disagreed that the use of adequate facilities motivated and sustained the interest of the students. It is clear from the responses that adequate use of facilities by the students motivate and sustain their interest in studying Chemistry.

In item 4, tutors were asked whether practical activities were discussed with their students before they were carried out. From the responses given, three tutors agreed that practical activities were discussed with their students before they were carried out. However, one tutor disagreed to the statement. This means that students are aware of what their practical activity entails before they are carried out.

The use of technological tool, e-chem to support the learning of symbolic and molecular structure of compounds.

This item was also to find out whether the use of e-chem would improve the teaching and learning of symbolic and molecular structures of compounds. Four items were grouped under this major item.

In item1, it was requested from the tutors to indicate whether they had the technological tool, e-chem, in their colleges. Responses from this item showed that three tutors disagreed that their colleges had the tool e-chem whiles one tutor agreed to the statement.

In item 2, it was required of the tutors to indicate whether they used e-chem when teaching symbolic and molecular structure of compounds. Responses given on this item showed that three tutors indicated that they did not use e-chem when teaching symbolic and molecular structure of compounds. However, one tutor agreed to the statement. It is clear from the responses that since majority of the colleges do not have the tool, e-chem, available their tutors would not be able to use it.

In item 3, tutors were asked whether they were familiar with the use of e-chem. From the responses given three tutors indicated that they were not familiar with the technological tool, e-chem. However, one tutor agreed being familiar with it. It is clear that since majority of the tutors are not familiar with e-chem it is possible they may not be able to use it.

The use of alternative method in stoichiometry to help solve mole concept questions

The last major item under this study was to find out alternative methods used in solving problems involving mole concept. This was to enable students to select easier ways of solving one of the challenging topics. Four items were grouped to enable the research question to be answered.

In item 1, tutors were asked to indicate whether they had any knowledge of alternative methods used in solving mole concept problems. Responses to this item showed that two tutors indicated they had knowledge of alternative methods used. Whiles the remaining two of the tutors said they did not have any knowledge of alternative methods used.

Item 2 was aimed at finding out from the tutors which of the alternative methods they used in teaching mole concept. Responses gathered indicated three tutors used the algorithm method to solve mole concept problems. However, one tutor used the proportional method to solve mole concept problem. It is clear from the responses that majority of the tutors use the algorithm method which deals with the use of formula.

In item 3, tutors were asked which alternative method was often used to teach problems involving mole concept. From the responses given, three tutors indicated they often used algorithm method to teach how mole concept problems are solved. However, one tutor preferred to use proportional method. It is, therefore, clear that the use of logical reasoning to solve mole concept problems is rare and this may be due to a lot of reasoning that is involved in the procedure.

Discussions of Findings

In this section, the discussions of the major findings with their respective implications are presented on academic information of respondents and the five research questions, followed by summary of the findings.

Research Question 1. What problems do students encounter in learning Chemistry?

Major findings from items 1 - 4 answered part of this question while major findings from items 5 - 9 also answered the rest. In these findings, some commonalities were noticed between students‟ and tutors‟ major findings. Major findings from items 1- 4 indicated that 80% of the students perceived Chemistry to be difficult while 56% of the students agreed it was difficult solving questions involving symbols and numerals in Chemistry.

Also, 68% of the students agreed they memorized concepts without understanding them while 68% of the students agreed that topics to be treated in a semester were too loaded.

Similarly it was realized that majority of the tutors (3) agreed that students‟ perceived Chemistry to be difficult. Also, majority of the tutors (3) agreed that teaching some challenging topics in Chemistry was difficult. Also, it was realized that majority of the tutors (3) agreed topics in the chemistry course outline were too loaded. Major findings from items 5-7 indicated that 84% of the students agreed having difficulty in understanding the meaning of some terms and vocabulary used in teaching chemistry. According to Gardner (1972), the use of non-technical words by chemistry tutors was just not accessible to their students. 68% of the students agreed they were taught chemistry in abstract. Moreover, 76% of the students agreed their tutors did not motivate them to learn Chemistry. Major findings from items 8 and 9 showed 76% of the students agreed their prior knowledge was not considered when a new concept was to be learnt whiles 100% of the respondents agreed Chemistry concepts could easily be understood if activity method was used to teach the subject. It implies that the students‟ difficulty in studying Chemistry results from their perception about the subject, the effect of the use of non-technical vocabulary and terms during lessons, the loaded nature of their course outline and the way their tutors fail to consider their prior knowledge when introducing them to new lessons. Also, motivation of students is crucial in developing their interest in learning Chemistry but this was not the case.

Research Question 2. How can students be helped to use practical activities to learn Chemistry?

Major findings from items 1 - 4 answered this research question. Majority of the students (72%), indicated Chemistry was often taught them using practical activities. Moreover, majority of the students (64%) agreed that concepts in Chemistry were easily understood if practical activity of teaching was used. Seventy – two percent (72%) of the students agreed practical activities enabled them develop practical skills which helped in their understanding of Chemistry.

Moreover, 76% of the students agreed their tutors discussed practical activities with them before they were performed. Similarly, majority of the tutors (3) agreed practical activities helped to develop process skills of students and also create interest in studying Chemistry. However, majority of the tutors (4) also agreed students were often not involved in lots of practical work before their examinations.

The implication is that the use of practical activities in teaching would enable concepts in Chemistry to be easily understood. The more activities performed by students would enable them develop lot of process skills.

It was also noticed that students‟ interest is sustained in learning Chemistry when a lot of practical activities are performed.

Research question 3. What technological tool(s) can be used to support learning symbolic and molecular structures of compounds?

Major findings from items 1 – 5 answered this research question. From the major findings, it was indicated by the students that 84% of them agreed their tutors did not use e-chem whenever they teach symbolic and molecular structure of compounds.

Also, 68% of the students disagreed that the use of e-chem by their tutors would facilitate and motivate them grasp the way structures of compounds were drawn. Majority of the student (72%) indicated that the use of e-chem do not enable them construct, visualize and analyse structures of chemical compounds. Similarly, majority of the tutors were not familiar with the use of e-chem since they did not have the tool in their colleges to use. This contradicts Copollo & Hounshell (1995), who state that the advantages of manipulating models using e-chem enables students to visualize invisible atoms and molecules thus helping them to construct, visualize and analyse structure of compounds.

This implies that their tutors" not using e-chem in lesson delivery makes their understanding of structure of compounds difficult and this leads to some of their difficulty in understanding Chemistry.

Research question 4. What facilities are available for the effective teaching and learning of Chemistry?

Major findings from items 1 – 5 answered this research question. Majority of the students (72%) indicated that they always did not have access to their Chemistry laboratory.

Also, 72% of the students agreed their chemistry laboratory was not well equipped. Similarly, it was also realized that 2 tutors agreed their Chemistry laboratory was not well equipped with teaching and learning materials. This implies that students do not have materials available for them to use in their learning process which adversely affects them in understanding concepts relating to hands on practical activities.

It was also indicated that 64% of the students agreed availability of facilities in their Chemistry laboratory would have motivated them to study Chemistry and also sustained their interest. Also, all the tutors (4) indicated that their colleges did not have relevant and adequate equipment for practical work. This implies that adequate use of facilities plays a major role in sustaining student"s interest in learning chemistry. They tend to understand what is learnt best and this motivates them to learn more.

Research Question 5. Do alternative concepts in stoichiometry help in solving mole concept questions?

Major finding 1 – 4 answered this part of the research question. Majority of the students (68%) indicated that they found it difficult solving problems on mole concept. This implies that students do not understand the various concepts and methods of solving problems on mole concept.

Also, majority of the students (76%) agreed their teachers used algorithm method to teach mole concept. However, 60% of the students were taught how to use proportional method to solve problems on mole concept and, also, only 8% of the students were taught to use logical reasoning in solving mole concept problems.

From the findings, 4 tutors agreed their students, indeed, had problem with the way they solved mole concept question.

This implies that students" difficulty in grasping mole concept might be due to the methods of teaching used by their teachers. It may be necessary for tutors to use all the methods involved in teaching mole concept so that the students will select a suitable method that will enable them solve mole concept problems to their best of understanding.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

This chapter presents the discussions and implications of the findings in chapter four based on the five major research questions. Each research question was discussed based on the major findings of the study. Major findings for students and their tutors were both discussed together with their implications, followed by recommendations. The following headings were used for the discussions and implications of the findings: problems students encounter in learning Chemistry, use of activity method in helping students to study chemistry, use of the technology tool, e-chem, to support the studying of symbolic and molecular structures of compounds, availability of facilities for effective teaching and learning of Chemistry and using alternative methods in solving mole concept problems.

Summary of Key Findings

Summary of the findings from the study are presented based on the five research questions.

These findings showed that:

Students studying Science in the Colleges of Education really perceived Chemistry to be difficult as a result of the way they studied the subject. Students learnt in abstract and memorized concepts without understanding them.

It was also found out that students did not understand meaning of some Chemistry terms used in teaching. There was only little motivation coming from their tutors.

However, it was found out that students‟ prior knowledge, when considered during teaching and learning, coupled with lots of practical activities would enhance the way Chemistry is studied.

Students performing practical activities enabled them to develop a lot of process skills like: observation, manipulative and predictive skills that were helpful to them. Moreover, their tutors discussed practical activities with them before they were carried out.

It was found out that majority of the students were not able to translate between symbolic and molecular structures of compounds using e-chem. This was due to their tutors not being familiar with the use of e-chem. However, the use of e-chem by the students enabled them construct, visualize and analyse molecular structures.

Lack of adequate facilities like Chemistry laboratories and equipment in some Science Colleges of Education made the studying of Chemistry to be difficult though many practical activities were conducted by their tutors. This implies that students would only acquire some process skills whiles in college. This will affect their performance in practical lessons with their pupils after completing college.

Students, generally, were not happy about the way some challenging topics like mole concept and chemical bonding were taught. However, tutors were putting lots of teaching strategies in place to enable them overcome those learning difficulties.

Conclusions

Based on the findings made in this study, the following general conclusions are made:

1. Though the students perceived Chemistry to be difficult, tutors teaching them would have to motivate them by using lots of practical activities in their lessons. This would arouse and sustain their interest to study Chemistry. Moreover, their process skills are also developed.
2. E-chem must be used by all Chemistry tutors to enhance the teaching and learning of molecular structure and chemical bonding of compounds.
3. Both tutors and students were faced with inadequate facilities that often impeded academic work in the Science Colleges of Education.

Some of the constrains indicated include; lack of laboratories, apparatus and reagents and these put undue pressure on both students and tutors. Hence, it could further be concluded that though the training of science teachers for basic schools has started in the designated Science Colleges of Education, much needs to be done to improve the quality of training of teachers.

Recommendations

The recommendations to this study are presented based on the findings from the study and research questions used. It is recommended that:

Students selected to offer elective science and for that matter, Chemistry, should be students who offered elective science in the Senior High School.

Students with good grades should be selected to undertake the programme.

Government should, as a matter of urgency, complete all the building projects of the various science laboratories and stock them well with equipment to enable practical activities be carried out in a friendly environment. This should be done in order to equip the teacher trainees with those skills that would enable them to fully grasp the skills involved to help them practice it after training.

The technological tool, e-chem, should be used by chemistry tutors to enable students understand the formation of compounds through chemical bonding and, also, to allow their students to construct, visualize and analyse molecular structures of compounds.

Finally, tutors should not only impart knowledge but rather serve more as facilitators of activities to enable trainees come out with their own findings.

Implication for Education

Since science teacher education forms one of the top priorities in the development of human resource base of this nation, the major stake holders in education such as the Government of Ghana, tutors, and students would be awakened to the challenges identified in this study. Chemistry would be taught in a more practical way than emphasizing the theoretical aspect. Development of practical skills among students would be intensified in Colleges of Education to make teaching and learning of Science at the basic school level more practicable.

The use of e-chem should be established in the science colleges of education using the state of the art science and computer laboratory and other technological tools.

Suggestion for Further Studies

This study found out some of the learning difficulties of Chemistry students and the ways to mitigate them to enable the students learn effectively. Therefore, there could be other studies to find out other ways of reducing the learning difficulties and also the handling of the challenging topics in Chemistry.

REFERENCES

Abraham, M. R., Gizybowski, E.B., Renner, J.W., & Marek, E.A. (1992). Understanding and Misunderstanding of eight Graders of five Chemistry Concepts found in Chemistry Textbooks. *Journal of Research in Science Teaching, 29* (2) 105 – 120.

Abraham, M. R., Williamson, V.M., & West Brook, S.L. (1994). A cross – Age study of the understanding five concepts. *Journal of Research in Science Teaching, 31* (2), 147 – 165.

Alreck, P. L., & Settle, R.B. (1985). *The Survey Research Book*. Illinois U.S.A; IRWW. INC.

Ames, C., & Ames, R. (1984). System of Students and Teachers Motivation: Towards a Qualitative Definition. *Journal of Educational Psychology, 76,* 536 – 556.

Anderson, B. (1990). Pupils" conceptions of Matter and its Transformations. *Studies in Science Education, 18,* 53 – 85.

Anselm, A. L., & Corbin, J.M. (1990). *Basics of qualitative research*: Techniques and procedures for grounded theory. Thousand oaks, CA: Sage Publications.

Ausubel, D. P. (1968). *Educational Psychology;* a Cognitive View. New York: Holt Rinehart and Winston.

Ayas, A., & Costu, B. (2002). Levels *of Understanding of the Evaporation Concept at Secondary Stage.* The first International Education conference, changing times changing needs, Eastern Mediterranean University, Gazimagusa – Northern Cyprus.

Ayas, A., & Demirbas, A. (1997). Turkish Secondary Students" Conception of Introductory Chemistry concepts. *Journal of Chemical Education, 74* (5), 518 – 521.

Ayas, A., Kose, S., & Tas, E. (2002). *The Effects of Computer Assisted Instruction on Misconception about Photosynthesis.* The First International Education conference, changing Times changing needs. Eastern Mediterranean University, Gazimagusa – Northern Cyprus.

Baddeley, A. D. (1999). *Essentials of Human Memory.* Hove: Psychology Press.

Barrow, G. M. (2005). Learning Chemistry Intellectual Integrity or Mental Servility. *Journal of Chemical Education, 68* (6), 449 – 453

Ben – Zui, R., Eylon, B., & Silberstein, J. (1986). Is an Atom of Copper malleable? *Journal of Chemical Education, 63*, 64 – 66.

Best, J. W., & Kahn, J.V. (1995). *Research in Englewood cliffs*. NJ: Prentice Hall, Inc.

Biggs, J. B., & Moore, P.J. (1993). *The Process of Learning*. Sydney; Prentice Hall.

Bodner, G.M. (1986). Construct vision; A Theory of Knowledge. *Journal of Chemical Education, 63* (10), 873 – 878.

Bodner, G. M. (1991), I have found you an Argument: The Conceptual Knowledge of Beginning chemistry Graduate students. *Journal of Chemical Education, 68*(5) 385-388.

Bodner, G. M. (1991). I have found you an Argument: The Conceptual Knowledge of Beginning Chemistry Graduate students. *Journal of Chemical Education, 68*(5), 385 – 388.

BouJaoude, S., & Barakat, H. (2000). Secondary School Students" Difficulties with Stoichiometry. *School Science Review, 81* (296), 91 – 98.

BouJaoude, S., & Barakat, H. (2003). Students" Problem Solving Strategies in Stoichiometry and their Relationships to Conceptual Understanding and Learning Approaches, Electronic Journal of Science Education, 7(3), online journal, http://unr.edu/ homepage/jcannon/ejse/ejse. html.

Bradly, F.D., & Brand, M. (1985). Stamping out Misconceptions. *Journal of Chemical Education, 62* (4), P. 318.

Bunce, D. M., Gabel, D.L., & Samuel, J. V. (1991). Enhancing chemistry Problem – solving Achievement using Problem categorization. *Journal of Research in Science Teaching, 28*(6), 505 – 521

Calik, M., Ayas, A., & Ebenezer, J.V. (2005). A Review of Solution Chemistry Studies: Insights into Students" Conceptions. *Journal of Science Education and Technology, 14*(1), 29 – 50

Cassels, J.R.T., & Johnstone, A.H. (1984). The Effect of Language on Students" Performance on Multiple Choice Tests in Chemistry. *Journal of Chemical Education, 6* (7), 613 – 615.

Cassels, J.R.T., & Johnstone, A.H. (1980). *Understanding of Non – Technical Words in Science*. London: The chemical society.

Chin E., Russell, J., & Marx, N. (1997). The roles of representations and tools in the Chemistry laboratory and their implications for chemistry instruction (Technical Report). Menlo Park. CA: SRI International.

Christie, A. (2005). Constructivism and its implications for educators" http://alicechristie con/ed tech/learning/constructivism/index, Gtm.

Clow, D. (1998). Teaching, Learning and Computing. *University Chemistry Education* (2) , 21 – 28.

Cohen, L., & Manion, L. (1994). *Research methods in Education*. (4th ed.) Croom Helm.

Cohen, L., Manion, L., & Morrison, R. (2003). *Research Methods in Education*. (5th ed.). Routtlege Falmer, London & New York.

Coll, R. K., & Treagust, D.F. (2009). Learners" use of Analogy and Alternative Conceptions for Chemical Bonding, *Australian Science Teachers Journal, 48*(1), 24 – 32.

Copolo, C. F., & Hounshell, P.B. (1995). Using three – dimensional models to teach molecular structures in high school chemistry. *Journal of Science Education and Technology, 4*(4), 295 – 305.

Creswell, J. W. (1994). *Qualitative and quantitative approaches*; Thousand Oaks: SAGE Publications Ltd.

Driver, R. (1981). Pupils Alternative Frameworks in science. *European Journal of science Education, 5,* 61 – 84.

Driver, R., & Easley, J. (1978). Pupils and paradigms: A Review of Literature Related to concept Development and Adolescent science studies. *Studies in science Education, 5*, 61 – 84.

Duit, R, & Treagust, D. F. (2003). Conceptual change: A powerful framework for improving science teaching and learning. International. *Journal of science Education, 25*, 67 – 688.

Duncan, I. M., & Johnstone, A. H. (1973).The Mole concept. *Education in chemistry, 10*, 213 – 214.

Duschl, R., & Osborne, J. (2002). Supporting and Promoting Argumentation Discourse in Science Education. *Studies in science Education 38*: 39 – 72.

Duun, D. S. (1999). *The practical researcher*: A student‟s guide to conducting psychological research, New York: McGraw – Hill.

Ebenezer, J. V. (1991). *Students' conceptions of solubility:* A Teacher – Researcher collaborative study, Unpublished Doctoral Dissertation, University of British Columbia, Vancouver, British Columbia, Canada.

Ebenezer, J. V. (2001). A Hypermedia Environment to Explore and Negotiate students conceptions; Animation of the solution of Table self. *Journal of science Education and Technology, 10*(1), 73 – 92.

Ebenezer, J. V., & Gaskell, P. J. (1995). Relational *conceptual* change in solution chemistry. *Science Education 79*: 1 – 17.

Entwistle, N., & Ramsden, P. (1983). *Understanding student learning*. New York: Nichols Publishing Company.

Entwistle, N. J., Thompson, J., & Wilson, J.D. (1974). Motivation and Study Habits. *Higher Education, 3*, 379 – 396.

Fensham, P. (1988). *Development and Dilemmas in Science Education*. 5th Edition. London: Falmer.

Fensham, P., & George, S. C (1973). Learning structural concepts of simple Alcohols. Education in chemistry, 10 (1), 24.

Fox, M. (1993). *Psychological Perspective in Education*. London: Cassell Educational Limited.

Fraser, B., McRobbie, C. J., & Giddings, G. J. (1993). Development and Cross – national validation of a laboratory classroom instrument for senior high school teacher – trainees. *Science Education, 77*, 1 - 24.

Frazer, M. J., & Servant, D. (1986). Aspect of stoichiometry titration calculations *Education in Chemistry, 23*, 54 – 56.

Frazer, M. J., & Servant, D. (1987). Aspects of stoichiometry – where do students go wrong? *Education in Chemistry, 24*, 73 – 75.

Furio, C., Azcona, R., & Guisasola, J. (2002). The learning and teaching of the concepts "amount of substance" and „mole": a review of the literature. *Chemistry Education Research and Practice, 3,* 277 – 292.

Gabel, D., & Sherwood, R. (1980). The effects of students" manipulation of molecular models on chemistry achievement according to Piagetian level. *Journal of Research in Science Teaching, 17*(1), 75 – 81.

Gabel, D. L. (19992). Modeling with Magnets a Unified approach to chemistry Problem Solving. *The Science Teacher,* March, 58 – 63.

Gabel, D. L. (1993). Use of the particle Nature of matter in Developing conceptual Understanding, *Journal of Chemical Education, 70* (3), 193 – 194.

Gabel, D. L. (1999). Improving Teaching and Learning through Chemistry Education Research; A Look to the future. *Journal of Chemical Education 76*(4), 548 – 554.

Gabel, D. L., & Bunce, D. M. (1994). Hand book of Research on science Teaching and Learning. pp. 301 – 326, New York; Macmillan.

Gabel, D. L., Samuel, K. V., & Hunn, D. (1987). Understanding the particulate nature of matter. Journal of Chemical Education, 64, 695 – 697.

Gadner, P. L, (1972). Words in Science. Melbourne: Australian Science Education Project.

Garforth, F. M., Johnstone, A. H., & Jazonby, J. N. (1976). Ionic Equations: Difficulties in Understanding and use. *Education in Chemistry, 13,* 72 – 75.

Gassels, J. R. T., & Johnstone, A. H. (1985). *Words that matter in science*, London: Royal Society of Chemistry.

Gilbert, J. K., Osborne, J. R., & Fensham, P. J. (1982). *Children's Science and its Consequences for Teaching. Science Education 66*: 623 – 633.

Grasbowsli, B. (2004). Generative learning contributions to the design of instruction and learning. In D. H. Jonassen (Ed.), Handbook of research on educational communications and technology (3rd ed.), pp 719 – 743, Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Griffiths, A. K. (1994). A critical Analysis and synthesis of Research on Chemistry Misconceptions. In H. F., Schmidt, (Ed), Proceedings of the 1994) International symposium Problem solving and misconceptions in chemistry and Physics, The International council of Associations for science Education Publications, 70 – 99.

Harrison, A. G., & Treagust, D. F. (2000). Learning about Atoms, Molecules and chemical Bonds; A case study of Multiple. Model use in Grade 11 chemistry, science Education, 84, 352 – 381.

Helm, H. (1980). Alternative Conceptions in Physics amongst South African Students, Physics Education, 15, 92 – 105.

Heron, J. D. (2000). "Piaget for chemist". *Journal of Chemical Education, 52* (3), 146 – 150.

Hoffmann, R., & Laszlo, R. (1991). Representation in Chemistry. Angewandte chemie, 30, 1 – 16.

Hofstein, A., & Kempa, R.F. (1985). Motivating Strategies in Science Education: Attempt at an Analysis, *European Journal of Science Education, 7*(3), 221 – 229.

Hogan, K. (1999). Thinking aloud together: A test of intervention to foster students" collaborative scientific Reasoning. *Journal of Research in Science Teaching, 36* (10), 1055 – 1109.

Huddle, P. A, & Pillay, A. E. (1996). An in – depth study of misconceptions in stoichiometry and chemical equilibrium at a south African University. *Journal of Research in Science Teaching,* 33, 65 – 77.

Institute of Education University of Cape Coast (2009). Chief Examiners" Report. Cape Coast; University of Cape Coast.

Institute of Education University of Cape Coast (2010). Chief Examiners „Report, Cape Coast: University of Cape Coast.

Jenkins, E. W. (1992). School Science Education: Towards a Reconstruction, Journal of Curriculum Studies, 24(2), 22 – 26.

Johnstone, A. H. (1974). Evaluation of Chemistry Syllabuses in Scotland, *Studies in Science Education,* 1, 20 – 49.

Johnstone, A. H. (1980). Chemical Educations Research; Facts, Findings and Consequences, *Chemical Society Review, 9*(3), 365 – 380.

Johnstone, A. H. (1982). Macro and Micro Chemistry, *School Science Review 64*(277), 377 – 379.

Johnstone, A. H. (1984). New Stars for the Teacher to steer By? *Journal of Chemical Education, 6*(10), 847 – 849.

Johnstone, A. H. (1991). Why science is Difficult to learn? Things are seldom what they seem, *Journal of Computer Assisted Learning 7*, 75- 83.

Johnstone, A. H. (1999). The Nature of Chemistry, *Education in Chemistry, 36*(2), 45 – 48.

Johnstone, A. H. (2000). Teaching of Chemistry – Logical or Psychological? *Chemistry Education; Research and Practice in Europe, 1* (1), 9 – 15.

Johnstone, A. H., & El–Banna, H. (1986). Capacities, Demands and Processes – *A Predictive Model for Science Education in Chemistry, 23*(3), 80 – 84.

Johnstone, A. H., & Kellett, N.C. (1980). Learning Difficulties in School Science towards Working Hypothesis, *European Journal of Science Education, 2*(2), 175 – 181.

Johnstone, A. H., & Letton, K. M. (1991). Practical Measures for Practical Work, *Education in Chemistry, 28*(3), 81 – 83

Johnstone, A. H., & Percival, F. (1976). Attention Breaks in Lectures. *Education in Chemistry, 13*(2), 49 – 50.

Johnstone, A. H., & Selepeng, D. (2001). A language Problem Revisited, *Chemistry Education; Research and Practice in Europe (CERAPIE) 2*(1), 19-29

Johnstone, A. H., MacDonald, J. J., & Webb, G. (1997). Chemical Equilibrium and its Conceptual Difficulties, *Education in Chemistry, 14*(6), 169 – 171.

Jonassen, D., Mayes, T., & McAleese, R. (1993). A Manifesto for Constructivist Approach to uses of Technology in Higher Education. In T. M. Duffy, J. Lowyck, & D.H. Jonassen (Eds.), Designing Environment for Constructive Learning (pp. 231 – 247). Heidelberg: Springer – Verlag.

Kaminski, B., Jansen, W., & Flint, A. (1994). *Chemical Formulae in Freshmen Chemistry Courses, 1*(4), 183 – 188.

Keig, P. F., & Rubba, P. A. (1993). Translation of Representations of the Structure of Matter and its Relationship to Reasoning, Gender, Spatial Reasoning, and Specific Prior Knowledge. *Journal of Research in Science Teaching, 30(* 98), 883 – 903.

Kellett, N., & Johnstone, A. H (1974). Condensation and Hydrolysis – An Optical Problem*?* *Education in Chemistry, 11*, 111 – 114.

Kempa, R.F, & Diaz, M. (1990). Motivational Traits and Preference for Different Instructional Modes in Science, *International Journal of Science Education, 12* (2), 195-203

Kempa, R. F. (1983). Learning Theories and the Teaching of Science: Implication for Science Teacher Training. In P., Tamir, A. Hotstein, and M., Ben – Peretz, Pre Service and In Service Training of Science Teachers. (Balaban International Science Services: Philadelphia, U.S.A).

Kempa, R.F., & Nicholls, C. (1983). Problem Solving Ability and Cognitive Structure – An Exploratory Investigation. *European Journal of Science Education, 5*(2), 171 – 184.

Krishman, S. R., & Howe, A.C. (1994). The Mole Concept: Developing Instrument to Assess Conceptual Understanding*, Journal of Chemical Education, 71*(8), 653 – 655.

McAlecse, R. (1993). A manifesto for a constructivist approach to uses of technology in higher education. In T. M. Duffy, J. Lowyck, & D. H. Jonassen (Eds.), Designing environments for constructive learning (pp. 231 – 247). Heidelberg; Springer – Verlag.

Millar, R. (1998*). Rhetoric and Reality. What Practical Work in Science Education is real for?* In J. Wellington (Ed.), Practice work in school science (pp. 16 34). London Routledge.

Miller, G. D. (1956). The Magical Number Seven plus or Minus Two: Some limits on our Capacity for Processing Information, Psychological Review 63, 81 – 97

Ministry of Education (2004). New education reform programme: Ministry of Education.

Ministry of Education (2006). *New education reform implementation document*. Accra Ministry of Education.

Ministry of Education (2006). New education reform implementation document. Accra Ministry of Education.

Mitchell, I. J., & Gustone, R. F. (1984). Some Students‟ Conceptions brought to the study of Stoichiometry. *Research in Science Education, 14*, 78 – 88.

Modermott, L. (1984). Research on Conceptual Understanding in Mechanics, Physics Today, 37, 4 – 32.

Nakhleh, M. (1992). Why some Students do not Learn Chemistry; Chemical Misconceptions, *Journal of Chemical Education, 6* (3), 191 – 196.

Nakhleh, M. B., & Mitchell, R.C. (1993). Concept Learning Versus Problem solving: These are on Difference. *Journal of Chemical Education, 70*(3), 190 – 192.

Nicoll, G. (2001). A Report of Undergraduates‟ Bonding Alternative Conceptions, International Journal of Science Education, 23(7), 707-730.

Norman, E. W. (2000). How to Design and Evaluate Research in Education. New York: MC Graw – Hill companies.

Novak, J. D. (1977). A Theory of Education, Cornell University Press, Ithaca, N.Y.

Osborne, J.R., & Cosgrove, M.M. (1983) Children‟s Conceptions of the Changes of State of Water, Journal of Research in Science Teaching, 20(9), 825 – 838.

Osuala, E. C. (1991). Introduction to Research Methodology. NW, Province Cameroon. African - FEP Publishers Ltd.

Otis, K. (2001), Metacognition: A Valuable Aid to Understanding for Medical Students in Problem Based Learning. PhD Thesis, University of Glasgow, 2001.

Packer, J. E. (1980). Letters to the editor titrimetric calculations, *Education in Chemistry*, 17, 154.

Pattorn, M. (2002). Qualitative Evaluation Methods, (2nd ed.). Thousand oaks, CA; Sage.

Peterson, R. F., & Treagust, D.F. (1989). Grade – 12 students‟ Alternative Conceptions of Covalent Bonding and Structure, *Journal of Chemical Education, 66*(5), 459 – 460.

Piaget, J. (1970). Piaget‟s Theory. In P.H. Mussen (Ed) Carmichael‟s Manual of Child Psychology, 1(3), 703 – 732.

Prawat, R. (1996). Constructivism, Modern and Postmodern. *In Educational Psychology, 31*(3/4), 215 – 225.

Quiles – Pardo, J., & Solaz – Portol‟es. J. J. (1995). Students and Teachers Misapplication of le Chatelier‟s Principle: Implications for Teaching of Chemical Equilibrium. *Journal of Research in Science Teaching 32*, 939 – 967.

Ravialo, A. (2001). Assessing Students‟ Conceptual Understanding of Solubility Equilibrium, *Journal of Chemical Education, 78*(5), 629 – 631.

Reid, N. (1999). Towards an Application led Curriculum, *Staff and Educational Development International. 3*(1), 71 – 84

Reid, N. (2000). The Presentation of Chemistry; Logically driven or Application led? Chemistry Education: *Research and Practice in Europe, 1*(3), 381 – 382.

Resnick, L. B. (1987). Learning in School and out, Educational Researcher, 16, 13 – 20.

Ross, A. R., & Lewin, K.M. (1992). Science Kits in Developing Countries; An Appraisal of Potentials. Paris, UNESCO IIEP.

Rossa, E. (1998). Das Mol in Bild [The mole in a picture], chemic in der schule, 45, 8 – 13.

Salvaratnam, M. (1993). Coherent, Concise, and Principle – Based Organization of Chemical Knowledge, Journal of Chemical Education, 70(10), 824 – 826.

Sarantakos, S. (1995). *Social Research*. The Macmillan press Ltd.

Sawrey, B. A. (1990). Concept learning versus Problem solving – revisited, *Journal of Chemical Education, 67*(3), 253 – 254.

Scerri, E.R. (2003). Philosophical Confusion in Chemical Education. *Journal of Chemical Education, 80,* 468 – 474.

Schmidt, H. J. (1990). Secondary School Students‟ Strategies in Stoichiometry. *International Journal of Science Education, 12*, 457 – 471.

Schmidt, H. J. (1994). Stoichiometric Problem Solving in High School Chemistry. *International Journal of Science Education, 16,* 191 – 200.

Schmidt, H. J., & Jigneus, C. (2003). Students‟ strategies in solving algorithmic stoichiometry problems. *Chemistry Education: Research and Practice, 4,* 305 – 317.

Sirhan, G. (2000). A study of the Effects of Pre – learning with First Year University Chemistry Students, Ph D Thesis, University of Glasgow.

Sirhan, G., & Reid, N. (2001). Preparing the Mind of the Learner – Part 2. *University Chemistry Education, 5*(2), 8.

Sirhan, G., & Reid, N. (2002). An Approach in Supporting University Chemistry Teaching. *Chemistry Education: Research and Practice in Europe, 3*(1), 65 – 75.

Sirhan, G., C., Johnstone, A. H., & Reid, N. (1999). Preparing the Mind of the Learner, University Chemistry Education, 3(2), 43 – 47.

Song, J., & Black, P. (1991). The effects of Task contexts on pupils‟ performance in science process skills*, International Journal of science Education, 13*, 49 – 53

Stavy, R. (1988), children‟s conception of Gas. *International Journal of science Education 20,* 533 – 560.

Stavy, R. (1991) Using Analogy to overcome Misconceptions about Conservation of Matter. *Journal of Research in Science Education, 84* (4), 305 – 313.

Stavy, R. (1995). Learning Science in the Schools (Hillsdate, NJ: Research In Forming Practice; Lawrence Erlbaum), 131 – 154.

Su, W. Y. (1991). *A Study of Student Learning through Lectures Based on Information Processing Theory*, Ph. D. thesis, University of Glasgow.

Taber, K. S. (2000). Chemistry Lessons for Universities: A Review of Constructivist Idea. *University Chemistry Education 4:* 26 – 35

Taber, K. S. (2002*). Alternative Conceptions in Chemistry*; Prevention, Diagnosis and Care. London the Royal Society of Chemistry.

Toth, Z., & Kiss, E. (2005). Hungarian Secondary School Students" Strategies in Solving Stoichiometric Problems. *Journal of Science Education, 6,* 47 – 49.

Treagust, D. F. (1988). Development and Use of Diagnostic Tests to Evaluate Students" Misconceptions in Science. *International Journal of Science Education, 10* (2), 159 – 169.

Treagust, D. F., Chittleborough, G., & Mamiala, T.L. (2003). The Role of Submicroscopic and Symbolic Representations in Chemical Explanations. *International Journal of Science Education 5*:1353 – 1368.

Trumper, R. (1995). Students" Motivational Traits in science: A cross – Age study. *British Educational Research Journal, 21(*94), 505 – 515.

Vallerand, R. J., & Bissonnette, R. (1992). Intrinsic, and a Motivational styles as Predictors of Behaviour; A Prospective study. *Journal of personality, 60,* 599 – 620.

Wallen, N. E., & Frankel, J.R. (1998*). Educational Research: A Guide to the Process*. New York: MC Graw – Hill.

Wandersee, H., Mintzes, J. J., & Novak, J. D. (1994). *"Research on Alternative Conceptions in Science"*. In Handbook of Research of Science Teaching and Learning, ed. by Gabel, D.L., p. 198, New York; Macmillan

Ward. R., & Bodner, G. (1993). How Lecture can Undermine the Motivation of our Students. *Journal of chemical Education, 70*(3), 198 – 199.

West African Examinations Council (2009). Chief Examiners" Report, Accra; West African Examination Council.

West African Examinations Council (2010). Chief Examiners" Report. Accra; West African Examinations Council.

White, R. (1977). Model of Cognitive Processes, *Research in Science Education, 7*, 25 – 32

White, R. (1988). *Learning Science*, Oxford: Basil Blackwell.

Williams, D. G. (1980). Letters to the Editor Titrimetric Calculations, *Education in Chemistry, 17*, 182.

Woolnough *Science*, B. E. (1998*). Practical.* Milton Keynes: Open University Press.

Yin, R, (1994). *Case Study Research; Design Methods. (2nd ed.)* Thousand Oaks, CA: Sage.

Zoller, U. (1990). Students" Misunderstandings and Alternative Conceptions in College Freshman Chemistry (General and Organic), *Journal of Research in Science Teaching, 27*(10), 1053 – 1065.

APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA

INVESTIGATING THE LEARNING DIFFICULTIES OF CHEMISTRY STUDENTS IN SOME SELECTED COLLEGES OF EDUCATION

QUESTIONNAIRE FOR STUDENTS

This questionnaire seeks to solicit information on the learning difficulties of chemistry students in selected Mathematics and Science Colleges of Education. I would be grateful to you if you could respond to the items on the questionnaire as objectively as possible. You are being assured your responses will be kept strictly confidential.

Thank you for your cooperation.

You may respond to each of the items by filling the spaces provided.

Part 1

1. Which science subjects did you offer in the senior high school?

……………………………………………………………………………………………

……………………………………………………………………………………………

2a. if you took chemistry, give the reason.

……………………………………………………………………………………………

……………………………………………………………………………………………

b. Which grade did you obtain in chemistry?

……………………………………………………………………………………………

……………………………………………………………………………………………

3. Which is your best science subject?

……………………………………………………………………………………………

……………………………………………………………………………………………

Part 2

Respond to each of the items in the table by ticking ☐ the preferred option.

The option are SD = Strongly Disagree, D = Disagree, A = Agree, SA = Strongly Agree

A. Students' problem in learning Chemistry.	**SD**	**D**	**A**	**SA**
1. Students perceive chemistry to be a difficult subject.				
2. Students find it difficult solving questions that involve symbols and numbers in chemistry.				
3. Students memorize concepts in chemistry without understanding them.				
4. Topics to be treated in the semester are too loaded to contain.				
5. Students have difficulty in understanding the meaning of vocabularies and terms used in teaching chemistry.				
6. Chemistry is often taught in abstract at the Colleges of Education.				
7. Teachers do not motivate students to study chemistry.				
8. Students‟ prior knowledge is often not considered when a new concept is to be learnt.				

B. Learning Chemistry using practical activities in the laboratory	SD	D	A	SA
1. Practical activity is often used in teaching chemistry.				
2. Chemistry concepts can easily be understood when activity method is used to teach it.				
3. Practical activities enable students to develop practical skills which help in understanding of Chemistry.				
4. Tutors discuss practical activities with their students before performing them.				
C. Technology tools support learning of symbolic and molecular structure of compounds				
1. Teachers do not use e-chem when teaching symbolic and molecular structures of a compound.				
2. The tool, e-chem motivates students to grasp the drawing of structures of chemical compound				
3. The use of e-chem enables students to construct, visualize and analyse structures of chemical compounds.				
D. Availability of facilities for teaching and learning of Chemistry				
1. Students often do not have access to Chemistry laboratory.				
2. Chemistry laboratory is not well equipped with teaching and learning materials in my college.				
3. Facilities in the chemistry laboratory do not motivate students to study Chemistry.				
4. Regular use of facilities by students motivates and sustains their interest in learning Chemistry.				

E. Solving mole concept problems				
1. Students find it difficult to solve problems involving calculation on mole concept.				
2. The use algorithms methods to teach the mole concept.				
3. Teachers use proportional method to solve problems on the mole concept.				
4. Teachers use logical reasoning to solve problem on the mole concept.				

The option are SD = Strongly Disagree, D = Disagree, A = Agree, SA = Strongly Agree

APPENDIX B

UNIVERSITY OF EDUCATION, WINNEBA

INVESTIGATING THE LEARNING DIFFICULTIES OF CHEMISTRY STUDENTS IN SOME SELECTED COLLEGES OF EDUCATION

QUESTIONNAIRE FOR TUTORS

This questionnaire seeks to solicit information on the learning difficulties of chemistry students in selected Mathematics and Science Colleges of Education. I will be very grateful if you could respond to the items on the questionnaire as objectively as possible. You are being assured your responds will be kept strictly confidential.

Thank you for your cooperation.

Respond to each of the item by ticking ☑ preferred option.

Part 1

1. What is your academic qualification?

BEd. Sc ☐ **B. Sc** ☐ **M. Sc** ☐ **M Phil** ☐ **Ph. D** ☐ **M Sc** ☐

2. **Which science subject did you major in?**

Chemistry ☐ **Physics** ☐ **Biology** ☐ **Agriculture** ☐ **Integrated science** ☐

3. **List the challenging topics encountered below.**

i. ……………………………………………………………………………

ii. ……………………………………………………………………………

Part 2

Respond to the items in the table by ticking ☑ the preferred option.

The option are SD = Strongly Disagree, D = Disagree, A = Agree, SA = Strongly Agree

	SD	D	A	SA
A. Students' difficulty in learning chemistry.	**SD**	**D**	**A**	**SA**
1. Chemistry is perceived by students to be difficult.				
2. Teaching some challenging topics in Chemistry is difficult.				
3. Chemistry topics are too loaded for the students.				
4. Students find it difficult to understand major fundamental concepts in chemistry.				
5. Students find it difficult to understand the meaning of terms/ vocabularies used during instructional periods.				
6. Chemistry is perceived as an abstract subject.				
7. Students lack self motivation.				
8. Students" prior knowledge is often related to new concepts to be learnt.				
B. Using practical activities to learn chemistry.				
1. Tutors use practical activities to teach chemistry.				
2. Practical work is normally linked to the theory to be learnt.				
3. Practical activities help to develop practical skills of students.				
4. Practical activities help to sustain students" interest in learning chemistry.				
5. Practical activities are discussed with the students before they are carried out.				
C. Availability of facilities for teaching and learning of Chemistry	**SD**	**D**	**A**	**SA**
1. Students have equipment for laboratory work.				
2. Chemistry laboratory is adequately equipped with teaching and learning materials in my college.				
D. Using technology tool to support the learning of Chemistry.				
1. The tutors have the technological tool, e-chem, in their College.				
2. Technological tool, e-chem is used by teachers when teaching symbolic and molecular structures of compounds.				
3. Teachers are not familiar with the e-chem.				
E. Solving mole concept problems				
1. Students hardly understand mole concept.				
2. Teachers find teaching of mole concept very challenging.				

3. Algorithm (mole) method is often used by teachers to teach problems involving mole concept.				
4. Teachers do not vary their methods of teaching the mole concept.				