UNIVERSITY OF EDUCATION, WINNEBA

THE STATUS OF THE TEACHING AND LEARNING OF BIOLOGY IN SELECTED SENIOR HIGH SCHOOLS IN THE VOLTA REGION OF GHANA

GAMELI AHORLU

2013

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GAMELI AHORLU

A THESIS IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE EDUCATION SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF PHILOSOPHY DEGREE IN SCIENCE EDUCATION

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DECLARATION

Student's Declaration

I, GAMELI AHORLU, hereby declare that this thesis, 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 that it has not been submitted, either in part or whole, for another degree elsewhere.

....

Gameli Ahorlu Date

Supervisors' Declaration

We hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of dissertations laid down by the University of Education, Winneba.

....

Prof. John K. Eminah Date

....

Dr. J. Nana Annan Date

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DEDICATION

DEDICATED TO

MY HELPER

My helper

And my helpers

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ABSTRACT

The study investigated the status of the teaching and learning of biology in selected senior high schools in the Volta Region of Ghana. Data was collected from 21 biology teachers and 295 students in the selected schools. The main instrument was a questionnaire but was supplemented with interviews and observations. The content validity of the main instrument was determined with the help of the supervisors of the study. The target population comprised the 72 senior high schools in the Volta Region of Ghana. The accessible population however consisted of 17 senior high schools in the Ketu, Kpando, Ho and Hohoe Districts. Twelve schools from the accessible population were sampled for the study using stratified random sampling techniques. The 12 schools comprised 3 schools each from category A, B, C and D schools in the study area. The study revealed that although on the whole the biology teachers were academically qualified, their output in some cases were unsatisfactory. It was also found that practical activities were not organized in some schools. Additionally, practical activities were not being organized as expected in some of the schools. Among other recommendations, it was suggested that biology laboratories should be well equipped. It was also recommended that biology teachers should be supplied with handbooks to aid their instructional functions.

CHAPTER ONE

INTRODUCTION

Overview

This chapter contains information on the background of study, statement of the problem, the purpose of study, educational significance of the study and the research questions addressed by the study. It ends with the presentation of the limitations and delimitations of the study.

Background to the Study

After independence in 1957, the government of Ghana realized that the type of formal educational system inherited from the colonial masters was not compatible with her development aspirations. Equipping the Ghanaian child with scientific knowledge and skills has been the ardent desire of many well-meaning Ghanaians since independence. This was underscored by Dr. Kwame Nkrumah, the first President of Ghana, in one of his sessional addresses to parliament on the 15th of August, 1963. He said "We must ensure that our children from the earliest stages of education are given a lively interest in science and scientific pursuits".

Since then, the direction of science education has been set to train students to play meaningful and effective roles in socio-economic and technological development of the country. To ensure that this objective is achieved in the ever changing needs of the society, the national curriculum has undergone continual transformation.

The Ministry of Education in September, 1987 introduced a new educational reform programme which tried to re-align the educational system and to make the students function usefully in the nation's development programme.

As a result of the reform programme, the Ministry of Education and the Ghana Education Service put in place programmes that would revamp the educational system, and make it more productive. This attempt involved the introduction of innovative science programmes at all levels of the educational ladder.

Several problems appear to be hindering the teaching of science world-wide. Kofie (1996) observed that shortage of science teachers, science equipment and poor methods of teaching affected the teaching and learning of science in the Ho District of the Volta Region. Tuffour (1989), in related studies stated that National Service personnel were recruited to teach in Junior Secondary Schools (JSS) without essential training in teaching.

Studies conducted by concerned researchers, (e.g. Eminah, 2007) have revealed serious gaps between the intended curriculum and the realities of the science classroom transactions between the learners and teachers.

According to CRDD, (2008) the aims of senior high school biology teaching are to develop:

(i) Knowledge and awareness of the natural environment

(ii) An awareness of the application of biology teaching in the home;

(iii) Understanding of and the importance of technology/biotechnology;

(iv) Scientific attitudes;

(v) Good attitude to biology,

(vi) Practical (drawing) skills;

(vii) Manipulative skills;

(viii) Logical thinking skills; and

(ix) Problem-solving skills

Sokolove (1998) found-out that students excelled in biology when teachers involved them in hands-on activities. He contended that hands-on activities such as the handling of biological specimens in the laboratory improved scientific skills and confidence. It also gave them the opportunity to use biological knowledge to answer questions and solve problems. The New Educational Reform in biology at the Senior High School (SHS) had attached importance to the use the activity method in schools rather than passively reading about biology for the mere acquisition of knowledge (CRDD, 2008).

The importance of science and for that matter biology, in the school curriculum from the basic level to the senior high school level to the tertiary level reflects accurately the vital role played by the subject in contemporary society. The importance of the subject is not restricted to the development of the individual alone but for the advancement of the social, economic and political goals of the countries all over the world (Yeboah, 2008).

In every teaching-learning process, the teacher is a very important figure. He/she is more often than not blamed for the failure of students in most external examinations. It appears that teachers have been found wanting in certain aspects of their instructional functions. Voss and Brown (2006) emphasized the need to motivate future biology teachers along productive lines to teach the subject successfully. Seawell (1970) and Eminah (2007,

2009) have said that a science lesson could not be taught successfully without adequate pieces of apparatus and thorough preparation on the part of the science teacher. The key to teaching biology successfully is the instructors' ability to make the subject exciting to his/her students. Voss and Brown (2006) have noted that the key to the success of teaching biology is the teacher himself. Although there are several ways of teaching biology, there are stereotyped ways of teaching biology students in Ghana.

Many teachers rely heavily on the dictation of notes to their students while teaching, a practice which reduces entirely both student-teacher and student –student verbal interactions. The students apparently become passive listeners and perceive the teacher as the "brain bank". This method is popular among teachers because it is easier to use. The lecture method leads to early completion of the syllabus. This method also gives very little attention to practical work. This makes the subject appear abstract to the students. According to the West African Examinations Council (WAEC) Report (2005), biology practical work in Senior High Schools appears to be sacrificed and this is evident by the quality of answers to questions demanding practical experience. Findings reported by Yeboah (2008) indicated similar student poor performances in biology at the SHS level. It is to be noted however that Yeboah's study focused on SHS biology students in the Eastern Region of Ghana.

A search of the available literature revealed that no study was focused on biology teaching and learning in Senior High Schools in the research area. This apart, the researcher's personal experience, coupled with his interactions with seasoned science educationists indicated that there were gaps between the expected performance of SHS biology students and their actual output in their final examinations. The above mismatch occasioned this study

Statement of the Problem

Educators have given special recognition to biology among the sciences because of its close relation to the human being as a living organism, its peculiar field of experimentation and interrelationships with the other sciences. (Akinmade, 1992).The study of biology is very important to every student of the natural sciences. Many students who study biology find themselves in the field of the applied sciences such as medicine, pharmacy, agriculture, dentistry, biochemistry, and many others.

In recent times biology students have been performing poorly in their final examinations. Every year the Chief Examiner's Reports from WAEC highlights this poor performance. Records show that since the inception of the Senior Secondary School (SSS) programme as one of Ghana's educational reforms in 1987, the Chief Examiners' Reports from the West African Examination Council (WAEC) have consistently underlined the poor performance of SHS students in the sciences (WAEC, 1994; 1995; 1996; 2002; 2003; 2004; 2005; 2006; 2007; 2008; 2009).

In the case of biology in particular, most students fail or get low grades than in the other science subjects, such as physics and chemistry. Apart from the Biology Chief Examiners' Reports other concerned individuals have suggested several causes for the negative trend in the students' performance in biology. For example Akinmade (1987) reported that some students perceived biology as the easiest among the pure science subjects. Also Abdul-Mumuni (1995) stated that students' poor performance in biology resulted from their negative attitudes towards the subject. This he noted was the cumulative effect of the students' social, religious, and cultural background.

On the contrary, Shaibu and Olawareju (2007) reported that some students perceived biology as being too difficult compared to physics and chemistry. Yeboah (2008) on his part noted that the poor teaching methods, the ineffective communication of biological ideas during lessons coupled with inadequate practical work interacted to cause the students to perform poorly in their biology examinations. Yeboah also noted that the dismal performance of biology students is not limited to any one part of the country.

In the study area biology students have consistently performed below expectations. This was manifested in academic records in senior high schools in the Region (WAEC, 2004 – 2010). It is to be noted that there are wide differences in the educational provisions among the schools in the research area. For example while some schools are classified as Grade A, others are Grade B, Grade C, or Grade D Schools-all offering biology as an elective subject (GES, 2008).

Although studies focused on the teaching and learning of biology have been conducted in the Central and Eastern Regions (Yeboah, 2008, Brako, 2007, Sampah, 2010, Abass, 2008) no study was found that dealt with the state of biology teaching and learning in the research area. For this reason, this study was designed to determine the causes of the overall poor performance of elective biology students in the subject. With the continued failure of an appreciable proportion of biology students in their final examination, their prospects of academic and social advancements and hence their contribution to the socio-economic development of the country would be severely handicapped.

Purpose of the Study

The purpose of the study is to find out how biology is taught, and learnt in selected senior high schools in the Volta Region of Ghana.

The study focused on the following areas:

a) School specific factors, including classroom transactions between the learner and the teacher, class sizes in selected schools, availability of textual materials for biology teaching and learning

b) Teacher factors.

c) Instructional factors, such as teaching methods adopted by teachers during biology lessons.

d) Educational provisions and resources.

e) Evaluation of the promptness with which the assignments of the students and class exercises are marked and scored.

Research Questions

This research focused on the following questions:

1) What is the academic background of the biology teachers in the selected senior high schools?

2) What are the predominant instructional materials in the schools and how are they used during biology lessons?

3) How are the theory and practical lessons taught in the senior high school and what influences the selection of a particular teaching method?

4) What are the perceptions of students and teachers on the practical aspect of biology?

5) How do the students and teachers perceive biology in relation to the other pure science subjects?
6) Which support services are available to enable the biology teachers update their knowledge and skills?

Significance of the Study

The goal of the thesis is to study the teaching and learning of biology in selected Senior High Schools in the Volta Region. At the end of the research, it is expected that constructive suggestions will be useful to policymakers, teachers and students as a way forward to improving teaching and learning of biology in order to improve students' performance in the subject.

Limitations

The study should have covered all the Senior Secondary schools in the Volta Region but due to financial constraints and other limited resources such as lack of adequate time, only selected senior high schools in the Volta Region were used for this research.

The use of structured questionnaires alone might not give a true reflection of what is expected from the teachers and students, since they might give false information for fear of victimization. Frequent visits to observe status of teaching and learning may improve the reliability of the findings.

Delimitations

The participants of this study were biology teachers and elective biology students from the selected public senior high schools in the Volta Region of Ghana.

Elective biology students selected for this purpose were in SHS 2. This was because the SHS 3 students were at the time preparing for their examination and SHS 1 were also not involved because they have just been admitted into SHS1 and have not been able to cover many aspects of topics in biology. The total number of schools used for the study was 12 and 295 students.

Definition of Terms

Professional teachers: Teachers with a teaching qualification

Non-professional teachers: Teachers without any teaching qualification.

Old Mawulian: Past student from Mawuli School

Abbreviations

C.R.D.D:	Curriculum Research Development Division of Ghana Education Service.
DNA:	Deoxyribonucleic Acid.
GAST:	Ghana Association of Science Teachers
G.E.S:	Ghana Education Service
G.N.P:	Gross National Product
HIV:	Human Immune Deficiency virus
HND:	High National Diploma
I.G.B.P	International Geosphere and Biosphere Program
I.H.D.P	International Human Dimension of Global Change
J.S.S:	Junior Secondary School
ÖSS	Öðrenci Seçme Sýnavý (Turkish: National University Entrance Exam)
R.Q	Research Question

SHS:	Senior High School
S.S.S.C.E:	Senior Secondary School Certificate Examination
S.S.S:	Senior Secondary School
S.P.S.S:	Statistical Package for the Social Sciences (SPSS version 16)
S.R.C :	Science Resource Centre
STMIE:	Science Technology Mathematics Innovation Education
S.T.O.S:	Science Teaching Observation Schedule
U.E.W:	University of Education, Winneba
W.A.E.C:	West African Examinations Council
W.A.S.S.C.E:	West African Senior Secondary School Certificate Examination
U.M.Y.U:	Umaru Musa Yar Adua University

Organization of the Research Report

This research report was presented in five chapters.

The **first chapter** dealt with the background of study, statement of the problem, purpose of the study, research questions, and significance of the study and limitations as well as the organization of study.

The literature review on the study constituted chapter two.

Chapter three dealt with the methodology. This comprised with the design of the study, population, sample and sampling techniques used, instrument and data collection procedure; as well as the procedure for analyzing the data.

Chapter four, dealt with the presentation and analysis of data. The **final** chapter dealt with the discussion of findings and the recommendations.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Overview

This chapter contains the review of the literature related to the study and theoretical framework related to the study. This literature review will be done under the following headings:

- The Aims of Teaching and Learning of Biology in Second Cycle Institutions
- New Educational Concepts and Approaches to Biology Education
- Goals for Learning, Discrepancies, and Matching Goals with Practice in the Biology Classroom
- The Various Methods Used in the Teaching of Biology
- Communication in the Biology Classroom, Reading and Understanding of Biology Texts in the Biology Classroom
- Suitability of Biology Books for Classroom Instruction
- Teaching of Practical Lessons in Biology
- Learning Science in the School Laboratory
- Students' Attitudes towards Practical Work in Biology
- Students' Perceptions of the Laboratory Learning Environment
- Assessing Students' Skills and Understanding of Inquiry
- Professional Qualification of Biology Teachers in the S.HS
- Relevance of Academic Background and Qualification of Teachers
- Knowledge of Teachers of the Syllabus and Chief Examiners Reports

The Aims of Teaching and Learning of Biology in Second Cycle Institutions

Generally speaking, education represents the domain through which humankind proceeds to transmit, consolidate and develop into human culture, the ensemble of knowledge systems, science, arts, values and religions. In a report entitled "Learning - the Treasure Within," presented in 1996 to UNESCO, Jacques Delors, former President of the European Commission, and his colleagues recommended that education must be given top priority on the agenda of nations. Priority to the role of education in providing citizens with a 'passport to life' with which they learn to be, learn to know, learn to do and learn to live together (Tobin, 1990).

Educational activities now represent a major occupation of human societies. In-school education is a full-time occupation of a large part of the world's population (more than one billion students and 20 million teachers, in 1992), and occupies, on average, one quarter of every individual's life. Increasingly some form of out-of-school education is pursued throughout life. From an economic point of view, the world expenditure on formal education in 1996 totalled approximately 1,200 Billion US$ (an average 5.1% of the world GNP). This budget represents the largest investment in the national accounts of many countries, yet it is still considered insufficient to cover actual needs.

During the 1990's, with their eyes fixed on the approaching year 2000, a large number of governments, national and international organizations and groups engaged in a trendy exercise. They participated at large scale conferences with the express aim to assess past achievements and failures, reap the lessons gained throughout the 20th century and identify the key challenges facing humankind at the beginning of the new Millennium.

The first such event was the Earth Summit on Environment and Development held in 1992 in Rio-de-Janeiro, followed by the World Population Conference in 1994 in Cairo, the World Conference on Higher Education in 1998 in Paris, and the World Conference on Science in 1999, in Budapest, Hungary. From these fora, there emerged a world consensus on the role of education, science and technology as the prime movers and most decisive factors of development. International programmes and action plans were launched: the Agenda 21, Education 2000+, Taxonomic Agenda 2000, Species 2000, and the Programmes 'International Geosphere and Biosphere Programme (IGBP), and the International Human Dimension of Global Change (IHDP), etc.

The recent history of human societies shows how scientific and technological progress have helped trigger economic, social and cultural development. In the 19th century, advances in physics, chemistry and engineering contributed to the industrial revolution.
And in the 20th century, advances in agricultural sciences, physiology, genetics and breeding of plants and animals provided the basis for the agricultural (green) revolution; new knowledge in microbiology, immunology, medical and pharmacological sciences helped reduce the toll of diseases, and resulted in an increased life expectancy.

The discovery of the DNA structure and function ignited a biological revolution which will continue and expand during the 21st century. Deciphering the genetic code (alphabet) represents an essential step in the human endeavour to read the book of life, unravel the complexity of biological systems (molecules, cells, organisms and ecosystems), and perceive the unity of life through the diversity of living forms. Progress in the biological sciences is not only bringing about an understanding of the evolutionary processes and pathways which led to the present world, but also giving the humankind the power to modify drastically the course of biological evolution, including his own.

Like other scientific disciplines, biological sciences form a part of the overall human culture, which represents a specific evolutionary trait of *Homo sapiens* and marks the border line with other primate species. However, whereas biological traits are transmitted between generations through reproduction and modified through mutation processes, cultural traits (values and knowledge) are inherited and modified (scientific and technical innovations) through education, i.e., the ensemble of learning, training and research processes.

In all these processes, biological education, education about life, education through life and education for life, occupies the center stage. New biological knowledge during the second half of the 20th Century, impressive achievements and breakthroughs have been made in the fundamental and applied knowledge of the living world, with far reaching implications impacting almost every aspect of human life and society. At the micro-level, the development and use of sophisticated molecular biology techniques have lead to a revolution and the emergence of new disciplines, such as Molecular Biology, Molecular Genetics, Molecular Evolution and Genomics.

Tremendous progress and breakthroughs have been achieved in our understanding of animal and plant reproduction and development, and more generally, our understanding of evolutionary processes. At the macro-level, the development of new concepts, new approaches and techniques, and the use of modelling, remote sensing and informatics are bringing about a revolution in the ecological sciences and the emergence of subecological disciplines such as Functional Ecology, Landscape Ecology, Global (Biosphere) Ecology and Ecological Networks. The biological sciences have seen the emergence of important interdisciplinary scientific domains, such as biodiversity, bio-complexity and integrative biology.

A new perception and formulation of the world problematique emerged at the Earth-Summit of 1992, in Rio-de-Janeiro, Brazil, replacing the traditional and fragmented vision of the problems facing human societies (individually and collectively). There is now a better understanding of the relationships and interconnections between the problems affecting human health, food and environment, problems related to agriculture and agro-industry, fisheries and aquaculture, pharmaceutical industry and biotechnologies, the problems of pollution (physical, chemical and biological), as well as problems related to the conservation and management of biological resources (deforestation, desertification, soil salinization and loss of biodiversity, etc.)

The new problematique that emerged at the Rio Summit is based upon a trilogy consisting of biodiversity, global change and sustainable development.

The awareness of biodiversity at the three levels of biological organization: the genetic, organismic and ecological levels (Di Castri & Younès, 1996), highlighted the need to better understand such issues as the origins, maintenance and change of biodiversity over space and time scales, the ecosystem function of biodiversity and the many hidden ecological services it provides to humankind, the need to better conserve and manage the biodiversity of terrestrial, marine and inland-water systems, providing clues of how to restore degraded ecosystems. There is also a growing perception for the need to take into consideration the human dimension of biodiversity and, in particular, cultural diversity.

The second important issue, the global change and globalization phenomena, has been considered at the environmental, economic, and information/communication levels. Pollution problems do not recognize political boundaries between states, and global warming and ozone holes affect the whole biosphere. To face these problems, it is necessary to form a global coalition, with all nations working hand-in-hand, if we are to succeed. The third and last “mot d'ordre” of the trilogy consists in sustainable development. This new concept, developed during the Earth Summit, aims at promoting a much needed solidarity over both space and time scales. On the geographical scale, this means a solidarity between North and South, between developed and well-off nations and the developing poor countries of the third world. And, over a time scale, it implies solidarity with the future generations, taking into consideration the well-being of the generations to come, and leaving their options open. Facing these challenges, research, training and education in science, particularly biology, are pre-requisites if we are to succeed in bringing about an economically efficient, socially equitable and environmentally sustainable development.

New Educational Concepts and Approaches to Biology Education

The goals, scope and content of biological education vary greatly with its target populations and the groups and parties involved in its implementation. Biological education means different things to different people. For biology researchers, education means the acquisition of the scientific knowledge, data and techniques that are necessary to perform research projects. For developers, professionals and engineers in a large variety of domains such as agriculture, health, industry, biotechnology and environment, education must provide the biological foundations underlying their respective domains of expertise. And for the general public, the principal aim of biological education, whether at schools (primary and secondary) or through the media, must be to develop citizens' biological literacy, i.e., provide them with the core biological knowledge, the ability to formulate questions, and an idea of how and where to look for answers, in order to help them to participate responsibly in the life of the society.

The diversity of the objectives assigned to biological education reflects its social function which is to re/produce knowledge, apply it and adapt to its impact on society. Therefore, addressing the challenges of biological education for the next century requires taking into consideration not only the new problematique and new scientific knowledge, but also to address the ethical dimension of biological sciences as well as the new findings of research on education processes and learning theory.

Biology, psychology and cognitive sciences are generating knowledge about how the human brain learns; and have shown us that we can use this knowledge to intervene effectively in the learning process of virtually any and all humans beings. In a comprehensive study of the theory of learning, Giordan (1998), explains that learning is better achieved through a process of deconstruction. Concepts have evolved from the old passive process, whereby teachers passed or communicated their knowledge to students considered as empty containers; to the behaviourist and constructivist approach by which the teachers help the learners to construct knowledge, moving from the simple to the complex and from the specific to the general; and finally the development of a more active approach, whereby the re-construction of knowledge follows a necessary phase of deconstruction, i.e. a process by which the knowledge is generated (appropriated) by the learners themselves. The adoption of this new learning concept has important consequences for the organization and functioning of educational institutions and curricula, the definition and practice of the respective roles of teachers versus learners, and the relationship between knowledge acquisition and learners' attitudes, behaviour and ability to adapt to complex and ever-changing environments.

The development of the deconstructivist concept and the reconstructivist approach have led to more educational institutions adopting a new method of "learning science as scientists do." Students are invited to participate in research projects designed for them and the results of which are presented at major scientific congresses and published. At the AAAS Congress in 1999, held in Anaheim, USA, there were two major poster sessions with hundreds of 'young' scientists (students at secondary schools) presenting their research results. Another important consequence of adopting the re-constructivist approach consists in its great potential to reinforce the societal relevance of biological education, i.e., the link between science education and the needs of society, which, in turn, calls for the development of ethical dimensions of science education.

Today, the statement that “If only biologists knew what biology knows” is more true than ever (Hofstein and Lunetta, [1982], pp. 22). The explosion of scientific knowledge and the rapid production and accumulation of staggering amounts of scientific data and information are creating the need for knowledge management, i.e., knowledge about knowledge. Actually, knowledge management is about learning. It is impossible for educational systems to cover all domains of knowledge, there is a need for school science curricula to provide citizens with basic scientific literacy, i.e., a common core of understanding, a knowledge basis and the intellectual ability to formulate questions and find answers. At the same time, the explosion of scientific and technological knowledge is introducing new concepts and tools for distance learning, new access to the world storehouse of knowledge, and new interpersonal and group communication capabilities.

Two subsequent approaches will also be needed: (i) to develop mechanisms for "learning on demand" within. (ii) a framework for continuous, life-long education. The success of such an endeavour will mark the passage of education to the society.

Biological training and education will be more and more about knowledge management than the simple traditional teaching of scientific data. Increasingly, modern Information and Communication Technology (ICT) is being developed and used for education in-school and out-of-school situations. In the developed countries, more and more ICT educational material, CD-ROMs and/or online education tools are becoming more available for learners. Modelling and simulation games are being developed. Benefits of introducing ICT are numerous, to mention but a few: increasing interactivity, availability of immediate links with almost an infinite world library, encouraging group work, and providing good tools for auto-evaluation.

However the development of ICT in education, and in particular in biological education is still in its infancy. There is here a large domain for development and research towards reconsidering the learners and teachers' functions and role and rethinking the structure of the school, college and university.

Parallel to the explosion of scientific knowledge, the emergence of a new problematique, and the development of new concepts, approaches and tools, there also are a host of new parties with huge stakes and interest in biological education. Among these parties, there are natural partners wishing to strengthen their role in biological education, such as botanical gardens, national parks and nature reserves, and natural history museums, and science centres. In addition, a large number of organizations, foundations, and agricultural and industrial corporations (pharmaceutical industries and biotechnology) are concerned with and, to a certain extent, involved in the development of biological education programmes.

Goals for Learning, Discrepancies, and Matching Goals with Practice in the Biology Classroom

In their review, Hofstein and Lunetta (1982) wrote that laboratory activities offer important experiences in learning science that are unavailable in other school disciplines. For well over a century, laboratory experiences have been purported to promote key science education goals including the enhancement of students':

- Understanding of scientific concepts
- Interest and motivation
- Scientific practical skills and problem solving abilities
- Scientific habits of mind (more recent)
- Understanding of the nature of science (more recent)

In 1983, the National Commission on Excellence in Education (1983) in the United States of America, published *A Nation at Risk: The Imperative for Educational Reform*. This frequently cited report (in the 1980s and 90s) offered recommendations for schooling in the United States that promoted the movement toward National Standards. Recommendations included those noted above and emphasized that high school science should provide graduates with experiences in

- methods of scientific inquiry and reasoning and
- application of scientific knowledge to everyday life.

Often the goals articulated for learning in the laboratory have been almost synonymous with those articulated for learning science more generally. Hodson (2001) claimed that in the past 30 years the motives for laboratory/practical work have remained unchanged although relative priorities may have shifted.

To guide teaching and learning, it is very important for both teachers and students to be explicit about the general and specific purposes of what they are doing in the classroom. Explicating goals for specific *students*' *learning* outcomes should serve as a principal basis upon which teachers design, select, and use activities; the goals can also serve as the most important bases for assessment of students and of the curriculum and teaching strategies. To these ends, it is important to acquire information and insight about what is really happening when students engage in laboratory activities, i.e., we need to examine what the students are perceiving in the light of important goals for science learning.

In most school laboratory activities, the student's laboratory guide, handbook, or worksheet, sometimes delivered in electronic form, continues to play a central role in shaping the students' behaviours and learning. The guide focuses students' attention on the questions to be investigated and on what is to be done, observed, interpreted, and reported. It plays a major role in defining goals and procedures.

Lunetta and Tamir (1979) developed a set of protocols for analyzing student laboratory activities, which they used in the 1980s to analyze several secondary school science laboratory programmes systematically. Similar protocols were used more recently in Australia by Fisher *et al.* (1999). The analyses continue to suggest that to date, many students engage in laboratory activities in which they follow recipes and gather and record data without a clear sense of the purposes and procedures of their investigation and their interconnections. In addition, the quantity of information presented in the laboratory guide is often so substantial, according to Johnstone and Wham (1982), that the details can distract the learner from the main goals of the practical task. Consistent with the findings of Lunetta and Tamir (1979) and others, students are seldom given opportunities to use higher-level cognitive skills or to discuss substantive scientific knowledge associated with the investigation, and many of the tasks presented to them continue to follow a "cookbook" approach (Roth, 1994).

Hofstein and Lunetta, (1982) also reported that there were vast differences in the learning strategies implicit in different laboratory guides that were bound to influence students' learning. The nature of the instructions and especially of the evaluation shapes the expectations, purpose, and behaviours of the students in laboratory activities. Gathering and analyzing such information is a very important element of research in the laboratory that should be included in research reports. At this writing, the recommendations of science education standards and reform documents appear to have had only marginal influence on the development and publication of laboratory guides, practical assessment, and on the school laboratory practices that follow. In fact, the almost simultaneous emphasis on *conventional* paper and pencil assessment (not performance assessment) has almost certainly had a negative effect (Bryce & Robertson, 1985; Lazarowitz & Tamir, 1994). Nevertheless, there are some noteworthy exceptions such as the resources developed and implemented in the Learning through Collaborative Visualization project and the Detroit urban science initiative project and reported by Polman (1999), and others. These projects have developed curriculum and teaching strategies that incorporate constructivist pedagogy enhanced by appropriate computer and communication technology tools; they have also incorporated formative and summative research to inform and assess development and teaching in the projects.

"Inquiry empowering technologies" can assist students in gathering, organizing, visualizing, and interpreting data. Students can use probes to gather many data points rapidly.

They can also use new technology tools to gather data across multiple trials and across long time intervals (Krajcik, Blumenfeld, Marx & Soloway, 2000; Lunetta, 1998). By using associated software they can examine graphs of relationships generated in real time as the investigation progresses, and examine the same data in spreadsheets and in other visual representations. When inquiry empowering technologies are properly used by teachers and students to gather and analyze data, students have more time to observe, to reflect, and to construct conceptual knowledge that underlies the laboratory experiences. In addition, the associated graphics offer visualization that can enhance students' understanding. When students have the time, and when the activity is valued by the instructor (and by the evaluation system), they can examine functional relationships and the effects of modifying variables; they can also make and test predictions and explanations.

Such experiences also offer opportunities that may help students to perceive a more complete inquiry process rather than discrete, perhaps disconnected, segments of the process. Furthermore, incorporating appropriate high technology tools can enable students to conduct, interpret, and report more complete, accurate, and interesting investigations. Such tools can provide a medium for communication, for student–student collaboration, and for the development of a community of learners in the laboratory-classroom and beyond. Land and Zembal-Saul et al. in Press) reported that "while engaging in an original science investigation *Progress Portfolio* [software] assisted prospective teachers in developing elaborated explanations that were grounded in evidence and . . . [in exploring] alternative hypotheses."

The *Progress Portfolio* (Loh et al., in press) software was designed "to promote reflective inquiry during learning in data-rich environments. Inquiry empowering software can also "provide scaffolding to support scientific practice and can be integral in new inquiry practices" (Reiser, Tabak, & Sandoval, 2001). These tools can also assist students in supporting assertions they are making about explanations and about relationships among variables with data-based evidence. As mentioned earlier, using such tools, prompted "learners to articulate and connect their experimental findings back to the larger driving questions" and to negotiate and struggle with explaining the significance of their data. It also prompted reflective social discourse that resulted in explanation and justification (Land & Zembal-Saul, in press).

During the past 20 years there have been many optimistic claims about the potential of technology tools to enhance learning, but only a limited amount of objective information has been gathered to this date regarding the effectiveness of these technologies on important learning outcomes. This domain of research is a very important area for scholarly study needed to shape the development of state-of-the-art technology tools and teaching strategies that can facilitate more meaningful and holistic science learning.

Hofstein and Lunetta (1982) noted that interacting with instructional simulations can help students understand a real system, process, or phenomenon. They suggested that within school settings, both practical activities and instructional simulations can enable students to confront and resolve problems, to make decisions, and to observe the effects.

Whereas laboratory activities are designed to engage students directly with materials and phenomena, simulations can be designed to provide meaningful representations of inquiry experiences that are often not possible with real materials in many science topics. In such cases, simulations engage students in investigations that are too long or too slow, too dangerous, too expensive, or too time or material consuming to conduct in school laboratories.

Research findings on effective ways to use simulations are far from conclusive. However, it is well established, in general, that engaging students in appropriate simulations takes considerably less time than engaging them in equivalent laboratory activities with materials. Until carefully conducted research provides further information, it is reasonable to assume that teaching and learning practices that have been shown to be effective in promoting more effective laboratory experiences will also tend to be appropriate for students who are exploring simulations. It can be observed that some school administrators and teachers make decisions to use simulations with students instead of hands-on practical experiences (such as dissections) because the simulations are thought to be less troublesome or less expensive. Other teachers may elect to use simulations in lieu of dissections to avoid “wasting life,” or they may let students and their parents decide on the basis of their religious or moral views. It is probable that the learning that will result from engaging in a well-conducted dissection or other practical experience will be quite different from the learning that will result from a good simulation. While resources and ethical and cultural issues and resources are important elements in the school/community environment, decisions about when to have students work with simulations instead of equivalent activities in the laboratory should be made principally on the basis of the intended learning outcomes and informed by research on learning and the positions of appropriate professional societies. The intersections of laboratory activities and simulations warrants special attention by science educators at this nascent and important time in the development of new simulation technologies appropriate for school science.

The Various Methods Used in the Teaching of Biology

Many studies have been conducted to compare lecture with discussion methods with respect to their effectiveness on students' achievements. Some of the researchers indicated there are no differences in applying either discussion or lecture in the students' learning achievement. Others reached the conclusion that the discussion has some advantages over the lecture with regard to some respects. and the lecture has some advantages over the discussion method in different respects. Also, other researchers have stated that the lecture is superior with respect to the students' performance.

Therefore the literature review in this part will be organized in accordance to the researchers' findings indicated above. First and foremost, the author will review those studies that found no significant differences between the two methods. Secondly, the author will discuss those studies that reached conclusions regarding the advantages and disadvantages of the two methods. Finally, those studies that supported the lecture methods will be reviewed.

A study by Corey (1967) had many questions to answer. One of the questions was: In terms of content mastery will there be any difference between a lecture class and a discussion class? There were two groups involved in this study: small group discussion with a total of 40 students and small group lecture with a total of 26 students. These two groups were taught by the investigator. The conclusions of this study showed that mastery of the subject matter of psychology is not influenced by the method of instruction.

Blezer and Conti (1973) conducted a study to test three hypotheses. One of these hypotheses was: there is a significant difference in grades achieved in traditional versus non-traditional methods in biology courses. The authors in this study meant by traditional that the course was taught by lecture and laboratory. And non-traditional is that the course was taught by discussion method, independent study and laboratory. There were 134 students in two classes which were taught by the same teacher who participated in this study. The result indicated that there were no significant differences in the grades of the students who were taught by these two methods.

Nolan (1974) had stated that Dubin and Taveggia (1968) indicated there were many studies of variation in teaching techniques supporting the general conclusion that there is no significant difference among methods of teaching when measured by the students' performance in final examinations. Tomm and Leahey (1980) conducted a study where three methods of teaching were compared. Method 1 was lecture with demonstration videotapes. Method 2 was discussion with the same videotapes. Method 3 was that students had a family interview and then presented videotapes for small discussion. There were 72 students involved in this study, and each method was taught by different instructors. The results of this study highlighted there were no significant differences among these three teaching methods with respect to students' scores in the tests.

A study by Kanzanas and Frezier (1982) had four questions that the authors wanted to answer. One of them was: To what extent does the lecture-discussion method effect the students' achievement and retention? Twenty-five students were randomly selected to participate in this study. The conclusion of this study reported that there were no significant differences existing between the lecture, discussion approaches on the students' exams. Mcrae and Young (1988) conducted a study on 149 students, not randomly selected in Introductory Business, to determine if the students in the lecture methods would outperform those students in the discussion methods on the final exam. They found there were no significant differences in the students' performance with regard to lecture or discussion methods. Furthermore, they pointed out that Atherton (1972) conducted an extensive review, related to lecture versus discussion, which showed that many researchers indicated that no one method is more effective than any other.

According to Moyer (1968) lecture method discourages creativity and encourages passivity. In discussion-dominated classes a teacher is able to see how much work his/her students do, while classes taught by lecture method only enable students to see how much work a teacher does. When lectures are bad, there is only one person to blame; the teacher, of course. But when discussions are bad, there is more than one person to blame; the teacher and the students. Furthermore, the students' creativity is better served in the discussion method than in the lecture; however, there is no evidence to support that.

Atherton (1972) had a study comparing the effect of three teaching methods (lecture, discussion, and independent study) on recall of facts, understanding of content, and application of principles. The sample for this study was very small, and it was not random. The author concluded there was a differential effect on students' learning as measured by examination among these three methods. As indicated from this study, the students' mean scores for recalling and understanding were higher in the discussion method than the lecture method, but for application the scores were higher in the lecture method than the discussion method.

Lecture is a better method for retention of the content than is discussion. However, the discussion method allows students to become active and creative (Blizek, Jakson and Lavie, 1974). McKeachie and Kulik (1975) found that the lecture method was superior in performance in examination than the discussion method. But, for retention and a higher level of thinking, the discussion method was superior.

Randall (1978) compared five different teaching methods. Two of them were lecture and discussion. In this study, the author indicated the lecture method was an inefficient way of instruction because it does not involve the students. Also, he stated that lecture can be used to introduce a new subject and for making a summary at the end of a session. This method, as the author highlighted, permits the teacher to cover a great deal of material in the least amount of time, and enables the teacher to go directly to his/her objectives. When there is a large number of students, lecture method is a good method for a teacher to use.

On the other hand, the author concluded that in the discussion method a teacher leads his/her class and steers the group in order to accomplish the objectives. Discussion method involves thinking, and any student can participate. As the author stated, the discussion method leads to better learning and retention. However, this method is more time consuming than the lecture, and it is more adaptable to a small group of 25 students or less.

Jones, Bagford, and Wallen (1979) stated that the discussion method had some advantages such as: students learned better through discussion, the discussion helped students raise questions and answer them, the students were free to give comments or not, and discussion had a positive effect upon the mental activity of the students.

Moreover, there were some disadvantages such as: discussion methods need a lengthy time, some students may never participate, and there were problems in evaluating the students.

Also, they said the lecture method had some advantages. The lecture method was very helpful in introducing a new topic, it allowed many students to receive information quickly, and it helped the students to develop note-taking. There were also some disadvantages like: the teacher was not able to know if the students understood the lecture or not, the students were not permitted to ask questions or share opinions, and it seldom achieved a higher level of effective learning.

Peterson *et al* (1979) investigated aptitude-treatment interaction with three teaching approaches: lecture, inquiry, and discussion. The subjects were 145 ninth-grade students enrolled in seven social studies classes. There were three teachers who taught his/her classes according to one of three approaches. The result of this study showed that, on average, students in lecture were significantly lower in ability than students in both inquiry and discussion. Furthermore, students in lecture were, on average, significantly more anxious than students in discussion. Finally, students in lecture were significantly lower in their average score on achievement than students in inquiry.

Tomm and Leahey (1980) noted that Costin (1972) had previously indicated that the lecture method tends to be more effective in teaching factual knowledge, and the discussion method tends to be more effective in teaching intellectual abilities and skills.

In the lecture method, a teacher is active, and students are passive, while both students and teacher are active in discussion method. The discussion method is appropriate for teaching when a teacher is concerned about interaction, involvement adjustment and good feedback. The lecture method is the appropriate 'one when there are large numbers of students and/or subject objectives are based on new knowledge. However, when the objectives are based on new and old attitude or old knowledge, the discussion method is the most appropriate for teaching (Whitman, 1981).

Mcrae and Young (1988) stated that lecture is better for immediate recall of the material content. But discussion is better for retention.

A study by Ruja (1954) examined three courses over two periods: Fall, 1951-1952 and Spring, 1951-1952. There were four hypotheses that the author wanted to test. One of them was: the students in discussion classes show greater subject-matter mastery as measured by course examination than the students in lecture. This hypothesis was rejected. The author also found that lecture was superior in subject matter mastery.

Byers and Hedrick (1976) conducted an experimental study to compare two teaching strategies (lecture and discussion) in a small night class. There were two classes with a total of 33 students. And two instructors involved in this study. The authors concluded that the students who were taught by lecture method had higher scores than the students who were taught by discussion method.

Handleman (1976) carried out a study to compare the students' scores who were taught by lecture method with a similar group taught by discussion; he took a random sample of 120 students selected from a group of 420. He concluded that the lecture method was more effective. Also, he added that both lecture and discussion methods are important but other methods also should be applied. Another study was conducted by Elfner (1980) to determine whether the lecture method was superior to two different discussion methods (a teacher centering the discussion and a student centering the discussion). The students in this study selected themselves, and the instructor for all three methods was the same. The result of Elfner's study indicated that the lecture method was superior in students' performances on final exams to the discussion method. The review of the literature has indicated there are three types of results when comparing discussion method with lecture method with respect to students' performances. The first type indicated that there were no differences between applying either discussion or lecture in the students learning achievements. The second type concluded that discussion and lecture methods have some advantages and disadvantages over each other. The third type revealed that the lecture is better than the discussion as it is shown in students' performance in examinations.

As indicated from the previous literature, most of the studies revealed that each method has some advantages and disadvantages. Therefore, the author believes that no method is better than the other with respect to students' performance. Combining the two methods in teaching will meet most of the teacher and students' needs. Furthermore, using both methods enables the teacher to get all students, with different personality types, involved in the subject matter. The discussion method may be an effective tool for revision.

Communication in the Biology Classroom, Reading and Understanding of Biology Texts in the Biology Classroom

There is no precise definition for communication since there are many people who want to define it in the way they see it. Hence, the word means many things to many people. The word itself is derived from the Latin word '*Communis*' which means comrnon. The meaning implies that communication involves two or more people. The Concise Oxford Dictionary defines the word communicate as impart, transmit or sharing of ideas or information. It is true to say therefore that effective communication depends more on the sender's attitudes towards the receiver than on the sender's gift for writing or for the speaking in front of an audience.

Barnard (1938) viewed communication as a means by which people are linked together in an organization to achieve a common purpose.

Eldridge (1950) defines communication as the transfer of meaning through the use of symbols. There is an objection to this definition because there is a sense in which meaning is always individual. But the same objection can be raised in regard to the definition of communication by Emery, Ault and Agee (1963). According to them, communication is the art of transmitting information, ideas and attitudes but it must be understood by the receiver. Souza (1990) also sees communication as a mutual exchange of information and understanding by any effective means. This implies that, for communication to be effective there must be an exchange of ideas with understanding. Unless the flow goes both ways, no real communication has taken place. Cole (1986) also put it that communication is the process of creating, transmitting and interpreting ideas, facts, opinions and feelings. He continues by saying that it is a process that is very essential in a sharing relationship. Thus it is a mutual interchange between two or more persons. According to Kotter (1977), communication is the process consisting of a sender transmitting a message through a media to a receiver who responds.

From the above definitions and descriptions, it can be deduced that communication is seen as the process of transferring information and understanding from one person or more persons to another person or persons. Communication is said to have taken place and successful if only the message is understood. If the message is not understood, then communication has not taken place. In effect, the objectives of communication are to convey information and to ensure understanding. Science literacy is a major goal of science educational reform (NRC, 1996; AAAS, 1998; NCLB Act, 2001). Some believe that teaching science only requires pedagogical content knowledge (PCK) (Shulman, 1987). Others believe doing science requires knowledge of the methodologies of scientific inquiry (NRC, 1996). With these two mindsets, the challenge for science educators is to create models that bring the two together. The common ground between those who teach science and those who do science is science communication, an interactive process that galvanizes dialogue among scientists, teachers, and learners in a rich ambience of mutual respect and a common, inclusive language of discourse (Stocklmayer, 2002).

Communication is one of the most used mediums through which information is sent and interpreted in the classroom. Communication could be verbal or non-verbal. According to Barnes (1978), the mode of classroom teaching can be classified into two. These he called transmission and interpretation. In transmission, the knowledge is seen as some kind of commodity owned by the teacher and displayed to the learners only according to the decree of the teacher. This mode of teaching or communication involves the teacher playing the central role whilst the learners act passively. Here the learners are presumed to have no knowledge at all. In other words, transmission could be said to be teacher centered. According to Barnes, when knowledge is seen as something to be shared by the act of learning, then the teacher is said to be using interpretation mode of teaching. In this mode the learning is said to be student centered. The teacher only serves as a facilitator who guides students to shape their knowledge and this agrees with the constructivist model.

Speech, as a basic function of individual cannot be separated from other activities of the student but his speech training must be an integral part of his normal and everyday use of oral communication that learners understand the knowledge the teacher tries to impact. It is through communication that learners are able to demonstrate their knowledge to teacher and use it properly in his or her general development. According to Vygostky as cited by Tough (1977) although meaning clearly resides within the child, it is only through the outward evidence of the learner's response, through his or her general behavior and use of language that we are able to infer what 'meaning' is for him or her. Once language has been acquired, it becomes the vehicle for carrying meaning not only for communication with others but as a means of communicating with ourselves. That is, it allows us to reflect on meaning.

In recent years, the value of talk in the classroom is being given more the attention. This has been manifest in the steady flow of articles and books stressing the need for greater emphasis on spoken words in schools. That need came about because some believe we have tended to devalue talk in the classroom and school. Whether this is true or not, one cannot deny that a considerable amount of talk does go on in schools and this is because our own culture depends on a large extent on the spoken words as a means of transmitting knowledge. According to Dillon (1995), ideas in science are communicated through words, charts, diagrams and symbols. Various pieces of evidence suggest that students do not get such opportunities to express their ideas in the classroom. Too many students are unwilling to contribute an answer for fear of having their ignorance exposed. According to Rowe (1974), many teachers allow only a minimal time of a few seconds before seeking for a response. Yet it is indicated that only a few of us can compose a half-decent answer in less than fifteen seconds, let alone five seconds. There is the irony that most of the communications in the science classroom is conducted by the science teacher and that it is the teacher who knows the answer, who asks the questions rather than the student who does not.

Barnes (1969) says that the types of language used by science teachers could be classified into specialist language presented, specialist language not presented and language of secondary education. According to them, the specialist language presented refers to words and forms of language unique to the subject which the teachers are aware of, as a potential problem and therefore present them and explain them to their learners. In this case the students are able to get a proper understanding of the scientific concepts and able to construct knowledge of their own. Specialist language not presented according to Barnes (1969) are the language special to the subject which is not deliberately presented either because it has been explained before or the teachers are unaware that they are using it. It could also be that, the teachers are not aware of the problem it is posing for students. The third category of words or language called the secondary language of education refers to terms, words and forms of language used by teachers which learners would not normally hear, see, or use except in the world of the school.

In science education, the role of verbal communication to attain stated objectives is always complemented by non-verbal communication. This may include body language, graphical, tactile, symbolic etc. According to researchers, communication is more than words and it is very important for science teachers to understand the non-verbal message they are sending and receiving in the classroom. Education psychologists and sociologists define non-verbal communication as communication without words. It includes overt behaviours such as facial expression, symbolic, touching, eye contact and tone of voice. It can also be less obvious however as through dress, posture and spatial distance.

In the classroom, teachers and learners send and receive non-verbal cues several hundred times a day. Teachers should be aware of nonverbal communication in the classroom for two basic reasons

i. To become better receiver of students message and
ii. To gain the ability to send positive signals that reinforce students' learning whilst simultaneously becoming skilled at avoiding negative signals that stifle their learning.

Touching is an important aspect of any culture but touching in the classroom is a very delicate matter. Touching can be used in communicating positive ways and to also offer encouragement and support. Patting a student on the arm, shoulder or back to congratulate him or her for a job well done is a much used and usually favourably accepted as a form of praise. Research has shown that younger children or learners tend to learn significantly more when teachers exhibit touching, close proximity and smile of approval. As children grow older however, touching behaviours become less appropriate.

Cohen and Mannion (1981) state that the process of communication in the classroom is a vastly complicated phenomenon involving the transmission of information from a source and its reception and interpretation by a receiver. More simply, and for much of the time, communication in the classroom may be seen as an interpersonal process between the teacher and his/her students. It included in this personal process the many incidental exchanges that takes place among the learners themselves.

Communication in the classroom relies heavily on the written and spoken words; this is to say that communication is verbal. At times, the substance of communication can be indicated quite independently of words, posture and facial expression. These words can be common means of non-verbal communication. Barnes as cited by Cohen and Mannion (1981), assumed that language was a major means of learning and that pupils' use of language for learning is strongly influenced by the teacher's language which they argue prescribes them their role as learners. By studying teacher-pupil interaction, one can begin to see how classroom communication offers different possibilities of learning to pupils.

According to Cohen and Mannion (1981), it would be most useful to teachers if they could be made more aware of the linguistic means by which students communicate messages, especially where these differed from adult usage. Cohen and Mannion, placed useful emphasis on the precise linguistic signals which convey social messages in the classroom and show that these signs may not only be the words or sentences used but the way utterances are sequenced and the paralinguistic signs as intonation and rhythm'.

Stubbs (1983) further indicates that the characteristic of much classroom talk is the extent of the teachers' conversation control over the topic, over the relevance or correctness of what pupils say and' over when and how much learners may speak. In traditional lessons, learners have few conversational rights.

Notwithstanding this, the occasions when students talk to members of the class, when they offer comments and pose question when requested to do so, or when they talk 'unofficially', their main communicative role as far as the traditional classrooms are concern, is to listen. This means that communicative right of teachers and students are unequal. In effect, teacher tells student when to talk, what to talk about, when to stop and how well they talked.

Edward and Furlong as cited by Cohen and Mannion explain that, as far as learners are ready to be taught, they are likely to acknowledge that an able and competent teacher has the right to talk first, most and last. This is to control the content of the lesson and organize the content by allocating speaking turns to learners. They referred to such arrangement in class as participant-structure which they define as communicative networks linking those who are in contact with one another already. When the classroom communication is teacher oriented, then the learners learn less communicative skills and the performance of these students decline. This means that to increase or influence the performance of the students the teachers must teach students good reading and writing skills whilst giving the student the opportunity to talk in class.

Although secondary school teachers are frequently aware of the expanded choice of materials available, they do not usually consider themselves responsible for teaching reading or studying strategies. A major reason why secondary school subject matter specialist feels they know nothing about reading and study strategies is that, reading in a content area is not set apart from the subject itself.

In spite of all these, Cassel and Johnstones (1985) indicated that one problem that faces students in their academic pursuit is the problem posed by words in the subject context. Cassel and Johnstones again indicated in their research carried out in Australia; found that logical connectives pose problems to students' understanding of concepts in science.

Logical connective frequently occur in everyday speech and writing which may be complete mystery to students. The list of connectives that posed problems to science students include alternatively, consequently, furthermore, in terms of etc.

According to the report by the chief examiners for the WASSCE science subjects (2006), biology candidates were weak in terms of spelling both ordinary English words and technical terms. The report also indicated that the candidates' answers were sometimes very difficult to understand what they put across due to poor grammatical construction. The report again indicated that some candidates were unable to differentiate the major points from minor or supporting points which the examiners attributed to lack of reading skills. All these are pointed to the fact that, communication in the classroom is not given any special attention. The terms, though students are able to pronounce correctly but spelt wrongly in the subsequent cases due to the use of rote learning in the classroom. The performance of such candidates affected negatively as a result of these shortcomings.

According to Mackinnon (1959), one of the problems students face in reading is difficulty in conceiving accurately the meaning of words used in writings. The difficulty occurs not because the words had no meaning for the child but because they have too many meanings. Because of this some learners do not understand the lessons or ideas written but only cope with certain words by guessing their meaning and this leads to lack of permanency in learning. When there is lack of permanency in learning, learners fail to comprehend those same words in their subsequent readings. Mackinnon (1985) states that, there is some sort of language now commonly used to bring about learning to read. In reading, learners use pictures to secure clues for the meaning of the printed symbols. As reading material increases in complexity, learners tend to lose interest and leave material without any power to handle new problem. When reading materials present many opportunities for perceptual mistakes and confusion it provide little encouragement for learners to see clearly what they were doing and the pictures frequently distract then-attention.

Mackinnon (1985) reported that in a concept attainment experiment that when materials used are susceptible to perceptual mistake, over-complex and are such that the learners cannot identify clearly what they are to do, then the learners adopt rote memory techniques. Thus learners only memorize the concepts but do not really understand and cannot relate or link it to other related matters or issues. He reported that this technique leads to 'cognitive strain' in the learners.

Angline as cited by Nelson (1978) argued that young learners are strongly instance oriented. That is he or she has a tendency to focus on a particular instance and to name properties specific to that instance but not generalizable to the class as a whole. Young children have difficulty coordinating the intension and extension of word meanings as evidenced by his including in a category objects which do not meet his definition whilst he may exclude objects which do meet his or her definition. At the meta-linguistic level at which a child is asked to report on his definition and the word referents (extension), one might well find a lack of coordination even though the sources of the various knowledge systems are in place. It is obvious that the lexical system reflects the language system of the child's community.

Suitability of Biology Books for Classroom Instruction

Textbooks are very important in the teaching and learning process. There is therefore the need for a science library in every School where science is taught. Murray (1967) indicated that science library should be in the science laboratory or at a convenient point where there should be easy access to the books. According to Murray books that should be added to science libraries should have good background information in science. Carin (1993) stated that science books have the following importance in students learning

1) Textbooks help meet the individual learning styles of students because some students learn best through reading or reinforcement of what they have learnt previously.
2) Students learn to crosscheck data from different sources.
3) Critical reading and thinking skills can be developed by students comparing books on the subject to evaluate objectivity, qualifications and accuracy of authors.
4) Textbooks encourage self-reliance because one enjoyable discovery can motivate students to make further investigations.
5) For students who have difficulty in reading, textbooks can be helpful by increasing their motivation and involvement.

Das (1985) stated that certain criteria should be followed in selecting a textbook and these are; the content, subject matter and the language.

Content: The contents selected should be appropriate for the age level of the pupils and should conform to the syllabus prescribed for the particular grade. The content selected should be consistent with pupil's needs, interest and previous background.

Subject matter: The subject matter should be organized in a psychological sequence with the content in such a way as to make the subject meaningful to students for whom it is meant for. A textbook should not contain lessons of mere narrative type but should present the content through topics of interest to the students.

Language: The language in a science textbook should be easy and within the understanding of the pupils for whom the book is written. Scientific terms should be defined and explained clearly. Biology text books should have a glossary.

Teaching of Practical Lessons in Biology

According to Hofstein and Lunetta, (1982) for over a century, the laboratory had been given a central and distinctive role in science education, and science educators have suggested that there are rich benefits in learning that accrue from using laboratory activities. In the late 1970s and early 1980s, some educators began to seriously question both the effectiveness and the role of laboratory work, and the case for the laboratory was not as self-evident as it seemed (Bates, 1978). Hofstein and Lunetta (1982) provided perspectives on the issue of the science laboratory through a review of the history, goals, and research findings regarding the laboratory as a medium for instruction in introductory science teaching and learning. Various science educators (Schwab, 1962; Hurd, 1969; Lunetta & Tamir, 1979) have expressed the view that uniqueness of the laboratory lies principally in providing students with opportunities to engage in processes of investigation and inquiry. Another interesting issue can be raised under the same context on the definition of the goals and objectives of the laboratory in science education. A review of the literature revealed that by and large these objectives were synonymous with those defined for science learning in general. Thus, it is vital to isolate and define goals for which laboratory work could make a unique and significant contribution to the teaching and learning of science.

Hofstein and Lunetta, (1982) wrote that while the laboratory provides a unique medium for teaching and learning in science, researchers have not comprehensively examined the effects of laboratory instruction on student learning and growth in contrast to other modes of instruction, and there is insufficient data to confirm or reject convincingly many of the statements that have been made about the importance and the effects of laboratory teaching. Research has failed to show simplistic relationships between experiences in the laboratory and student learning.

Studies have identified several methodological shortcomings in the science education research that inhibits the ability of researchers to present a clear picture regarding the utility of the science laboratory in promoting understanding for students. According to Hofstein and Lunetta, (1982), these shortcomings included

- insufficient control over procedures (including expectations delivered by the laboratory guide, the teacher, and the assessment system);
- insufficient reporting of the instructional and assessment procedures that were used;
- assessment measures of students' learning outcomes inconsistent with stated goals of the teaching and the research; and
- insufficient sample size in many studies, especially in quantitative studies.

Ten years later, Tobin (1990) prepared a follow-up synthesis of research on the effectiveness of teaching and learning in the science laboratory. He proposed a research agenda for science teachers and researchers. Tobin suggested that meaningful learning is possible in the laboratory if the students are given opportunities to manipulate equipment and materials in an environment suitable for them to construct their knowledge of phenomena and related scientific concepts. In addition, he claimed that, in general, research had failed to provide evidence that such opportunities were offered in school science. Four years later, Roth (1994) suggested that although laboratories have long been recognized for their potential to facilitate the learning of science concepts and skills, this potential has yet to be realized.

The National Science Education Standards (National Research Council [NRC], 1996) and other science education literature (Bybee, 2000; Lunetta, 1998) emphasize the importance of rethinking the role and practice of laboratory work in science teaching. This is especially appropriate because in recent decades we have learned much about human cognition and learning (Bransford, Brown, & Cocking, 2000). In addition, learning by *inquiry* (NRC, 2000) is posing challenges for teachers and learners (Krajcik, Mamlok, & Hug, 2001). *Inquiry* refers to diverse ways in which *scientists* study the natural world, propose ideas, and explain and justify assertions based upon evidence derived from scientific work. It also refers to more authentic ways in which *learners* can investigate the natural world, propose ideas, and explain and justify assertions based upon evidence and, in the process, sense the spirit of science.

In the 1980s, multiple reports were published by prominent groups and authors identifying "crisis" and calling for reform in science education (Harms & Yager, 1981; Hurd, 1983; Kyle, 1984; Press, 1982; Yager, 1984). In addition, in the first half of that decade, meta-analysis studies were published that examined the effectiveness of science education curricula developed during the 1960s; for example, Shymansky, Kyle, and

Alport (1983) conducted a meta-analytic investigation on students' performance in science resulting from schooling using the science curricula developed in the 1960s. Although their study showed some positive effects of these curricula on students' science learning, the impact was limited because of shortcomings in dissemination and implementation of these curriculum projects.

Within the last 20 years, the science education community has substantially expanded knowledge of students' understanding of science concepts and of the nature of science. There has also been a substantial paradigm shift in thinking about the ways in which learners construct their own scientific knowledge and understanding. In addition, substantive developments in social science research methodologies enable much richer examination of laboratory and classroom processes and of students' and teachers' ideas and behaviours. Furthermore, throughout the past 20 years the exponential growth of high-technology tools has powerful implications for teaching, learning, and research in the school laboratory.

Used properly, the laboratory is especially important in the current era in which inquiry has re-emerged as a central style advocated for science teaching and learning (NRC, 1996, p. 23).

Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.

The term inquiry has been used in multiple ways in the science education literature. It has been used somewhat broadly to refer to learning science in classrooms and labs in which the students and their teachers explore and discuss science in a "narrative of enquiry" context. As the science education field develops, it is increasingly important to define and use technical terms like *inquiry* in the learning of science with greater precision and consistency, and progress to these ends is visible in recent scholarship.

The National Science Education Standards in the United States and other contemporary science education literature continue to suggest that school science laboratories have the potential to be an important medium for introducing students to central conceptual and procedural knowledge and skills in science (Bybee, 2000). Hodson (1993) emphasized that the principal focus of laboratory activities should not be limited to learning specific scientific methods or particular laboratory techniques; instead, students in the laboratory should use the methods and procedures of science to investigate phenomena, solve problems, and pursue inquiry and interests. Baird (1990) is one of several persons who has observed that the laboratory learning environment warrants a radical shift from teacher-directed learning to "purposeful-inquiry" that is more student-directed.

In preparing the current review, the author consulted several databases to identify the most appropriate studies and reviews addressing issues associated with teaching and learning in the school science laboratory. This review examined associated science projects, investigations, and practical activities both inside and outside school walls, when such activities were perceived as formal elements of the school science curriculum.

In this review, science laboratory activities are defined as learning experiences in which students interact with materials and/or with models to observe and understand the natural world.. Principal sections and issues included in this presentation are as follows:

- Learning science in the laboratory with special attention to *scholarship associated with models of learning, argumentation and the scientific justification of assertions, students' attitudes, conditions for effective learning, students' perceptions of the learning environment, social interaction, and differences in learning styles and cognitive abilities*.
- Goals for learning, discrepancies, and matching goals with practice with special attention to: *goals for learning, students' perceptions of teachers' goals, teachers' expectations and behaviour, the laboratory guide, incorporating inquiry empowering technologies, simulations and the laboratory, assessing students' skills and understanding of inquiry, and the politics of schooling*.
- Teacher education and professional development.
- Synthesis and implications.

Learning Science in the School Laboratory

In reviewing the literature, Hofstein and Lunetta (1982) observed that it was difficult to identify a simple relationship between students' science achievement and their work with materials in the laboratory. During the 1980s the centrality of Piagetian models diminished and attention was increasingly focused on a developing *constructivist* view of learning. Several studies had shown that often the students and the teacher are preoccupied with technical and manipulative details that consume most of their time and energy. Such preoccupation seriously limits the time they can devote to meaningful, conceptually driven inquiry. In response, Woolnough (1991) wrote that for these reasons, the potential contribution of laboratory experiences to assist students in constructing powerful concepts has generally been much more limited than it could have been. Such comments have been made often throughout the past 20 years.

Tobin (1990) wrote that “Laboratory activities appeal as a way of allowing students to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science” (p. 405). This important assertion may be valid, but current research also suggests that helping students achieve desired learning outcomes is a very complex process. According to Gunstone and Champagne (1990), using the laboratory to have students restructure their knowledge may seem reasonable but this idea is also naive since developing *scientific* ideas from practical experiences is a very complex process. Gunstone and Champagne (1990) suggested that meaningful learning in the laboratory would occur if students were given sufficient time and opportunities for interaction and reflection. Gunstone wrote that students generally did not have time or opportunity to interact and reflect on central ideas in the laboratory since they are usually involved in technical activities with few opportunities to express their interpretation and beliefs about the meaning of their inquiry.

In other words, they normally have few opportunities for metacognitive activities. Baird (1990) suggested that these metacognitive skills are “learning outcomes associated with certain actions taken consciously by the learner during a specific learning episode” (p. 184). Metacognition involves elaboration and application of one’s learning, which can result in enhanced understanding. According to Gunstone, the challenge is to help learners take control of their own learning in the search for understanding. In the process it is vital to provide opportunities that encourage learners to ask questions, suggest hypotheses, and design investigations-"minds-on as well as hands-on." There is a need to provide students with frequent opportunities for feedback, reflection, and modification of their ideas (Barron, Schwartz, Vye, Moore, Petrosino, Zech & Bransford,1998). As Tobin (1990) and Polman (1999) have noted, in general, research has not provided evidence that such opportunities exist in most schools in the United States, or, for that matter, in other countries.

A constructivist model currently serves as a theoretical organizer for many science educators who are trying to understand cognition in science (Lunetta, 1998), i.e., learners construct their ideas and understanding on the basis of series of personal experiences. Learning is an active, interpretive, iterative process (Tobin, 1990). Moreover, there is a growing sense that learning is contextualized and that learners construct knowledge by solving genuine and meaningful problems (Brown, Collins, & Duguid, 1989; Polman, 1999; Williams & Hmelo, 1998). Experiences in the school laboratory can provide such opportunities for students if the expectations of the teacher enable them to engage intellectually with meaningful investigative experiences upon which they can construct scientific concepts within a community of learners in their classroom Roth (1994). A social constructivist framework has special potential for guiding teaching in the laboratory.

Millar and Driver (1987) were among those who recommended the use of extended, reflective investigations to promote the construction of more meaningful scientific concepts based upon the unique knowledge brought to the science classroom by individual learners. An assumption is that when students interact with problems that they perceive to be meaningful and connected to their experiences, and when teachers are guided by what we know about learning, the students can begin to develop more scientific concepts in dialogue with peer investigators.

Research has also suggested that while laboratory investigations offer important opportunities to connect science concepts and theories discussed in the classroom and in textbooks with observations of phenomena and systems, laboratory inquiry alone is not sufficient to enable students to construct the complex conceptual understandings of the contemporary scientific community. “If students’ understandings are to be changed toward those of accepted science, then intervention and negotiation with an authority, usually a teacher, is essential” (Driver, 1995). Lunetta (1998) reported that hands-on activities with introductory electricity materials in clinical studies with individual students facilitated their understanding of relationships among circuit elements and variables. The activities provided clear tests of the validity of the subject’s ideas. “Frequently they led to cognitive conflict.

However, the carefully selected practical activities alone were not sufficient to enable the subject to develop a fully scientific model of a circuit system. The findings suggested that greater engagement with conceptual organizers such as analogies and concept maps could have resulted in the development of more scientific concepts in basic electricity. When laboratory experiences are integrated with other metacognitive learning experiences such as “predict–explain–observe” demonstrations, etc. (White & Gunstone, 1992) and when they incorporate the manipulation of ideas instead of simply materials and procedures, they can promote the learning of science (Polman, 1999).

Pursuing that theme in *Designing Project-Based Science: Connecting Learners Through Guided Inquiry*, Polman (1999) conducted an extended case study of a teacher who created a collaborative learning community and provided his high school students with opportunities to "learn by doing" *authentic* science in a science classroom. The teacher was guided by constructivist pedagogy giving special attention to *collaborative visualization.* Polman's analysis provides detailed information about the teacher's strategies and behaviours while implementing a *Project-Based Science* model. Polman discussed the teacher's efforts to organize and support his students in various stages of inquiry learning such as in *asking researchable questions* and in *gathering, analyzing, and presenting data* to construct and justify scientific responses to those questions. Polman also discussed the difficulty and complexity of changing practices by describing conflicts that emerged when the teacher, who was the subject of the study, challenged conventional approaches to teaching and learning science. He demonstrated how the structural and cultural realities of the school complicated the enactment of pedagogical innovation in general and the *Project-Based Science* model, in particular. Polman suggested that teachers who wish to foster science learning through projects and inquiry must play a complex role in discourse with their students.

While there have been substantial developments in scholarship that can guide the development of teaching and curriculum, that scholarship has had only marginal impact on schools. In a summary of five, studies focused on *Project-Based-Learning*, Williams and Hmelo (1998). Although several decades of research have given us a strong theoretical basis about the nature of learning and the value of problem-based methods, this information has had relatively small impact on education practices. We do not, as yet, have a widely accepted theory of instruction or carefully thought out manageable methods of implementation consistent with constructivist theory.

To acquire a more valid understanding of these important issues, science educators need to conduct more intensive, focused research to examine the effects of specific school laboratory experiences and associated contexts on students' learning. The research should examine the teachers' and students' perceptions of purpose, teacher and student behaviour, and the resulting perceptions and understandings (conceptual and procedural) that the students construct. Research and development projects like those conducted by Polman (1999) and by Krajcik *et al*. (2000) offer examples of what is needed.

Developing assertions about the natural world in school science and then justifying those assertions with data collected in investigations within or beyond the science classroom walls is considered increasingly to be an important element of school science learning (Newton, Driver, & Osborne, 1999;). The National Science Education Standards (NRC, 1996) also indicates the importance of engaging learners in describing and in using observational evidence and current scientific knowledge to construct and evaluate alternative explanations "based on evidence and logical argument" (p. 145).

Engaging in scientific argumentation assists students in constructing meaningful science concepts and in understanding how scientists develop knowledge of the natural world. Newton, Driver, and Osborne (1999) have written that weighing and interpreting evidence, thinking about alternatives, and assessing the viability of scientific claims are essential elements of scientific argumentation and of school science. These experiences are part of students' "enculturation" into science. "Argumentation is particularly relevant in science education since a goal of scientific inquiry is the generation and justification of knowledge claims, beliefs, and actions taken to understand nature" (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000). As elaborated later in the *Inquiry Empowering Technologies* section of this review, new technology tools such as *Progress Portfolio* (Loh, Reiser, Radinsky, Edelson, Gomez & Marshall, in press) can help students negotiate, support explanations and assertions about relationships, connect their findings to driving questions in their investigations, and struggle with the significance of their data (Land & Zembal-Saul, in press). Examining and elaborating the nature of scientific argumentation in general, the utility of engaging students in these processes, and the most appropriate ways to engage students in meaningful argumentation in the laboratory and school science are contemporary domains for research in science education that should have important implications for science teaching and curriculum.

Students' Attitudes towards Practical Work in Biology

Several studies published in the 1970s and early 1980s reported that students enjoy Laboratory work in some courses and that laboratory experiences have resulted in positive and improved student *attitudes* and *interest* in science. Shulman and Tamir (1973) wrote "We are entering an era when we will be asked to acknowledge the importance of affection, imagination, intuition and attitude as outcomes of science instruction as at least as important as their cognitive counterparts" (p. 1139). Nevertheless, beginning in the 1980s, the pendulum of scholarly research attention within the science education literature moved away from the affective domain and toward the cognitive domain in general and toward conceptual change in particular. Two comprehensive reviews that were published in the early 1990s (Hodson, 1993; Lazarowitz & Tamir, 1994) did not discuss research focused on affective variables such as attitudes and interest. Nevertheless, the science education literature continues to articulate that laboratory work is an important medium for enhancing attitudes, stimulating interest and enjoyment, and motivating students to learn science. The failure to examine effects of various school science experiences on students' attitudes is unfortunate since experiences that promote positive attitudes could have very beneficial effects on interest and learning. The failure to gather such data is especially unfortunate in a time when many are expressing increasing concerns about the need for empowerment of women and underrepresented minority people in pure and applied science fields.

The science laboratory is central in our attempt to vary the learning environment in which students develop their understanding of scientific concepts, science inquiry skills, and perceptions of science. The science laboratory, a unique learning environment, is a setting in which students can work cooperatively in small groups to investigate scientific phenomena. Hofstein and Lunetta (1982) and Lazarowitz and Tamir (1994) suggested that laboratory activities have the potential to enhance constructive social relationships as well as positive attitudes and cognitive growth. The social environment in a school laboratory is usually less formal than in a conventional classroom; thus, the laboratory offers opportunities for productive, cooperative interactions among students and with the teacher that have the potential to promote an especially positive learning environment. The learning environment depends markedly on the nature of the activities conducted in the lab, the expectations of the teacher (and the students), and the nature of assessment. It is influenced, in part, by the materials, apparatus, resources, and physical setting, but the learning environment that results is much more a function of the climate and expectations for learning, the collaboration and social interactions between students and teacher, and the nature of the inquiry that is pursued in the laboratory.

Students' Perceptions of the Laboratory Learning Environment

The need to assess the students' perceptions in the science laboratory was approached seriously by a group of science educators in Australia (Fraser, McRobbie, & Giddings, 1993), who developed and validated the Science Laboratory Environment Inventory (SLEI). This instrument, consisting of eight learning environment scales, was found to be sensitive to different approaches to laboratory work, e.g., high inquiry or low inquiry and different science disciplines such as biology or chemistry, etc (Hofstein, Cohen, & Lazarowitz, 1996). The SLEI has been used in several studies conducted in different parts of the world.

One comparative study examined students' perceptions in six countries: United Kingdom, Nigeria, Australia, Israel, United States, and Canada (Fraser & McRobbie, 1995). Fraser, McRobbie, and Giddings (1993) in Australia, found that students' perceptions of the laboratory learning environment accounted for significant amounts of the variance of the learning beyond that due to differences in their abilities. In Israel, in the context of chemistry and biology learning, Hofstein, Cohen, and Lazarowitz (1996) used a Hebrew version of the SLEI. They compared students' perceptions of the *actual* and *preferred* learning environment of laboratories in chemistry and biology classes.

They found significant differences between chemistry and biology laboratory environments in two scales, namely, *integration*, which describes the extent to which the laboratory activities are integrated with non laboratory activities in the classroom and *open-endedness*, which measures the extent to which the activity emphasizes an open-ended approach to investigation. Differences were also found in comparing the students' perceptions of the *actual* and *preferred* learning environments. A more recent study conducted in Israel by Hofstein, Levi-Nahum, and Shore (2001) in the context of learning high school chemistry showed clearly that students who were involved in inquiry-type investigation found the laboratory learning environment to be more *open-ended* and more *integrated* with a conceptual framework than did students in a control group.

If positive students' perceptions of the science laboratory learning environment, i.e., cooperative learning, collaboration, and developing a community of inquiry are among the important intended outcomes of school laboratory experiences, then these outcomes should be assessed by teachers as a regular part of course evaluation. The *science laboratory learning environment inventory* could be used by teachers as one part of *action research* intended to examine the effects of a new laboratory teaching approach or strategy and as part of improving instruction. Researchers can also use this instrument for more summative-type studies in which they examine effects of different kinds of teaching in the laboratory on students' perceptions of the learning environment.

Science educators increasingly perceive the school science laboratory as a unique learning environment in which students can work cooperatively in small groups to investigate scientific phenomena and relationships. Hofstein and Lunetta (1982), Lazarowitz and Tamir (1994), and Lunetta (1998) suggested that laboratory activities have the potential to enable collaborative social relationships as well as positive attitudes toward science and cognitive growth. As noted earlier in this paper, the more informal atmosphere and opportunities for more interaction among students and their teacher and peers can promote positive social interactions and a healthy learning environment conducive to meaningful inquiry and collaborative learning. The laboratory offers unique opportunities for students and their teacher to engage in collaborative inquiry and to function as a classroom community of scientists. Such experiences offer students opportunities to consider how to solve problems and develop their understanding. Through collaboration, they can also come to understand the nature of an expert scientific community. These are among the learning outcomes now thought to be very important in introductory science.

The importance of promoting *cooperative learning* in the science classroom and laboratory received substantial attention during the 1980s (e.g., Johnson *et al.,* 1981; Johnson& Johnson, 1985; Lazarowitz & Karsenty, 1990) as a way to engage diverse students in collaboration with others in inquiry and to develop a classroom community of scientists. Large numbers of studies demonstrated distinct benefits in students' achievements and productivity when cooperative learning strategies were utilized in the classroom-laboratory. In the intervening years, research intended to examine the effects of student collaboration and the development of "classroom community of scientists" has been increasingly visible. Okebukola and Ogunniyi (1984) compared groups of students who worked cooperatively, competitively, and as individuals in science laboratories and found that the cooperative group outperformed the other groups in cognitive achievement and in process skills. Similarly, Lazarowitz and Karsenty (1990) found that students who learned biology in small cooperative groups scored higher in achievement and on several inquiry skills than did students who learned in a large group class setting. Several papers have reported that the more informal atmosphere and opportunities for more interaction among students and their teacher and peers can promote positive social interactions and a healthy learning environment conducive to meaningful inquiry and collaborative learning (DeCarlo & Rubba, 1994; Tobin, 1990). More recently Land and Zembal-Saul (in press) reported that by prompting learners to articulate and connect their experimental findings back to the larger driving questions, learners negotiated and struggled with explaining the significance of the data, prompting explanation and justification and reflective social discourse.

While promoting and examining reflective social discourse is an important and promising area for further research in science education, observations of science laboratory classrooms today continue to suggest, more often than not, that little attention is given to promoting collaboration, group/community process, and *reflective discourse,* knowledge, understanding, abilities, and experiences of students and work together as colleagues within and across disciplines and grade levels.

Assessing Students' Skills and Understanding of Inquiry

Several researchers have criticized much of the previous research on the laboratory because it failed to assess learning outcomes that one might assume would be developed and enhanced in laboratory activities. Assessments of students' performance and understanding associated with the science laboratory should be an integral part of the laboratory work of teachers and students. Assessment tools should examine the students' inquiry skills, their perceptions of scientific inquiry, and related scientific concepts and applications identified as important learning outcomes for the investigation or the series of investigations.

Over the years, knowledge about how to assess learning in the school science laboratory has increased substantially, and new techniques and media that can support the assessment of students' practical skills and associated understanding have been developed. In Israel, for example, Tamir, Nussinovitz, and Friedler (1982) developed a standardized practical test in biology that includes 21 assessment categories. Each year novel "experiments" are developed for that Israeli test, and the students' performance is assessed using the 21 categories. In the United States, Doran *et al.* (1993) developed and validated a test to assess the laboratory skills of students completing high school science courses (chemistry, biology, and physics).Their aim was to develop an authentic and alternative assessment method to measure outcomes of school science programs, including inquiry and activity in the laboratory. In their tests, students had to design an investigation, collect and analyze data, and formulate findings. The students' visual representation and interpretation of their quantitative data was incorporated in the analysis.

Several observational assessment methods were developed in the 1970s and 1980s (e.g., Hofstein et al., 2001 ;). Using certain criteria, the researchers or teachers unobtrusively observe and rate each student during normal laboratory activities. They assess students according to the following broad phases of activity: (1) planning and design, (2) performance, (3) analysis and interpretation, and (4) application.

Recent developments in the use of new technology tools that are now beginning to be used in science classrooms have high potential to help researchers and even busy teachers to monitor students' work and ideas. *Progress Portfolio* (Loh *et al.,* in press) software, referenced in the *Inquiry Empowering Technologies* section earlier in this paper, is one example of software used by students that can provide teachers with relatively easy electronic access to student performance data to be included in assessing a student's development and progress. Teachers can also use that kind of information as formative assessment to inform their teaching and their interactions with students. The new practical assessment resources and strategies can be used by researchers and busy teachers to assess learning associated with inquiry and laboratory performance. Development and use of assessment resources is also a very important area for further discipline focused research in science education. Such research could also serve as a foundation for developing assessment protocols for teachers to use effectively in their own classrooms without expending large quantities of their very limited time. In addition, such assessment protocols should provide feedback for teachers to improve the effectiveness of their own teaching. That feedback, of course, could also be used to help students understand how they are progressing as learners. Gitomer and Duschl (1998, p. 803), wrote:

"The most promising efforts in assessment reform are those that address directly the relationship of assessment and instruction, specifying precisely how assessment can be used to support improved instructional practice".

If we truly value the development of knowledge, skills, and attitudes that are unique to practical work in science laboratories, appropriate assessment of these outcomes must be developed and implemented continuously by teachers in their own laboratory-classrooms. The National Science Education Standards (NRC, 1996) indicates that all the student's learning experiences should be assessed and that the assessment should be authentic. Attention to such standards, however, has promoted testing that has generally not incorporated the assessment of performance and inquiry, although there have been a few noteworthy efforts to do that researchers, teachers, and testing jurisdictions whose goal is to assess comprehensively the learning that takes place in school science generally, or in school laboratories more specifically, should use appropriate assessment tools and methodologies to identify what the students are learning (conceptual as well as procedural). The effects of such experiences on students' interest and motivation should also be assessed.

In summary, data gathered in many countries has continued to suggest that teachers spend large portions of laboratory time in managerial functions, not in soliciting and probing ideas or in teaching that challenges students' ideas, encouraging them to consider and test alternative hypotheses and explanations. In addition, most of the assessment of students' performance in the science laboratory continues to be confined to conventional, usually objective, paper and pencil measures. More sensitive measures of students' understanding of laboratory methodologies, the hypotheses and questions they generate from the laboratory experiences, and the practical skills they exhibit have all too often been neglected (Bryce & Robertson, 1985; Tamir, 1997). In this era when standards and external tests of students' achievement are increasingly popular, it is naive to think that students' and teachers' behaviour and practices will shift toward inquiry and the development of meaningful practical knowledge until such outcomes become more visible in the tests that increasingly drive what teachers, parents, and students think is important, and thus what they choose to do. The policy makers who control the testing programs and those who prepare the tests must be part of more functional efforts to improve the effectiveness of school science.

Professional Qualification of Biology Teachers in the S.H.S

Findings related to teachers' academic degrees (Bachelor's, Master's, doctorate, and other) are inconclusive. Some studies show positive effects of advanced degrees (Betts, Zau, & Rice, 2003; Ferguson & Ladd, 1996; Goldhaber & Brewer, 1997, 2000; Rowan, Chiang, & Miller, 1997); others show negative effects (Ehrenberg & Brewer, 1994; Kiesling, 1984) of teachers professional qualification on the academic performance of their students. Some researchers maintain that the requirement for teachers to have a second degree raises the cost, financially as well as in time, of teacher education, which may prevent quality candidates from choosing this profession (Murnane, 1996). This characteristic is related to the subject-matter knowledge teachers acquire during their formal studies and pre-service teacher education courses. The evidence from different studies is contradictory.

Several studies show a positive relationship between teachers' preparation in the subject matter they later teach and student achievement (Darling-Hammond, 1999, 2000b; Goldhaber & Brewer, 2000; Guyton & Farokhi, 1987), while others have less unequivocal results. Monk and King (1994) found both positive and negative effects of teachers' in-field preparation on student achievement. Goldhaber and Brewer (2000) found a positive relationship for students' mathematics achievement but no such relationship for science. Rowan et al. (1997) reported a positive relationship between student achievement and teachers with a major in mathematics. Monk (1994), however, found that while having a major in mathematics had no effect on student achievement in mathematics, having a substantial amount of under- or post-graduate coursework had a significant positive effect on students in physics but not in life sciences. Ingersoll (2003) considered the widespread phenomenon in the United States of teachers teaching subjects other than those for which they had formal qualifications. His study of out-of-field teaching (as it is known) portrayed a severe situation where 42% to 49% of public Grades 7 to 12 teachers of science and mathematics lacked a major and/or full certification in the field they were teaching (1999/2000 data). In Israel, a recent survey (Maagan, 2007) placed the corresponding percentages even higher for elementary teachers—42% for mathematics and 63% for science (2005/2006 data).

The literature shows a somewhat stronger, and more consistently positive, influence of education and pedagogical coursework on teacher effectiveness (e.g., Ashton & Crocker, 1987; Everston, Hawley, & Zlotnik, 1985; Ferguson & Womack, 1993, Guyton & Farokhi, 1987). Some of these studies compare the effect on student achievement of courses in pedagogical subject matter with the effect of courses in the subject matter itself, and present evidence in favour of the former. An example is a study conducted by Monk (1994) related to mathematics achievement. Other studies reveal no impact of education courses on students' achievement (see, for example, Goldhaber & Brewer, 2000, in relation to science achievement).

Certified teachers are usually those who have graduated from accredited teacher education programmes. Some of these teachers are also required to complete an induction programme or pass a national teacher examination test in order to obtain a license. There is debate in the USA between those in favour of full certification (Darling- Hammond, 1999; Darling Hammond, 2000) and those who argue that students of teachers who hold full certification achieve similarly to those who study under teachers with temporary “emergency” credentials (Goldhaber & Brewer, 2000). These authors also argue that relaxing requirements for certification is a way not only of attracting academically talented college graduates to teaching but also of recruiting a more diverse pool of candidates needed for a diverse student population. The TIMSS 2003 data at hand for Israel prevented examination of this issue, as all participating teachers were fully certified.

Studies on the effect of teacher experience on student learning have found a positive relationship between teachers’ effectiveness and their years of experience, but the relationship observed is not always a significant or an entirely linear one (Klitgaard & Hall, 1974; Murnane & Phillips, 1981). The evidence currently available suggests that while inexperienced teachers are less effective than more senior teachers, the benefits of experience level goes after a few years (Rivkin, Hanushek, & Kain, 2000). The relationship between teacher experience and student achievement is difficult to interpret because this variable is highly affected by market conditions and/or motivation of women teachers to work during the child-rearing period. Harris and Sass (2007) pointed to a selection bias that can affect the validity of conclusions concerning the effect of teachers’ years of experience: if less effective teachers are more likely to leave the profession, this may give the mistaken appearance that experience raises teacher effectiveness. Selection bias could, however, work in the opposite direction if the more able teachers with better opportunities to earn are those teachers most likely to leave the profession.

Professional development activities can be conducted by many different organizations, in school and out of school, on the job or during sabbatical leave. On these occasions, practicing teachers update their content knowledge and teaching skills so they can meet the requirements of new curricula, consider new research findings on teaching and learning, and adapt to changes in the needs of the student population, and so on. Criticism has been levelled against the episodic nature of these activities and concern expressed that very little is known about what these activities really comprise and involve. Conclusions in the literature on the relationship between teachers' participation in professional development activities and student outcomes are mixed. Some studies on in-service professional development have found no relationship to student achievement (see, in regard to mathematics and reading, Jacob & Lefgren, 2004).

Other studies have found higher levels of student achievement linked to teachers' participation in professional development activities directly related to the area in which they are teaching (see, in regards to mathematics, Brown, Smith, & Stein, 1995; Cohen & Hill, 1977; Wiley & Yoon, 1995; and in regard to language and mathematics, Angrist & Lavy, 2001). Wenglinsky (2000) found a positive correlation between professional development activities aimed at the needs of special education students, and students' higher-order skills and laboratory skills in science. More recently, Harris and Sass (2007) identified what they call the "lagged effect of professional development," that is, the larger effect of teachers' professional development on student outcomes not becoming apparent until three years after the teachers had completed their courses.

The interpretation of the positive effect of participation in teacher professional development activities is not clear cut, as this variable is confounded with other teacher attributes, that is, teachers who participate in these activities are also likely to be more motivated and, usually, more specialized in the subjects they teach.

Relevance of Academic Background and Qualification of Teachers

Biology is still rapidly expanding subject, both in the knowledge of living organisms and in the techniques. Selmes (1984) has mentioned that these changes have also been reflected in the Biology courses for secondary schools. He cited the Nuffield Biology project as an example to show how knowledge and techniques have been combined to produce the curriculum.

The biology teacher, according to Selmes is faced with increased demand for new knowledge and techniques and the application of biology to contemporary issues like conservation, pollution, sex education, drug abuse, DNA Science, HIV education, and others e.g. ecology and environment, food, health, sanitation, cloning. In addition new methods of teaching and evaluation are being advocated as well as the integration of biology with other sciences and social courses. With the current surge in knowledge in the subject, the traditional way of teaching the subject at both the secondary and university levels should give way to newer approaches (Selmes, 1984).

Stones (1968) stated that teaching is neither merely organizing lessons nor merely dispensing subject matter knowledge. In his opinion, what is needed to make the art complete is the involvement of students in the teaching and learning process where they are given the opportunity to participate fully in the process. Ryburn (1975) described teaching as a relationship which helps the child to develop all his/her powers. Through teaching, he gets information, he learns to work and do things, and he/she is helped to learn for himself, he is inspired to use all his powers so that he may make true adjustments and prepares himself for what lies ahead. When a child has had good teaching, he/she leaves school with a harmonious developed personality, he is self-reliant, and he/she has been given a desire to use all his powers in living worthy life. Slavin (1984) stated that learning is a change in an individual that results from experience.

Munn (1972) stated that learning is not restricted to what happens in formal education. It is constantly influencing almost all spheres of life. Generally, it is described as a process of having one's behaviour modified, more or less permanently, by what he does and the consequences of his actions or by what he observes.

According to Tamir (1997) teachers are the key factors to realizing the potential of any and all science practical activities. Teaching in the laboratory requires a special approach. Students need to be motivated to recognize and appreciate the link between science and technology in real life situation that is science enquiry using special instructional skills which include observing, experimenting, recording results, making inferences and interpreting data.

One of the major purposes of science practical work is the cultivation in students, scientific attitudes (Hodson, 1988). According to him, practical work should be divorced from the current practice of performing experiments that may not have bearing on the society. He indicated that, if practical activities involve every day situational cases, students will be motivated to recognize and appreciate the link between science and technology in real life situations.

One of the important resources for teaching biology in the senior high school is a well-equipped laboratory. But according to Abdul–Mumuni (1995) most teachers do not perform laboratory based biology practical work due to lack of time, large class size, the extensive nature of biology syllabus and the lack of biology equipment and materials.

Carin and Sund (2001) stated that, if science is seen as a list of theories, it can be a bore but if it is organized as a 'hands-on' adventure guided by a knowledgeable teacher, and can sweep students up to excitement and discovery. Physical practice with laboratory equipment provides concrete experience with apparatus and procedure.

Lewis (1972) called for the use of the discovery method that will enable the student construct his/her own ideas. He cautioned against too much talking by the teacher adding that, the teacher will not be by the student to continue lecturing and providing answers to him as he leaves the school to enter the society. Therefore the teacher will have to eliminate lecturing and try to perform more practical work with the students.

Teaching and learning are just like the opposite side of the coin (Farrant, 2004). Farrant again asserts that a lesson that is considered to have been taught is the one that has been learned very well.

Campbell (1978) also indicated that science achievements of students were positively influenced by major intervening variables of which teacher characteristics stood out prominently.

Some of the teacher characteristics which have been identified by Campbell are:

- Social Climate of the classroom.
- Teaching experience of the teacher.
- Teachers' attitude towards Science and knowledge of the subject matter.

Chiapetta (1978) observed that knowledge of the subject matter and skills are necessary to enrich the background of secondary school science teachers, and thus making them very competent. The first–six competency skills are enumerated below.

- Ability to communicate effectively
- Creation of a humanly supportive environment
- Incorporating effective laboratory activity into instruction
- Relate psychological development with the learning of science subject matter
- Exhibit sound science subject matter knowledge.
- Plan and organize instruction.

A science teacher who acquires all these competency skills, no doubt would be able to impart scientific knowledge and skills to the students effectively.

Carin and Sund (2001) noted that secondary school science teachers are often too busy to improvise teaching aids which they need for teaching biology, although many biology items could be improvised at the secondary school level.

The understanding of the principles of learning is essential for those who have the desire to teach in schools. Teachers, therefore need to know how learning takes place a process by which their ways of thinking becomes part of the way of thinking of those they teach. Professionally qualified teachers are very important for effective teaching and learning of biology since it is a technical subject and therefore requires a person with an in-depth knowledge of the subject matter as well as effective ways of imparting to learners.

Teachers' Knowledge of the Syllabus and Chief Examiners Reports

The teacher must be conversant with the teaching and examination syllabuses and the chief examiners report. The West African Examinations Council's chief examiners' report on senior secondary school certificate examination serves as a guide to teachers. The report normally shows some of the weaknesses of candidates in answering certain questions. For example, WAEC (2004) Senior Secondary School Certificate Examination. (SSSCE) students were asked to explain what crossing over is, Test cross, and linkages. But according to the report, candidates performed poorly in this question. Other questions which were not answered well, the chief examiners' report suggested remedies by which the weaknesses may be corrected. The suggested remedies are:

- Provision of more effective teaching;
- Intensifying class exercises, both theoretical and practical;
- Use of 'good' biology textbooks

The report attests that most teachers do not read the chief examiners' report; otherwise they would have made changes in their teaching to help students overcome their weaknesses in the answering of some questions.

CHAPTER THREE

METHODOLOGY

Overview

This section represents a comprehensive description of the methods and techniques that was used in carrying out the study. These are the research design, target population, sample size, sampling techniques, research instruments, data collection and methods which were used to analyze the data.

Research Design

The research design that was used in the study was the descriptive survey. The study looked at the status of the teaching and learning of biology in selected Senior High Schools in the Volta Region. The researcher collected the views of teachers and students about how biology was taught. Again the survey was extended to classrooms to see how the teachers interacted with the students during biology lessons.

Gay (1992) stated that, descriptive survey involves collecting data in order to test hypotheses or to answer questions concerning the current status of the subject under study. Data was collected through questionnaires and interviews. However the researcher also made use of observations to augment the data obtained through the questionnaires and interview sections. Separate questionnaires were designed to gather the relevant data from students as well as the teachers. In the second phase of data gathering, qualitative data was gathered from students and their teachers through the use of standardized interview protocols carefully constructed to obtain the needed information on the current status of biology from the points of view of both teachers and students. The researcher made careful use of frequencies and percentages of responses provided by the respondents to make valid judgements. Recurring themes and trends in the interviews conducted were carefully noted and summarized thematically.

The use of both quantitative and qualitative research approaches in the same study is referred to as a mixed-methods design (McMillan & Schumacher, 2010). Quantitative approaches adopt a positivist philosophy: they are objective, scientific, experimentalist and traditionalistic. By contrast, qualitative approaches are phenomenological, i.e. they are subjective, humanistic and interpretative (Neville, 2005), and, by involving aspects such as attitudes, values and perceptions to research studies, add qualitative flesh to quantitative bone (Brown 2004:97).

The reasons for employing mixed method for this study are: the researcher sought to view problems from multiple perspectives so as to enhance and enrich the meaning of a singular perspective. It also helped the researcher to contextualize the information, to take a macro picture of a system and add in information about individuals.

Another reason is that the merging of quantitative and qualitative data helped to develop a more complete understanding of the problem; to develop a complementary picture; to compare, validate and triangulate results; to provide illustrations of context for trends, and finally to examine processes and experiences along with outcomes as noted by Plano Clark (2010).

Shenton (2004) identifies the following advantages of mixed-methods designs: They

- improve the validity of research findings;
- provide more in-depth data;

- increase the capacity to cross-check one data set against another;
- provide details of individual experiences behind the statistics; and
- interrogate problems and seek solutions through further in-depth interviews.

The use of both approaches therefore addressed the disadvantages of using one approach only. According to Brown (2004), a mixed-methods design has the potential of producing holistic, comprehensive and insightful knowledge. Combining both approaches strengthens the study at hand and therefore strengthens the internal validity of the design (McMillan & Schumacher, 2010:395).

Area of the Study

The study was conducted in the Volta region of Ghana. The Volta region is one of the ten regions of Ghana. It is west of the Republic of Togo and to the east of Lake Volta. The region has 25 districts consisting of 5 municipal and 20 ordinary districts with all the administrative changes as of December 2012. The study focused on second cycle institutions in the region. The Volta region was chosen for the study due to several reasons. Firstly, it boasts of a large number of schools which are located in both rural and urban areas. The region also has schools in the all the four categories as stipulated by the Ghana Education Service (GES). The region was also chosen because of the willingness of the study participants to take part in the study. Finally the researcher selected the Volta region to undertake the study because of reasons of proximity and familiarity since he domiciles and works with the GES in the region.

Map of Ghana Showing the Volta Region

Population

The target population was all the biology teachers in senior high schools in the Volta Region. Van Dalen (1979) indicated that a survey should contain at least 10% to 15% of the accessible population. There are a total of 72 government S.H.S's in the Volta Region out of which 12 were selected for the present study. The selected schools constituted about 17%of the total number of senior high schools in the Volta Region. The accessible population was made up of biology teachers and students in the 12 selected senior high schools in the Volta Region. The schools involved in the study were carefully selected based on several factors. Importantly, the researcher carefully selected 3 schools from each category of schools starting from category A up to category D. As a result of financial and time constraints the researcher had to settle on only a few schools rather than all the SHS in the region.

Sample

In totality, the researcher gathered data from a total of 316 respondents consisting of 21 teachers and 295 students. Stratified random sampling techniques were used to select 25 students from each school involved in the study. In all the select schools, the students offering elective biology were assembled and 25 of them were randomly selected to fill the questionnaires items. The researcher intended to involve all elective biology teachers in the 12 select schools in the study. However due to several factors beyond the control of the researcher, several of the teachers were unavailable and some schools had no elective biology teachers. Thus eventually, a total of 21 teachers from the 12 schools were selected to fill the questionnaire.

Instrumentation

Several instruments were used to gather data for this research work. The two main instruments employed for data gathering were the questionnaire and an interview protocol. These two instruments were supplemented with classroom observation, checklists, and audio-recordings of the interview schedules. In the case of lesson observations, the Science Teaching Observation Schedule (STOS) developed by Eggleston and Galton (1990) was used to collect data. Respondents of the questionnaire were expected to provide demographic data on the names of their schools, the type of school as in boys, girls or co-educational school. They were also required to indicate their class levels, ages and gender on the questionnaire. The student's questionnaire was designed to elicit data from students with regards to their views and perceptions of several factors in the school. The key areas which were factored into the design of the final questionnaire are teaching methods adopted by biology teachers, adequacy of equipment and logistics for conducting biology lessons, views of students on the performance of biology teachers, adequacy of time designated for theory and practical lessons in biology as well as the perceptions of students on biology as a subject of study.

Finally an aspect of the student's questionnaire was designed to ascertain the perceptions and views of students on the conduct and effectiveness of practical biology lessons.

The questionnaire for teachers was designed to ensure that teachers provide demographic data and also some personal information about themselves. They were required to provide data on the category of their schools, the number of students in the elective biology classes, their individual ages and gender as well as location of the school as in rural or urban. Also the teachers were required to provide data on the subjects they specialized in or studied at the tertiary level. They also provided data on the years they had spent in the teaching profession and the academic qualifications that they held. The questionnaire itself was designed to gather data from teachers on various factors in and outside the school that has a bearing on the teaching and learning of biology in the SHS. The instrument sought to find out the frequency of in-service training for teachers and the sponsors of such in-service training programmes. Aspects of the questionnaire also tackled the perspectives of teachers on the conduct of biology practical and theory lessons in the school and the availability and adequacy of laboratory and practical equipment. Finally the questionnaire also solicited the views of the respondent teachers on the perceptions of school authorities on the procurement and allocation of biology equipment and logistics.

Reliability of Instruments

With regards to the reliability of the questionnaire, a pilot test of the instrument was carried out with 50 students in one of the schools which share similar characteristics with the selected schools. The students chosen did not form part of the main study. This was to avoid contamination of the sample for the study and hence the results. Reliability of the questionnaire was determined using Cronbach-Alpha to be 0.78. The inter item correlation was also determined to be 0.272. The corrected item correlation ranged from 0.38 to 0.66. According to DeVaus (2004), anything less than 0.30 is a weak correlation for item-analysis purposes.

The reliability of the interview protocol was also determined using Inter rater reliability techniques. The transcriptions of the audio recordings of the interviews were given to different experts to determine the inter-rater reliability of the data. According to Mays and Pope (1995). The analysis of qualitative data can be enhanced by organizing an independent assessment of transcripts by additional skilled qualitative researchers and comparing agreement between the raters" (p.110). These experts agreed that the interview protocol could be used to undertake the substantive study. The reliability of the interview protocol was also enhanced by the fact that the interviewer held one-to-one interview sessions with the various respondents using almost the same questions. According to Conway, Jako and Goodman (1995), one-to-one interviews with standardized questions appear to have the highest reliability.

Validity of the Instruments

The validity of the instrument represents the extent to which the instrument measures, what it purports to measure. It refers to the accuracy of the inferences or interpretations one makes from the data collected. Questionnaire items were developed for both students and teachers. Content validity of the two main instruments was determined with the help of the supervisors of the project who were science education experts in the UEW science department. After the examination of the instruments by the supervisors, changes were effected as a result of comments and suggestions from them. These changes were in the form of the deletion of incorrect items, addition of new items and modification of existing ones. This helped to improve the content validity of both the interview and questionnaire, because their collective judgments were used to establish congruence between all of them. The face validity of the instruments were also determined by the science educationists.

Data Collection Procedure

Initially, the researcher embarked on several familiarisation visits to the selected schools to introduce himself formally to authorities and teachers as well as to acclimatise himself with conditions in the various schools. The researcher then obtained an official letter from the Science Education Department of the University of Education, Winneba. (UEW), introducing him to the various schools and soliciting for their cooperation. The researcher was then given access to the students and teachers. He firstly assured the student of confidentiality and then administered the questionnaires to them. Students were given a standardized time of 40 minutes to use in filling the questionnaire. The researcher was at hand to give the students the needed assistance and also make the necessary clarifications to them. In the next phase of data gathering, the biology teachers in each school were given the teachers questionnaires to fill.

Interview sessions with the teachers followed the filling of questionnaire on other occasions. The researcher made arrangements with the teachers to meet them at convenient times for the interview sessions. The durations of the interview sessions were approximately 25 minutes and involved one on one sessions between the researcher and the interviewee teachers. Whilst the interviews were in progress the researcher conducted audio recordings and also took short hand notes of the salient points and themes stressed on by the interviewees.

The classrooms were visited to see how the subject was taught for the first-hand observation of the interactions that went on during biology lessons (theory and practical) between the biology teacher and the students. Visits were also made to the laboratories in the various schools to ascertain at first-hand the state of the facilities and the equipment and their suitability for practical work. The biology teachers were also given checklists on the status of facilities and equipment for biology practical lessons to fill.

Data Analysis

All statistical analysis were made using the Statistical Package for the Social Sciences (SPSS version 16). Data for answering the research questions was analysed using descriptive statistics i.e. percentages, standard deviations, means, etc. of the responses by the sample. In the second phase of the data analysis, the researcher analysed the responses of teachers to the interview items and summarised their responses based on recurring themes. Recurring themes were noted and the researcher made use of follow up questions to ascertain and seek clarifications on responses given by the various interviewees. The checklist on the state of the biology laboratory and the equipment in them were handed over to the heads of departments to be filled and handed over to the researcher after one week. The duration was to ensure that the heads of department had ample time to gather enough data on all equipment in the laboratories. The researcher then analysed the various checklists to come out with the average of the responses given by the various heads of department.

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

This chapter presents the results of the study obtained through the analysis of data. Results from data analysis of questionnaire are presented first followed by interview results.

Background Data on the Research Subjects

The sample for the study consisted of a total of 295 students from a total of 12 schools. Students were sampled from all four categories of schools under the GES. Out of the total number of 295 students, 89 each were from the category A and B schools. Sixty-five students representing 22% of the total sample were from category C schools and the remaining 52 respondents were students from the category D schools as summarized in Figure1.This will give a fair picture of the status of teaching and learning in these Schools in the Volta Region.

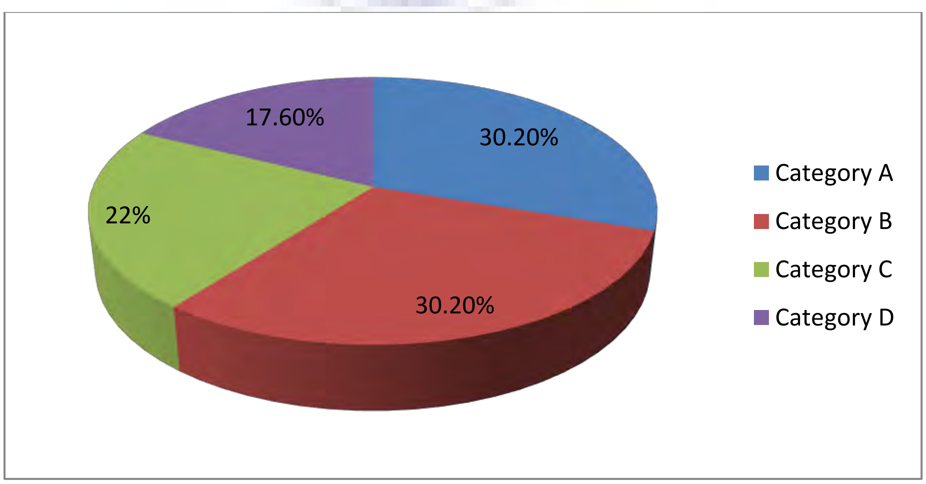

Figure 1: Distribution of the students based on school categories

Students were sampled from both single sex and co-educational schools. Majority of students were from the single sex schools but 60 students each were from the boys' schools and another 60 respondents were from girls schools because they are category A schools which are usually large schools. The entire breakdown of the number of students from each type of school is as seen in Figure 2.

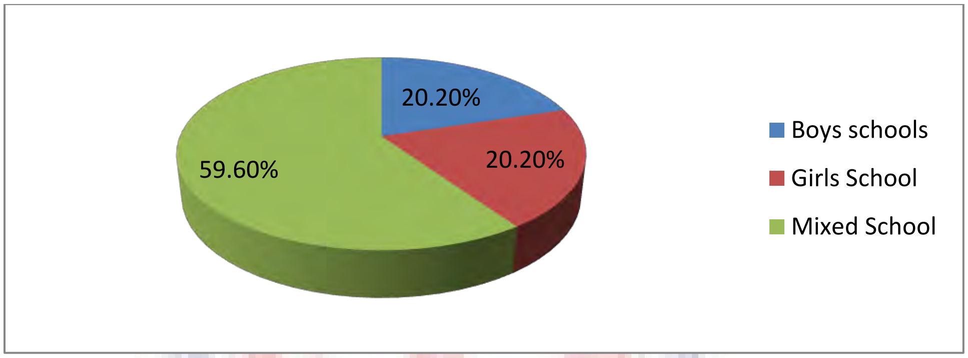

Figure 2: Number of respondents from the various schools

From Figure 3, it can be seen that the majority of student respondents were males. Approximately 55% of the students sampled for the study were males and the remaining 45% were females.

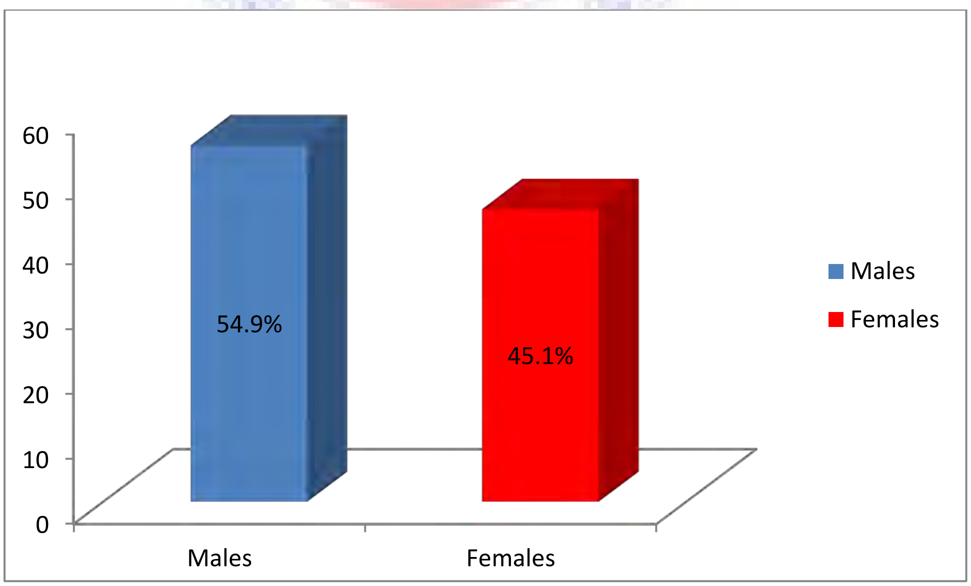

Figure 3: Gender Distribution of the students

The modal age of the respondents was 18 years as seen in Figure 3. Majority of the sampled students were between the ages of 17 to 19 years as respondents from that age range constituted 81.5% of the total sample. Approximately 9% of students were below the age of 17 and the remaining 9.5% above 19 years.

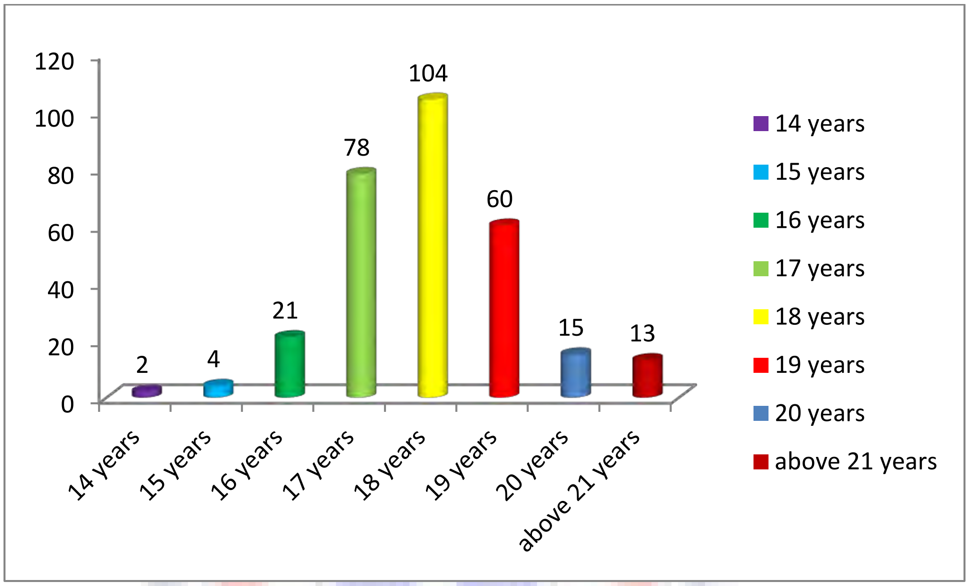

Figure 4: Age distribution of the students

The total number of teachers involved in the study was 21. Fourteen of them were teachers from rural schools and the remaining 7 were based in urban schools.

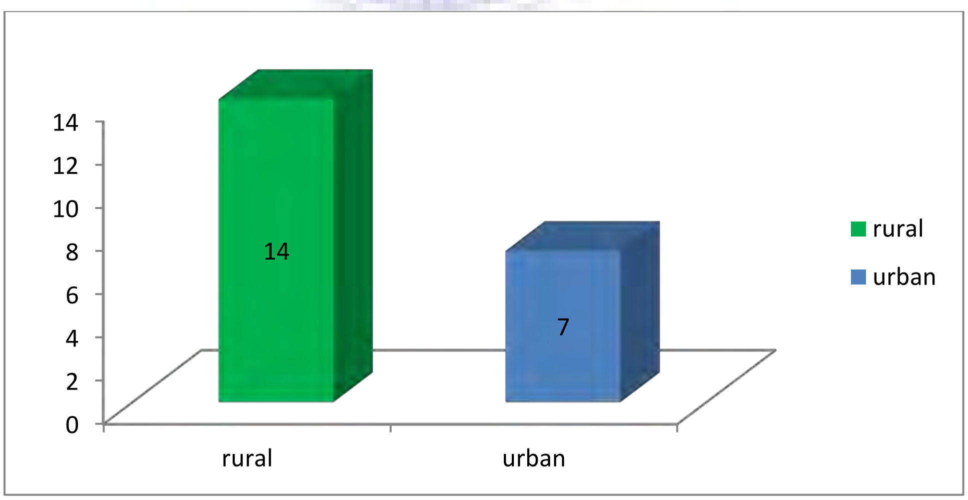

Figure 5: Distribution of teachers according to location of schools

As in the case of students, sampled teachers were from all the four categories of schools. As evident on Figure 6, 33.3% of teachers each were from the category A and B schools whilst 19.1% were from category C and the remaining 14.3% in category D as presented in Figure 6.

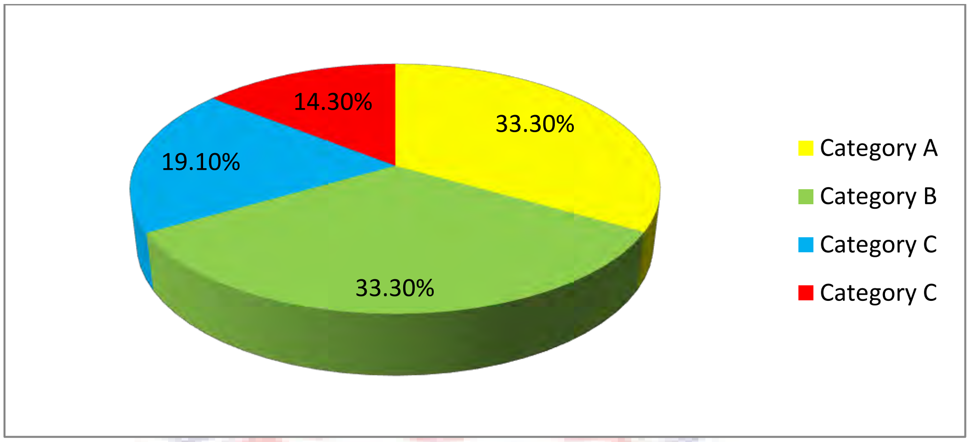

Figure 6: School grades of the teachers

From Figure 7, it can be seen that the ages of teachers ranged between 20 and 59 years. The vast majority of them though were between 30 to 49 years. Three teachers were below the age of 30 and only one was above 49 years.

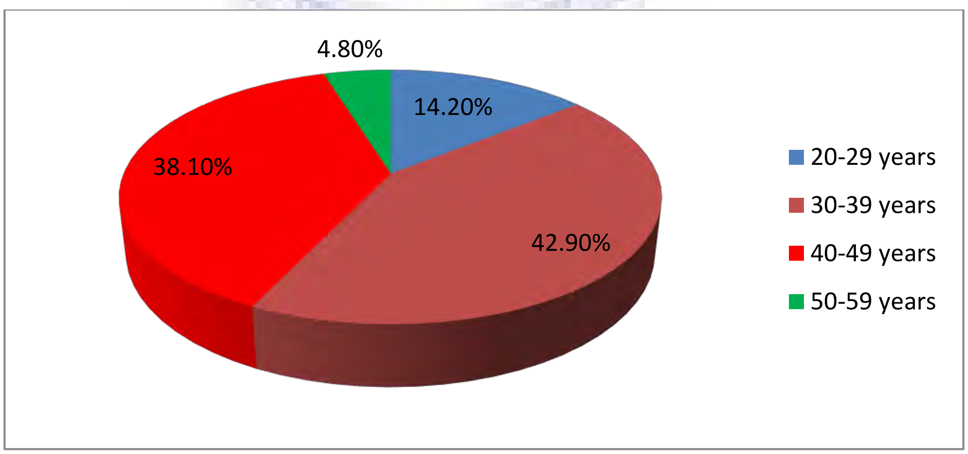

Figure 7: The age distribution of the teachers

The ratio of male to female teachers respondents was 2 is to 1. Fourteen teachers representing 66.7% were males compared to 7 females representing 33.3%.

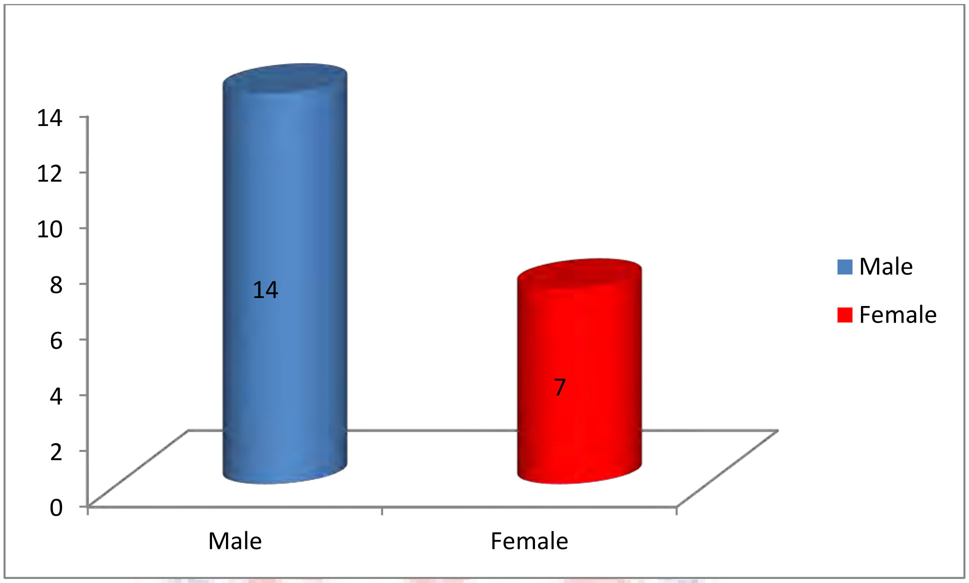

Figure 8: Gender distribution of the teachers

Presentation of the Results by Research Questions

The results of the analysed data are presented based on the research questions that were addressed.

R.Q 1: What is the academic background of the biology teachers in the selected senior high schools (SHS)?

The research question sought to ascertain the academic backgrounds of the teachers who taught biology at the SHS level of schooling, specifically in the Volta region. It also sought to find-out the number of years the various respondents had spent teaching biology as well as the types of qualifications held by various biology teachers. The research question was answered with the aid of questionnaire items specifically designed for such a purpose.

Analysis of questionnaire data gave an indication that the majority of teachers had less than 10 years of work experience. Seven out of the 21 teachers representing 33.3% of the teachers had taught for five years or less. A further 9 had taught for a period ranging from 6 to 10 years. Three out of the remaining 5 teachers had taught for 11-15 years and only one teacher had been in the field for more than 20 years. The breakdown of the years of teaching experience of various respondents is as indicated in Table 1.

Table 1: Teachers' years of working experience

Years	Frequency	Percentage (%)
1-5	7	33.3
6-10	9	42.9
11-15	3	14.3
16-20	1	4.8
21 years and above	1	4.8
Total	**21**	**100**

Majority of respondents were 1st degree holders who had acquired either a Bachelor of Education or Bachelor of Science degree. Only two respondents were working with an HND certificates. Another two teachers had acquired second degrees. This gave an indication that only 10% of respondents had pursued further education after their first degrees. The results have been summarised in Table 2.

Table 2: Academic qualifications of the teachers

Qualification	Frequency	Percentage (%)
HND	2	9.5
Degree	17	81.0
Masters	2	9.5
Total	**21**	**100**

Sixty-two percent of the sampled biology teachers had specialized in biology at the tertiary level. Two teachers each studied chemistry and integrated science. Fourteen percent of the respondents indicated that they majored in agricultural studies at the tertiary level and one person studied physics at the tertiary level.

Table 3: Areas of specialization of the teachers

Subject	Frequency	Percentage (%)
Biology	13	61.9
Chemistry	2	9.5
Physics	1	4.8
Integrated Science	2	9.5
Agriculture	3	14.3
Total	**21**	**100**

R.Q 2: What are the predominant instructional materials in the schools and how are they used during biology lessons?

This research question was tackled using the responses of teachers to several interview items checklist of equipment and also through observation of lessons and available equipment in the laboratories for biology practical lessons. The following interview items were used to collect data to answer the research question.

Use of Instructional Materials in Teaching

Majority of the 21 teachers interviewed stated that they made use of various teaching and learning materials to teach various topics. However three teachers said they scarcely ever used any instructional materials in carrying out lessons. This gives an indication that generally, many biology teachers in the area of interest adopt the use of various instructional materials in conducting biology lessons.

Frequency of Use of Instructional Materials

It was evident that from the responses of the 18 teachers who used instructional materials in teaching that most teachers did not use instructional materials as frequently as required. Nine out of the 18 said they used instructional materials such as charts and models about 4 to 6 times in a given term. A further four interviewee teachers said they used such teaching materials not more than 3 occasions throughout the term. The remaining four employed teaching materials to teach students either once or twice throughout the entire duration of the term. Thus it can be inferred from the responses that, the use of instructional materials in various SHS in the Volta region was not as predominant as required.

Types of Instructional Materials used during Theory Lessons

Instructional materials mentioned by teachers included charts, modules, pictures, animations, computers, videos and audio recordings. Generally majority of the teachers said they used charts and models in teaching practically every theory lesson. Some teachers said before they began to teach a particular topic they sometimes asked students to observe some charts and try to identify peculiarities. Only 14.67% of the teachers said they sometimes made use of videos to teach some particular topics. Computers were used alongside projectors to teach on several occasions.

Observation

This researcher observed that during theory lessons the major instructional material used by most teachers was the biology GAST textbook or any other relevant textbook. There wasn't the use of charts, slides, models etc. to help the teacher to carry-out the lessons and also to aid learners understanding of the concept being taught. In several instances though, some of the teachers used items of realia including flowers to teach a particular topic. At other instances students were asked to sit in groups of 5 and then the teacher distributed photocopies of pictures depicting some particular cycles to explain particular concepts to students. A few teachers did not use any instructional material at all throughout the entire lesson.

Types of Instructional Materials Teachers Use in Conducting Practical Lessons

The instructional materials which teachers made mention of included models, pictures, animations, computers, videos, wall charts. Teachers used specimens, objects of *realia,* videos, and charts and sometimes slide to teach practical lessons. Many schools also had laboratories which had specimens of some living organisms and this helped teachers to teach practical lessons more easily.

However, several respondent teachers said they were compelled to teach without adopting any instructional materials due to the absence of biology laboratories in their schools. Few teachers also complained that they could no longer use charts in teaching because the available ones had become outmoded or faded and new ones had not been supplied to the school.

Observation

It was evident on observation that the instructional materials mostly used were charts and models. The researcher found out that most laboratories in the select schools had charts and models of various biological structures and diagrams. However, visits to biology laboratories in several of the category C and D schools involved in the present study revealed that most of them had poorly equipped laboratories with no relevant teaching and learning materials and specimens for conducting lessons. In some instances this researcher observed that the available equipment were either obsolete or dusty. This gives an indication that teachers were either not well-trained to use such equipment or that broken down equipment were not replaced on time. The researcher observed that in most of the schools, there was not much difference in the types of materials used in conducting theory and practical lessons

R.Q 3: How are the theory and practical lessons taught in the senior high school and what influences the selection of a particular teaching method?

The main aim of this research question was to establish how biology instruction was carried out in the selected schools in the Volta region. It sought to find out the methods of instruction mostly adopted by teachers during practical and theory lessons and the factors that account for the choice of a particular instructional method. In answering this particular research question, consideration was given to such factors as class size, presence and role of laboratory technicians and state of the laboratory.

Analysis of how theory lessons are taught

Only one teacher handled a class of less than 21 students and 2 other teachers handled biology classes with class size ranging from 30-40 students. About 71% of teachers handled classes containing more than 40 students.

Table 4: Average number of students in class

Response	Frequency	Percentage (%)
Less than 21	1	4.8
21-30	2	9.5
31-40	3	14.3
41-50	10	47.6
51-60	3	14.3
Above 60	2	9.5
Total	**21**	**100**

Based on the responses of students, it became clear that most teachers adopted the lecture method in carrying out lessons. Approximately 10% of respondents said that theoretical lessons were conducted using the activity method. Nineteen percent of the students said their teachers adopt the demonstration method of teaching in carrying out theoretical lessons.

Table 5: Teaching methods adopted by the teachers during theory lessons

Method	Frequency	Percentage (%)
Activity	2	9.5
Lecture	11	52.3
Demonstration	4	19
Activity and Lecture	1	4.8
Lecture and Demonstration	2	9.5
All three	1	4.8
Total	**21**	**100**

Regarding the teaching of practical lessons, students indicated that approximately 14% of their teachers used the activity method. About 5 percent said that teachers used the inquiry based method of teaching in the practical class. The percentage of students who said that teachers used both activity and inquiry method was approximately 24. An appreciable proportion (33%) of the respondents said their teachers employed both activity and demonstration method of teaching practical lessons. Almost 10% said their teachers employed all 3 methods to teach practical lessons as displayed in Table 6.

Table 6: Teaching methods adopted by the teachers during practical lessons

Method	Frequency	Percentage (%)
Activity	3	14.3
Inquiry	1	4.80
Demonstration	4	19.0
Activity and Enquiry	5	23.8
Activity and Demonstration	7	33.3
All three	2	9.5
Total	**21**	**100**

Table 7: Are students allowed to practice on their own in the laboratory

Response	Frequency	Percentage (%)
Yes	108	36.6
No	187	63.4
Total	**295**	**100**

The information in Table 7 shows that around 37% of the students indicated that they were sometimes allowed to undertake biology practical activities in the laboratory. But the number of students who indicated otherwise was in the majority. This may be due to the fact that the facilities and equipment in the laboratory are inadequate to meet the needs of large numbers of students.

Table 8: Availability of laboratory technicians

Response	Frequency	Percentage
Yes	116	40
No	177	60
Total	**295**	**100**

Table 8 gives a summary of students' responses to the question of whether laboratory technicians were available during practical lessons or not. It is evident from students' responses that there were no laboratory technicians in most of the schools as evident in the fact that 60% of respondents said there were no laboratory technicians in their schools.

It was also established that practical lessons were conducted solely by teachers due to the absence of laboratory technicians. It is evident from the above table that only 40% of students had laboratory technicians in their schools. According to the student respondents, laboratory technicians mostly helped in setting up equipment but never participated in the teaching of students. Judging from students' response, most of the teaching was done by their biology teachers rather than the laboratory assistants.

Table 9 summarises students' responses to the question as to whether any form of educational trips such as field works and excursions were organised to supplement school lessons.

Table 9: How biology practical lessons are conducted in the laboratory

Item Nos.	Response	Frequency	Percentage
Item 18	Yes	86	29
	No	209	71
Item 19	Yes	230	78
	No	65	22
Item 20	Yes	3	14.3
	No	18	85.7

Note: Item 18: are field works organized for students; Item 19: Are teachers present in the laboratory; Item 20: Is the same laboratory used for all science subjects?

As many as 71% of students said there were no such field trips. The remaining 29% of students had either been part of an excursion or taken part in a field work to supplement biology lessons conducted in the classroom.

Most often, teachers were present in the laboratory during practical lessons and were the main instructors during such sessions. Twenty-two percent of students indicated that teachers were not present during practical lessons which indicate that probably laboratory assistants conducted lessons in such instances.

It is evident that most schools have different laboratories for various science subjects. However, 3 (14.3) out of the 21 teachers indicated that one laboratory was used to conduct practical's in all science subjects including biology.

Interviews

When interviewed about their methods of teaching, many teachers said they varied the method based on the particular topic being taught. However majority of the interviewee teachers also acknowledged that they mostly employed the lecture method in teaching theory lessons. Approximately 20% of teachers said they used the demonstration method in practical lessons due to the scarcity of laboratory equipment. They also indicated that sometimes role play is adopted in teaching practicals. Only one teacher said she used the activity method in teaching theory classes.

What factors influence your selection of topics?

According to the teachers, the particular topic which they treated with students was sometimes influenced by the attitude of students towards that particular topic. Teachers explained that they had to avoid teaching certain topics because students regarded such topics to be difficult to understand. According to other teachers, they sometimes avoided some topics because they deemed them to be less relevant compared to other topics which appeared quite often in WASSCE examinations. Another factor which influenced the selection of topics according to teachers was the unavailability of relevant equipment needed to teach some topics. However one teacher conceded that he avoided the teaching of some particular topics because he found it difficult to understand such topics.

Several respondent teachers also remarked that they considered the previous knowledge of students before tackling several topics.

According to respondent teachers, they preferred mostly to use the lecture method due to the large class sizes. Many of them argued that the lecture method enabled them to move rapidly through the course content in a given term. Some also said they deemed the lecture methods as the most appropriate way of teaching theory lessons since those lessons did not involve any practical.

However one teacher said he used the method because there were no appropriate graphics, animations and models in the school which could help him to teach particular topics. Consequently, he was compelled to use the lecture method even though it was against his wish to adopt it. Those who used the demonstration method said that they were restricted to use that method due to the problem of very few types of equipment to serve the needs of large numbers of students. However majority of teachers said they used the activity method when equipment and reagents needed for teaching a particular topic were readily available. Two teachers in the category D schools said they were compelled to use the lecture method frequently during practical lessons due to the absence of logistics needed to undertake practical's. A teacher said sometimes he varied the teaching methods based on the attitude of students. He elaborated that when students were not prepared to learn especially during the afternoon lessons, he would take them to the laboratory and tries to take them through some demonstrations of the concept or topic to be studied.

It was also established that the time of the day as well as the particular stage in a given academic term also had an influence on the method that teachers employed. Several teachers pointed out that getting to the latter part of the term when they were expected to summarise lessons for the term and take students through a revision of the terminal work, they were compelled to quickly move students through the remaining course content through the use of the lecture method.

It was found that while theory lessons were organized predominantly through whole class instructions, practical lessons were individualized. The practical lessons were characterized by the following:

1. Large class size
2. Insufficient materials/specimen and equipment
3. Constant teacher absenteeism
4. Rowdiness in the class

5. Use of untrained Laboratory assistants

On the other hand, theory lessons had the following characteristics

1. Large class size
2. Whole class instruction (the lecture method) with minimal student participation.

R.Q 4: What are the perceptions of students and teachers on the practical aspect of biology?

This question was answered using the responses of students and teachers to various questionnaire items designed to find out their perceptions of biology practical lessons. Views of various respondents were sought on factors such as the frequency of practical lessons, the availability and adequacy of equipment for undertaking biology teaching and learning and also the sufficiency of time allocated for biology practical lessons. A checklist on the state of existing equipment also enabled the researcher to gather enough data on the state of laboratory equipment in the various schools. Respondents were also asked to state the factors inhibiting against the conduction of effective biology practical lessons in the various schools.

Majority of the students felt that the number of biology practical activities they had in the school were not frequent enough. Only 16 out of the total number of 295 said there were frequent biology practical lessons in the school. This meant that in general students were not content with the number of biology practical activities conducted in the school.

Table 10: Frequency of biology practical activities

Response	Frequency	Percentage (%)
Not at all	67	22.7
Once in a while	202	68.5
Frequent	16	5.4
Very Frequent.	10	3.4
Total	**295**	**100**

Is your biology laboratory well equipped for practicals?

Many students also believed that their school laboratories were not adequately resourced enough to meet the standards which will help them to tackle the WAEC biology practical examination. Some students also thought that some of the existing laboratory equipment was inappropriate to serve the needs of students. This is because the syllabus had been revised several times but there had not been the provision of new equipment and reagents to help teachers adapt to the changes in the syllabus.

Majority of students also felt that the time allocated for biology practical lessons on the time table was insufficient. Only 6.7% of respondents felt that the time allocated for biology practical's on the school time table was sufficient.

Teachers Views on Practical Lessons

Majority of the teachers were of the view that the laboratory used for conducting biology practical's was not well equipped as seen on Table 11. Only 33.3% of the sampled teachers said their schools' laboratories were stocked to meet the standards required for students to pass WAEC practical examinations.

Table 11: Teachers views on state of laboratories

Dimension	Mean
Teachers views as to whether the laboratory is well equipped or not	1.33
Adequacy of Laboratory resources to meet the Needs of all Students	2.48
Supply of Equipment	2.64
Sufficiency of teaching time	1.52
Effectiveness of Teaching	2.68
Extra equipments needed	1. 38

About 57% of respondent teachers were of the view that the available resources were not adequate to serve the needs of all students in the laboratory at a given time. This was probably because of the large sizes of the biology classes. Nine percent though, were of the view that the resources were very adequate to serve all the students and the remaining 34% of respondent teacher also felt that the resources were adequate to serve the needs of all students during practical sessions.

Inferring from the table above, it is clear that mostly, teachers were displeased about the rate at which the biology laboratories were supplied with equipment and other logistics. They mostly felt that the laboratories were not supplied with much needed apparatus as frequently as should have been. Approximately 19% of the teachers expressed contentment with the frequency at which the authorities supplied the laboratory with equipment needed for biology practical lessons.

Teachers also generally agreed with students that the time allocated for biology practical within each week was inadequate. A paltry 14% of respondents indicated that the time allocated for biology practical's in their school was sufficient to undertake biology practical lessons adequately.

In the face of inadequate and ill-equipped laboratories, it was not surprising that teachers largely felt that they were unable to teach the practical aspect of biology as effectively as they would have liked to.

As evident in Table 11, teachers asserted the fact that there must be the provision of more equipments in order to meet the needs of the growing number of students and also to replace the existing obsolete ones in the face of changes in the syllabus and hence the corresponding changes in the practical component of the biology teaching and learning.

Table 12: Checklist on the state of equipment in the biology laboratory

Availability and condition of resources and facilities	Good	Fair	Poor
Sufficiency of laboratory facilities	21	31.5	47.5
State of repair of laboratory facilities	34	27	39
Supply of chemical reagents	19.5	10	70.5
State of repair of laboratory equipment	15.4	20.5	64.1
Amount of equipment for experiments	25	26	49

Problems Faced during Biology Practical Lessons

Problems the students mentioned have been categorized based on recurring themes and complaints as follows:

- Congestion
- logistics
- charts and models
- lack of comprehension of concepts
- obsolete nature of equipment and logistics
- scarcity of reagents and equipment

- teaching method of teacher. (lecture)
- Same laboratory for all subjects
- not much practical work as is required
- poor maintenance culture
- non-labelling of equipment
- Improper supervision by teachers and technicians

Suggested Interventions to Improve the State of the Laboratory

- provision of a modern laboratory
- supply of more models and equipment
- renovation of the laboratory
- provision of textbooks and laboratory manual

R.Q 5: How do the students and teachers perceive biology in relation to the other pure science subjects?

This research question was partly answered using responses of students to 5 questionnaire items designed to find out their perceptions on biology as a subject of study. The responses of teachers to several interview questions also helped the researcher to determine the perceptions of teachers about biology in relation to other science subjects.

Students' responses to the items are as summarized in the Table 13.

Table 13: Students perceptions of biology

Item	SA	A	NC	D	SD
1. I find biology as an interesting subject	40	48	14	83	110
2. There are many prospects in the study of biology	63	89	21	79	43
3. Biology is not a relevant subject	41	35	11	102	106
4. Biology is for only intelligent students	55	36	21	77	106
5. It is difficult to score high marks in biology	77	121	5	43	49

Note: SA: Strongly Agree, A: Agree, NC: Not certain, D: Disagree, SD: Strongly Disagree

Approximately 30% of students believe that biology is an interesting subject. The vast majority of the remaining 70% of the students however disagreed with the statement that biology is interesting. Thus, it can be inferred that majority of students perceive biology to be a boring subject. With regards to the second questionnaire item which sought to find out the views of students on the prospects in studying biology, 51.5% of the respondents agreed with the assertion that there are many job prospects associated with the study of biology. A significant 41% disagreed with the above assertion though. The third item wanted to find out from students whether they perceived biology as a relevant subject of study or otherwise. Almost 26% of the total number of students believed that biology is not a relevant subject but a sizable 208 of them making 70.5% of the total number of students perceived biology as a relevant subject of study. Thus it can be acknowledged that in the face of the problems militating against the study of biology by students, most of them deemed it as an important subject of study. A total of 183 students disagreed with the statement, thus indicating that students largely believed that biology could be studied by students of various academic backgrounds and competencies.

The responses of students to the next item indicated that majority of them disagreed with the view held by some persons that biology is a subject meant to be studied by only intelligent students. Interestingly most students indicated that it was difficult to score high marks in biology though they had earlier largely debunked the notion that biology was meant for only intelligent students. Out of the 295 students involved in the present study, a total of 198 thought that it was difficult to score high marks in biology as against 92 students who thought otherwise. Thus majority of the students (67.1%) perceived that it was difficult to score high marks in biology.

Interview Schedule for Teachers

What is the attitude of your students towards the study of biology?

Many teachers said that generally their students' attitude towards the study of biology was not very encouraging. A summary of teachers' responses to this question gave the idea that students regarded biology as a boring and voluminous subject compared to the other science subjects. However some teachers were quick to indicate that the students generally had poor attitudes towards the study of all the other science subjects.

Do you agree with those who hold the perception that biology is a difficult subject? Explain your answer

Some teachers said biology was a difficult subject to teach based on the fact that, students generally had poor attitudes towards the subject. Teachers were also discouraged in the teaching of biology because most often they were unable to get access to models and specimens needed in teaching. They explained that, that made the understanding of concepts by students very difficult. Teachers also complained about the boredom that comes with giving students voluminous notes in class. Teachers cited instances where they had to cancel educational trips for students due to the absence of financial and other forms of assistance from school authorities. Some also complained that despite the fact that there had been several curriculum reforms, there had not been any official in-service training programmes to update the skills of teachers on how to adapt to the changes in the curriculum. Conclusively, this made the handling of the subject difficult for teachers especially the new teachers.

In your opinion, are there any peculiarities which make the study of biology more difficult than other science subjects? If yes, please list them

Several teachers were of the view that biology was more difficult a subject than the other science subjects. A teacher backed this assertion by stating that over the years, the WASSCE grades attained by teachers in the other science subjects were relatively higher than their grades in biology. Some further stressed that, it was nearly impossible to teach students biology in the absence of a well-equipped biology laboratory. Others complained that the generally poor reading habits of students also had an adverse effect on their performance in biology. Another problem was that apart from the GAST textbook, there were no other good biology reference books which teachers and students could make use of. Finally some also stressed that the time allocated for the teaching of biology was inadequate considering the volume of work which needed to be covered as required by the syllabus.

Twelve of the interviewees however debunked the assertion that the problems inhibiting against the study of biology in their schools were peculiar to the subject only. They emphasised that their colleagues who taught the other science subjects and even the non-science teachers also complained about the unavailability of learning materials and the insufficiency of the time allocated for teaching. Several teachers indicated that they had moved from different fields to pursue biology because of the interesting nature of the course and also due to the fact that the problem of shortage in models and specimens could be tackled through the use of videos and graphic images.

R. Q 6: Which support services are available to enable the biology teachers update their knowledge and skills? This research question was answered using various items on the teachers' questionnaire and some items on the interview protocol.

Table 14 gives the breakdown of teachers' responses to the question as to whether they should be given additional incentives or not. All the 21 respondent teachers responded in the affirmative that they deserved to be given extra incentives for their efforts.

Table 14: Should biology teachers be given extra incentives

Response	Frequency	Percentage (%)
Yes	21	100
No	0	0
Total	**21**	**100**

As displayed in Table 15, it is evident that a vast majority of teachers had undergone in-service training. Only 4 teachers representing 19% of the total number of teachers said they had not received any in-service training in biology.

Table 15: Frequency of biology teachers who had received in-service training

Responses	Frequency	Percentage (%)
Yes	17	81
No	4	19
Total	**21**	**100**

Table 16: Organisers of in-service training

Responses	Frequency	Percentage (%)
GES	3	14.3
STMIE	5	23.8
GAST	11	52.4
Any other	2	9.5
Total	**21**	**100**

The main organizers of in-service training programmes and workshops for science teachers was GAST which accounted for approximately 52.4% of the total number of in-service programmes attended by respondents. The next in line after GAST was the STMIE which organised 23.8% of the in-service programmes attended by teachers interviewed. However the GES organized only 14.3% of the total number of in-service courses for teachers. Respondents however indicated that the school sometimes organised in-service training for teachers at the departmental level.

As evident in Table 17, teachers felt that in-service training was not organised as frequently as they should be. Some of those interviewed said they had not attended an in-service training programme for about 3 years. Only 23.8% of teachers said that in-service programmes were organized in their schools frequently. Approximately 57% of respondents attended in-service training programmes once in a while as displayed in Table 17.

Table 17: Frequency of in-service training and workshops

Responses	Frequency	Percentage (%)
Very often	4	19
Quite often	5	23.8
Once in a while	12	57.10
Total	**21**	**100**

Currently are you aware of any programmes or schemes sponsored by government, GES or any other agency which you can benefit from as a biology teacher?

In response to this question, several interviewees said they were not aware of any such interventions by governments to help science teachers update their skills though some of them had tried to make enquiries about such an issue. Several of them made mention of the study leave which was granted for teachers to enable them receive their salaries whiles pursuing further studies. Several interviewee teachers also remarked that there were currently several distance education courses mounted by some universities which enabled teachers to upgrade their skills and acquire more knowledge whiles still attending to the needs of their students in the school.

CHAPTER FIVE

DISCUSSION, SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

This chapter discusses the research findings, identifies implications, gives recommendations on how to improve perceptions of teachers on school climate and make suggestions for future research.

The study sought to investigate the status of Teaching and Learning of Biology in some selected senior high schools in the area of study. Among other things, it focused on the backgrounds of the biology teachers in the Volta Region. It also investigated into how the theory and practical biology lessons were handled by teachers. There was also an emphasis on the predominant instructional materials used during biology lessons as well as the perceptions of teachers and students on the practical aspect of biology as well as the subject biology as a whole.

Discussion

The results of this study revealed that there are serious problems in biology education that cause achievement to decrease. Students' perceptions of biology comes the first, that is, their thoughts are in the way that biology depends on memorization. This situation seems a great problem to both teachers and students. A Curriculum covering a large amount of topics and details is another reason causing low achievement in biology. In addition class hour allocated to biology lesson appears to be another problem. Furthermore the practical aspect of the biology coursework profoundly affects students' perceptions of biology.

Besides there are opinions that biology is not given sufficient importance by the authorities concerned.

In the following paragraphs these issues will be discussed.

Analysis of Teachers' Responses

The analysis of teacher interviews revealed that for a meaningful biology education, the lesson should be visual, include practice in addition to theory.

Students should actively participate in the lesson besides it should be far from memorization and the topics should be connected to examples of everyday life. Out-of-school observations are found to be an important component of efficient biology education.

On the other hand, teachers' instruction do not meet these prerequisites completely because of constrained economic conditions and time devoted for biology lessons and dense curriculum.

Actually from the responses of teachers, it can be deduced that after some time teachers become traditional teachers who do not employ different kinds of activities.

Surprisingly, there were teachers who even do not believe the benefits of laboratory studies anymore, although laboratory studies have proven to contribute to better learning (Sabri & Emuas, 1999). There were also teachers who defined strengths of their instruction as bringing well-prepared to the class, improving themselves, following innovations and recent developments, teaching biology far from memorization. Unfortunately, although all these are the matter of the fact that teachers should perform as their usual own works, these teachers are now thinking that these are extraordinary actions. Because current instruction of biology teachers emphasize the learning of factual information and transferring knowledge from textbooks to students. Therefore teachers adapt themselves to this situation sometime after they were graduated.

The findings also revealed that about half of the teachers thought students have positive attitudes towards biology, whereas the other half thought that students partly or don't have positive attitudes toward biology. However, the importance of having positive attitudes is evident (Singh, Granville & Dika , 2002).

Deducing from the results, teachers are aware of their students' expectations to better learn biology. Teachers' responses revealed that students wanted both to be actively involved in the lessons including practice and visual aids, students also expect that lessons should be enjoyable and connected to daily life. An important conclusion is that generally, high school teachers mentioned that their students expect their teachers to be confident on subject matter and dictate the notes to them. Another demonstration of views of teachers (of all school categories) is about the weaknesses of biology education. The main problem is insufficient time allocated to biology lessons.

Another problem revealed is that biology curriculum covers too many topics and details. The teachers, mostly, thought that these details are unnecessary. Chiapetta and Fillman (1998) also stressed the overwhelming quantity of the content of high school biology courses which doesn't permit meaningful learning through inquiry methods, in addition, this situation makes students memorize the terms. The teachers talked also about the strengths of biology education. Sadly, some teachers were so pessimistic that they thought that there wasn't any success in biology education. On the other hand, content of biology curriculum, the sequence of topics and presence of current biological developments in the curriculum are considered as strengths of biology education by most of the teachers in the area of study in the Volta Region.

The fact that some teachers complained about students not being interested in biology should be a source of concern to all stakeholders. This may be attributed to, as aforementioned, large content area and denseness of curriculum which discourages teachers to cover all the topics on time and also makes it difficult for students to study all the contents of the biology syllabus.

Additionally, many high school biology teachers complained about crowds of classes. Although contributions of field trip to effective biology teaching and learning is evident (Killerman, 1998), very few teachers make use of this method, because administrative procedure and the large class sizes are discouraging factors for out-of-school activities such as observations in the nature, visiting museums, exhibitions or zoos. Teachers mainly emphasized the importance of visual aids, experiments, combination of different teaching methods and active involvement of students for a better biology education.

Teachers' responses showed that the teachers mostly use questioning along with the other methods like lecturing, demonstration, discussion, experimental teaching.
Demonstrative materials are important that is, the presence of good materials provides activity-based teaching (Killerman, 1998; Vaidya, 1993). It is known that, different kinds of sensory experiences like listening, viewing, reading and doing contribute to overall learning and retention. This information emphasizes the importance of supportive materials and active involvement of students for effective learning.

When material usage is taken into account, the difference among school types appears again. According to the responses, the majority of the teachers working in Category A schools benefit from many kinds of resources like books, CD, video, models, overhead projector, laboratory, and internet..

Most category D schools do not use these aids due to lack of them. Many teachers complained about inadequate laboratory conditions which hindered them from undertaking experiments. Some stressed that, though they have video and overhead projector they don't use these tools. On the other hand, teachers' willingness and efforts are important for a meaningful teaching. It was understood from the responses that in the same school while one teacher uses a material such as a chart, the other does not use the available materials.

Asking questions in the class, bringing articles to the class, making comment are all indications of students' interest in biology lesson. Besides the content of question may indicate the level of thinking of the students who raised it (Yarden, Brill & Falk, 2001). Results at the present study revealed that teachers thought that their students aren't successful in biology lesson.

As Liras (1994) stated, biology must be understood as a complementary discipline to other sciences providing formal thought which can afterwards be transferred to other knowledge areas. Besides subject matters in biology are connected to each other and cannot be thought in isolation. Teachers' responses supported these statements but according to some teachers, students have difficulties to relate biology topics with other science disciplines. The sequence of topics in biology curriculum may be inappropriate which may account for this difficulty.

Knowing one's prior knowledge can help teachers design appropriate teaching strategies and students connect past experiences and new incoming information, and so enhance meaningful learning (Prosner, Strike, Hewson & Gertzog, 1982). All of the respondent teachers believed the importance of knowing students' prior knowledge which they measure through questioning. Teachers indicated their thoughts about curriculum. That the curriculum covers a high amount of content has been aforementioned.

Some of the teachers attached importance to subject matter knowledge. It is a very threatening fact, as teachers mentioned, that there are teachers who teach biology in many high schools but aren't biology teachers. It should be noted that, mostly high school teachers complained about this situation. Those teachers teaching outside their field cause low achievement in biology because they are not knowledgeable enough in biology thus they cannot meet students' needs.

In addition non-professional biology teachers offer explanations and analogies that reinforce misconceptions in pupils (Tobin, Tippins & Gallard, 1994) and provide inappropriate and misleading representations (Hashweh, 1987).The teachers agreed that there is a need for seminars that will improve teaching strategies and laboratory skills of teachers. Teachers can gain insights about developments in science and science education therefore the Ministry of Education should organize l seminars that should be facilitated by people who are competent in their biology teacher education.

The research findings indicated that majority of teachers who teach biology at the SHS level in the area of study in the Volta Region have worked for less than 10 years in the field. Only a small percentage of biology teachers had taught for more than 20 years. This is a worrying observation, taking into consideration the fact that experience counts a lot so far as teachers' perception of their job is concerned. As observed by Moriana and Herruzo (2006), demographic and professional or organisational characteristics such as the amount of teaching experience, or the characteristics of the students, have a direct or indirect influence on teachers' job satisfaction and perceptions. As also observed by Dembo and Gibson, 1985, teachers' confidence in their ability to teach increases throughout their teaching career.

Student Responses

Student interview results showed that students generally like biology. But on the other hand there are some students who do not like biology. Based on students' responses, the teacher is central factor to affect students' attitude toward biology. Teachers' instructional methods, behaviours towards students, affect negatively the attitude of students toward biology. Most of the students of all four categories of schools found biology necessary but especially human related topics engage students' interest. Most of the students had difficulties in biology, because according to them biology is dependent on memorization and is boring, verbal and uninteresting. They stated that there were too many topics and technical terms in biology.

The analysis of results showed that students perceive photosynthesis, respiration and systems as the most difficult topics. These topics were also mentioned by the teachers that students perceive as most difficult. No difference was found across school types for this finding. Photosynthesis and respiration seem confusing; they therefore depend on memorization according to students. On the other hand, there were students who had difficulties in genetics, cellular division and reproduction.

The results revealed students' greatest problem in learning biology, and that students think that biology depends on memorization. This pattern seems to be the greatest problem for both teachers and students (with no difference between responses across school types). Indeed the responses of most of the questions asked to teachers or students showed the problem of memorizing as a challenging issue.

Therefore this challenging issue of memorization should be examined with care. Ward and Wandersee (2002) stated that current science textbooks and instructional methods emphasize the learning of factual information and test for recall. Teachers present the textbook information by providing only one point of view of complex, abstract concepts. Teachers reward rote memorization and value isolated facts. This makes students continue memorizing. As Novak (1998) stated that students who learn by rote memorization fail to develop knowledge integration and fill the gaps in their minds with alternative conceptions to support their conceptual understanding. However, what should be is that learners must, after learning facts, assimilate and integrate their prior knowledge into concepts, constructs, principles, and conceptual frameworks (Ward and Wandersee, 2002). In addition some students stated their problems during biology learning as forgetting the topics quickly which is again an outcome of memorization. As Eraut (1994) stated unless knowledge is constantly used in daily life it is forgotten

With regard to the teachers' instruction, based on students' responses, teachers mostly used questioning method. As noted earlier, teachers' responses also revealed that most of the teachers use questioning method.

Compared to the teachers, the number of students who said demonstration and discussion methods were used in biology lessons is much lower. Some of the students were not pleased with instruction of their teachers who didn't teach but "told" biology then went out and made students "tell" the topics whereas "teaching" is not "telling". Most of the students stated that they didn't do laboratory studies. It is also worth noting that of the students who expressed that they did laboratory studies, the majority were from category A schools. This pattern can be explained by availability of adequate facilities to undertake laboratory work in these schools.

There were students who stated that they never made a study in the laboratory. Just like teachers, students also were aware of the importance of visualization, experiments, active involvement of students through discussion or questioning, and examples from real life for a good biology learning to occur.

The students further stated that teachers should be confident on the subject matter. Researchers confirm students' expectations. Watts, Gould and Alsop (1997) considered students' questions as important indication of their thinking. Thus students should be involved in the lessons by asking questions. With regard to the laboratory studies, Zitoon and Al-Zaubi (1986) concluded that laboratory method is more effective in developing scientific thinking skill of Jordanian science secondary students than traditional method.

The results revealed that most of the students (of all types of schools) think that biology has an abstract nature and is dependent on memorization. Therefore they consider biology difficult. Although most of the students are interested in biology, many of them find biology boring. As Delpech (2002) stressed, absence of practical, hands-on activities might make science lessons boring. With regard to the biology class hours, surprisingly, in contrast to the teachers' views some of the students found biology class hours more than enough. On the other hand, students' thoughts confirm teachers' about denseness of curriculum which, as they expressed, contains unnecessary details such as digestive system of an earthworm.

Furthermore students considered other science lessons especially mathematics as more important. These results confirm teachers' observation. In addition there were students, as teachers, who stressed that biology questions in school examinations are long and not clear, and are few questions in number. Some of the students stated that since biology is difficult, students don't study while few students stated that since biology is easy, students don't study.

Students were affected by methods of instruction, their level of interest in the course content, their ability to see application of the content, and the ability to make connections between the content and their everyday lives. When the instructor related personal stories and examples, students were more interested in the content. Students indicated positive responses and spoke of the effectiveness of using every day practical examples during lecture. This finding indicates that it would be worthwhile using case studies, a type of problem-based learning, to engage students.

Students also expressed a desire for more active learning and teaching strategies l. Interactive instruction between student and instructor, for clarification of the content, is preferred over pure lecture. According to Freeman's (2007) work, measurable results were even more positively pronounced when students were given points for their participation. Students commented on working on questions with other students during lecture where the answer was eventually given would be an improvement over straight lecture. Participants in the focus group discussions frequently commented positively about being able to interact with laboratory instructors as well. In addition, students identify "hands on" inquiry-based learning in laboratory as pivotal to their ability to "pull things together". The Participants also stated that laboratory helps them relate science to everyday life.

Topics related to the human body, the environment and DNA are of more interest and students find these topics are more practical. Students are also affected by the personality and instructional abilities of the teacher, as well as external factors such as the lighting and temperature of the room. While relevance is mentioned in Hohman's (2006) work, neither the abilities of the teacher, nor the external factors such as the lighting and temperature of the classroom. The results of this study have shown that these components are pivotal to the success of an instructor whose intent is to help students master the content and thought processes inherent in a general biology course for non-biology majors, while seeking to convey the content as relevant to everyday life.

Conclusion

This study revealed that both biology teachers and students are bothered about the fact that there are teachers who are not competent on subject matter furthermore teaching outside their expert areas. Therefore to meet students' curiosity teachers should absolutely be competent on subject matter, they should improve themselves about the developments and already changed information. Furthermore they should do additional background reading in the subject area prior to teaching the lesson.

Students' responses revealed that teachers made students feel positive or negative toward biology and involve in the lesson. For that reason teachers should motivate the desire to know, stimulate curiosity and cognizance and develop a creative and critical learning environment.

Teachers shouldn't use a textbook style during teaching but instead should use the textbook as a resource rather than the curriculum. Biology teaching shouldn't be in the traditional way in which information from teacher and text is transmitted to the students (Ward and Wardersee, 2002). Teachers should improve instructional strategies that lead students to grasp the meaning of a learning task. They should deemphasize rote learning of large numbers of facts. It is teachers' role to take the students from where they are and help them to better understand by making connections to things in the world, so that students can apply the knowledge learnt in the class to the real world. The teachers' role should be determined as a facilitator who engages student-centred instruction as consistent with the objectives of purposeful biology education relevant to life.

The results showed that biology teachers ask questions at knowledge level to evaluate their students' learning. Consequently biology teachers should develop and use evaluation mechanisms that assess students' higher-level thinking, process-skills and conceptual understanding. Accordingly they should teach biology in such a way as to increase motivation and strengthen problem solving skills. This is possible through lessons wherein both hands-on and minds-on activities take place.

Thus it is right for teachers to discuss scientific developments and controversial issues in the class so that students will be actively involved.

To provide meaningful learning, teachers should relate the subject maters to everyday life and connect subject matters to each other since concepts in biology do not exist in isolation. Furthermore teachers should consider students' prior knowledge, disregard misconceptions, taboos etc, upon which they should build new coming information. Therefore teachers should be competent on both knowledge of subject matter and knowledge of teaching strategies for the subject matter. Accordingly education in the universities should be improved in the way that beginning teachers feel confident, especially on designing experiment.

Some of the teachers complained that there isn't a curriculum of biology practice lessons which are optional to students' choice. Since practice is complementary to theory in biology, these courses should be compulsory for science students and a curriculum should be prepared.

An important cause of low biology achievement at the SHS level is the lack of emphasis on the practical aspect of biology unlike other science subjects. These are the factors that make students consider biology not important. So a balance in teaching between theory and practical lessons should be implemented in all senior high schools.

To conclude, teachers should be involved in seminars about efficient biology teaching, that are organized with a great care to respond adequately to the questions and needs of biology teachers and students. Therefore Ministry of Education should organize seminars facilitated by scholars in the field about teaching strategies, improvements in science, laboratory studies at a suitable time and place.

Implications

The significance of the study is the identification of what is and what is not working in the general biology classroom for schools in the area of study in the Volta region of Ghana. The goal of this study and the use of its findings were to develop ways to increase students' perception of relevance of biology as a subject and to go a step further to excel in it. It is the instructional means of choice in biology courses for Hohman, Adams, Taggart, Heinrichs, and Hickman (2006), Osborne (2003), and the principal researcher for helping students make connections between science content and their personal lives.

Educating citizens to make life-long knowledgeable decisions about their health, life, and the environment is the ultimate goal of the Ghana Education Service. Participants in the study helped identify barriers that mostly affect student's achievement in biology.

Teachers need to stimulate the interest of students in biology by equipping them with skills needed to understand situations that arise in everyday life that require knowledge of biological concepts and employ the use of skills learned in the biology classroom to solve real life dilemmas.

By stimulating interest, general biology courses have the potential of increasing numbers of students going into the field of science education and at the higher level, taking into consideration the integral nature of biology in the science programme. According to Knight and Wood (2005), with just a little effort utilizing active engagement methods of instruction, students show improvement in measureable outcomes.

Further implications of this study reach into the realm of the teachers handling biology lessons in our schools. Implementing the recommendations of this study, that is, focusing on the personnel and the provision of conducive environments for biology lessons, the GES must recruit instructors with high energy personal and instructional skills, who can utilize active engagement during instruction, provide interactive laboratory opportunities, and utilize innovative methods that foster student engagement in the lesson. With the acceptance and acknowledgement of the fact that science education is the bedrock of development under the current dispensation, there is a need for a shift in paradigm from content to conceptual knowledge, with students needing to be able to apply science to everyday life rather than to recite simple facts (Knight & Wood, 2005), higher education is the natural extension of the science literacy programme that exists at the junior levels of education and the opportunity to make all citizens scientifically literate in the end.

Suggestions for Future Research

In this study the sample of students were students at the SHS level. It is also worthwhile to conduct researches on other grades including both science students and other students. This study includes secondary schools. On the other hand, it is apparent that there are reasons of low biology achievement depending on basic school science education. It will be useful to conduct research on basic school science teachers to determine the students' views about science lessons and the problems of integrated science education.

This study showed that there are problems about the biology curriculum. Thus another study can be conducted to explore these problems deeply, compare with other countries' biology curricula and design an appropriate biology curriculum for Ghana.

The results indicated that most of the students found biology difficult. It is therefore worthwhile to develop a test to measure students' formal reasoning ability on biology and therefore determine whether the biology syllabus is at the level of high school aged people.

The findings of this study depicted that students are upset about teachers who are not competent on the subject matter. Therefore it is recommended that a study be conducted to explore the current situation and problems of higher education with undergraduate biology teachers at university. There were differences in responses among school types. A study to explore differences in biology education among category A, B, C and D schools would be very useful in designing effective intervention.

Recommendations

The following recommendations have been put forward based upon the findings made of the study.

Firstly, it is suggested that the lecture method of teaching should be combined with other various forms of instruction to include but not be limited to active learning and teaching strategies, inquiry-based learning, with laboratory work and lecture coordinated to reinforce one another, problem-based learning with practical application, and the use of analogies to provide students with connections to pre-existing experiences and cognitive constructs.

Instruction should take place in a room conducive to interaction between students and instructor, with comfortable temperature, adequate lighting, and visibility of areas where the instructor is displaying information. While room selection is often out of the control of the instructor, taking an active role in the selection of the instructional environment should be a priority prior to the start of instruction each term. Searching for alternate instructional environments on campus may need to take priority over convenience of the location of the lectures. Planning for the remodelling of existing facilities as well as participating in plans for new construction should incorporate the components of the learning environment that have shown to improve student involvement and increase student engagement in the non-major biology courses.

Training programmes such as seminars, in-service trainings and workshops must be organized for teachers in order to enable teachers to update their skills and acquire new skills needed to effectively undertake lessons in schools.

Collaborative strategies can foster significant gains in student learning. Training instructors in new methods of instruction and providing a mentor until they are comfortable would be most useful.

Head teachers and other stakeholders in education, should ensure that the requisite equipment and materials needed in science laboratories for undertaking biology practical lessons are provided. They must also see to it that specially trained laboratory assistants are employed to man the laboratories and organize effective biology practical lessons.

It is also highly recommended that the category C and D schools most of which lack the required facilities for undertaking practical lessons should take advantage of the Science Resource Centre (SRC) project to conduct practical lessons for their students in a bid to generate and sustain their interest in biology.

The authorities concerned must consider expanding the time slot for biology on the official timetable taking into consideration the voluminous nature of the course. This will enable teachers have sufficient time to teach all the topics in the syllabus.

Head teachers need to ensure that the biology department is well resourced to be able to conduct field-trips, industrial visits and other educational tours. There must be the provision of special incentive packages e.g. books, computers, opportunity for further education, and allowances for biology teachers as a way of motivating them to give off their best in the school.

Authorities must consider splitting large-sized classes into smaller and more controllable units which will enable teachers to be able to conduct lessons more effectively and easily. Consequently, more teachers must also be recruited to handle these new classes.

English as a medium of instruction is the problem of many students, in the SHS, and this may also be the problem of poor performance in biology. The teacher must therefore make sure that students understand the biological concepts.

Handbooks for biology teachers and students should be written and should take into account the results of the survey. It should respond to the misunderstanding of both students and teachers, and this should make teaching and learning of biology interesting and fruitful.

Sandwich and top up courses, distance learning for undergraduate and graduate teachers should address the problems of biology teaching and learning, so as to make it easier for students' understanding in biology.

Parents should take much interest in their wards' field of study because biology is for life. Parents should encourage their wards in the study of science.

Science coordinators, STMIE coordinators should be resourced to encourage teaching and learning of science, organize science/biology competition in the districts and Municipalities, and to reward participating schools.

Finally the learning environment affects student engagement. Utilizing classrooms where students can form groups easily and interact with one another and the instructor during the lecture is recommended. Vygotsky's (1978) social constructivism supports this finding in the study. In addition, adequate room temperature, visibility of the board that the teacher is writing on, and proper sound equipment, are necessary for students to become engaged in the course, according to the focus group discussions. Likewise, personality types and instructional abilities of the teacher also play a significant role in student engagement in general biology.

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APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA

QUESTIONNAIRE FOR STUDENTS

Dear Respondent,

This study is purely for academic purposes. Kindly read through each item carefully and indicate the opinion that is the nearest expression of your views on each of the issues raised. Your anonymity is assured.

General Instructions

Please tick in the box the answer you have chosen. Fill in the blank space where necessary

Name of School……………………………………………………………………………..

Type of School: Boy's only [ ] Girl's only [ ] Co-educational [ ]

Sex: Male [ ] Female [ ] Age……………………….years.

Class level: SHS1 [ ] SHS2 [ ] SHS3 [ ] SHS4 [ ]

1. Which of these methods of teaching do you consider effective to the learning of biology?

(a) Activity [ ]

(b) Lecture [ ]

(c) Demonstration [ ]

2. Do you have a laboratory for biology practical work?

(a) Yes [ ] (b) No [ ]

If no, where are biology practicals organized in your school?

Appendix A Continued

3. Is the laboratory for biology practical working the same for all the science electives?

(a) Yes [ ] (b) No [ ]

4. Which method does your biology teacher often use during practical lessons?

(a) Activity [ ] (b) Enquiry [ ] (C) Demonstration [ ] (d) all of them/ any two (specify)……………………………………..………………..

5. How often are biology practical lessons conducted in your school laboratory?

(a) Frequent [ ] (b) Quite frequent [ ] (c) very frequent

6. Is your biology Laboratory equipped with materials necessary for WAEC designated SHS biology practical work?

(a) Yes [ ] (b) No [ ]

7. How many times in a week do you have biology practical work?

(a) Once a week (b) 2 times a week [ ]

(c) 3 times a week (d) any other (specify) [ ]

8. Is the time allocated for biology practical work sufficient?

(a) Very Sufficient [ ]

(b) Quite sufficient [ ]

(c) Sufficient [ ]

(d) Not sufficient [ ]

9. Does the size of the class promote the organization of practical activities?

(a) Yes [ ] (b) No [ ]

(c) In a short sentence give a reason for answer.

……………………………………………………………………………………………

Appendix A Continued

10. Are you allowed by your teacher to practice on your own in the laboratory?

(a) Yes [ ] (b) No [ ]

11. Are the equipment and facilities in the laboratory adequate for biology practical work?

(a) Yes [ ] (b) No [ ]

12. Are the equipment and materials adequate to go round all the students during biology practical work?

(a) Yes [ ] (b) No [ ]

13. If no then what do you normally do in such situations?

……………………………………………………………………………………………

14. How are the available teaching materials used during biology lessons?

(a) Individual teaching work [ ] (b) Group work [ ]

(c) Whole class demonstration [ ]

15. Do you have laboratory assistant(s) or technician(s)? (a) Yes [ ] (b) No

16. If you answered YES to item 15, do the laboratory technician(s) assistant(s) assist you during biology practical lesson? (a) Yes [ ] (b) No [ ]

17. If YES, is / are the laboratory technician(s) or assistant(s) responsible for all the pure sciences? (a) Yes [ ] (b) No [ ]

18. (a) Is / are your biology teachers always present during biology practical?

(a) Yes [ ] (b) No [ ]

(b) If no what do you do when you are in difficulty?

……………………………………………………………………………………………

Appendix A Continued

19. What problems do you face during biology practical lessons?

……………………………………………………………………………………

20. Are there other facilities and the equipment that you feel should be added to the already existing ones?

…………………………………………………………………………………………

21. Do you go for field work and excursions?

(a) Yes [ ] (b) No [ ]

22. How do you grade your biology teachers?

(a) Excellent [ ] (b) Very good (c) Good [ ]

(d) Fair [ ] (d) poor [ ]

Section B: Perceptions of Students about biology

Statement	Strongly Agree	Agree	Not Certain	Disagree	Strongly Disagree
1. I find biology as an interesting subject					
2. There are many prospects in the study of biology					
3. Biology is not a relevant subject					
4. Biology is for only intelligent students					
5. It is difficult to score high marks in biology					

APPENDIX B

UNIVERSITY OF EDUCATION, WINNEBA

QUESTIONNAIRES FOR BIOLOGY TEACHERS

Dear Teacher,

This study is purely for academic purposes. You will be contributing to its success, if you answer the item as frankly and honestly as possible. Your response will be kept confidential. Moreover, your anonymity is assured by neither writing your name nor indicating your school. Kindly read through each of the items carefully and indicate the opinion that is the nearest expression of your view on each of the issue raised.

General Instruction

Please tick [√] the appropriate bracket or column or fill in the blank spaces where necessary.

Section A: Bio Data

1. Location of your School: Rural [ ] Urban [ ]
2. Grade of your School: A [ ] B [ ] C [ ] D [ ]
3. Your age: 20yrs and below [ ] 21-30yrs [ ] 31-40 yrs. [ ] 41-50yrs. [ ] 51yrs and above. [ ]
4. Your Sex: Male [ ] Female [ ]
5. How long have you been teaching biology? 0-5 years [ ] 6-10 yrs[ ] 11-15 yrs [ ] 16-20 yrs. [ ] 21yrs and above
6. What is your highest academic qualification? HND [ ] BSc [ ] MSc [ ] PhD [ ]
7. What is your professional qualification? Dip Ed. [ ] BEd. [ ] Med [ ]

Appendix B Continued

8. The average number of students in your class is ……………………………………

9. What is your area of specialization?

(a) Biology [ ] (b) Chemistry [ ]

(c) Physics [ ] (d) Biochemistry

(e)Any other (specify)………………….....…………..……………………………………..

10. Have you ever had any in-service training in the teaching of biology?

(a) Yes [ ] (b) No [ ]

11.If yes , who organized the in- service programme?

(a) GES [ ] (b) STIME [ ] (c) GAST Organizers [ ]

(d) Any other (specify)……………………………………………..…………………..

12. Do you have a laboratory in your school for biology practical work?

(a) Yes [ ] (b) No [ ]

13. Is the laboratory the same for all the pure sciences?

(a) Yes [ ] (b) No [ ]

14. How often are biology practical lessons conducted in your school biology laboratory?

(a) Once a week [ ] (b) 2 times a week [ ]

(c) 3 times a week [ ] (d) other specify……………………………………….

15. Is your school laboratory equipped with the necessary materials designated for WASSCE practical work?

(a) Yes [ ] (b) No [ ]

Appendix B Continued

16. If you answered yes to item 9, how adequate are the materials in your school laboratory?

(a) Very adequate [ ] (b) Adequate [ ] (c) Inadequate [ ]

17. Are these materials enough for effective teaching and learning of biology practical work?

(a) Yes [ ] (b) No [ ]

18. Are the equipment adequate to go round all the students during practical work?

(a) Yes [ ] (b) No [ ]

19. If no to item 18, what do you normally do in such situations?

……………………………………………………………………………………………

20. Do the student have access to practical equipment during leisure time?

(a) Yes [ ] (b) No[ ]

21. If no to item 20, give reason(s)……………………………………………………………

22. Do you think there other important equipment and facilities that should have been provided but are not available? (a) Yes [ ] (b) No [ ]

23. If yes to item 22, please list them …………………………………………………

25. How often do the school authorities provide /supply the laboratory with materials?

(a) Very frequent [ ] (b) Frequent [ ] (c) Quite frequent [ ]

(d) Not frequent [ ]

26. Do the school authorities perceive the provision of equipment and materials a waste of funds and resources? (a) Yes [ ] (b) No [ ]

Appendix B Continued

27. Give reason(s) for your response to item 26 …………………………………………

……………………………………………………………………………………………

28. Do you have laboratory assistant(s) in your school?

(a) Yes [ ] (b) No [ ]

29. If "yes" how many of the laboratory assistant(s) are trained?

(a) 0 [ ] (b) 1 [ ] (c) 2 [ ] (d) 3 [ ]

30. What type of practical work is commonly done in your school's biology laboratory? You can tick more than one.

(a) Drawing [ ] (b) Identification and classification [ ]

(c) Food test [ ] (d) Analysis/interpretation

31. What problems do you face during biology practical lessons?

……………………………………………………………………………………………

32. List some of the benefits of biology practical work.

……………………………………………………………………………………………

33. Should biology teachers be given some incentives?

(a) Yes [ ] (b) No [ ]

34. If yes to item 27, please specify the kind of incentives………………………………

APPENDIX C

UNIVERSITY OF EDUCATION, WINNEBA

INTERVIEW PROTOCOL FOR TEACHERS

1. What influences your selection of topics?
2. Does the state of the biology laboratory have an influence on the order and sequence and selection of topics?
3. To what extent does the relevant previous knowledge of students influence the sequence and selection of topics?
4. Are there any other factors which influence the sequence at which you teach the various biology topics in the syllabus? If yes, explain how each of those factors affect the sequence
5. Do you adopt the use of instructional materials in carrying out lessons in the classroom and in the lab?
   i. If yes, then how often do you use such materials?
   ii. Kindly mention some of those instructional materials
6. What instructional methods do you adopt in teaching non-practical biology lessons?
7. What influences your choice of instructional method?
8. Are you motivated as a biology teacher? Explain your answer
9. Currently, are there any specific programmes designed to help science teachers upgrade themselves in your school?
10. Are you aware of any programmes or schemes sponsored by Government, GES or any other agency which you can benefit from as a biology teacher?

Appendix C Continued

11. Generally what is the attitude of your students towards the study of biology?
12. Do you agree with those who hold the perception that biology is a difficult subject? Explain your answer
13. Are there any peculiarities which make the teaching of biology more difficult than the other science subjects? I f yes, what are those peculiar factors?
14. How do you rate the difficulty or otherwise of biology as a subject for both teachers and students compared to the other science subjects?

APPENDIX D

CHECKLIST ON THE STATE OF EQUIPMENT IN THE BIOLOGY LABORATORY

Availability and condition of resources and facilities	**Good**	**Fair**	**Poor**
Sufficiency of laboratory facilities			
State of repair of laboratory facilities			
Supply of chemicals/ reagents			
State of repair of laboratory equipment			
Availability of equipment for experiments			

APPENDIX E

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION, S/CAMPUS
P. O. BOX 25, WINNEBA - TEL. NO. 03323 - 20108

Our Ref. No. SD/M.Phil/Vol.1/249
Your Ref. No.

November 25, 2013

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

INTRODUCTORY LETTER

The bearer of this letter Mr. Gameli Aborlo is a Master of Philosophy student in the Science Department. He is investigating "The Status of teaching and learning of Biology in some selected senior high schools in the Volta Region."

I will appreciate it if you could kindly assist him with this investigation.

I count on your co-operation for a successful thesis write-up.

Thank you.

Yours faithfully,

Rev. [illegible] Boateng, Emmanuel
Ag. Head of Department