UNIVERSITY OF CAPE COAST

ASSESSING SENIOR HIGH SCHOOL BIOLOGY STUDENTS' SCIENCE PROCESS SKILLS

ERIC MANFRED DAH

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BY

ERIC MANFRED DAH

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

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DECLARATION

Candidate's Declaration

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

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

Name: Eric Manfred Dah

Supervisors' Declaration

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

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

Name: Dr. Eugene Adjei Johnson

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

Name: Dr. Christopher Beccles

ABSTRACT

This study was conducted to assess science process skills of drawing, classifying, interpreting and hypothesising among Senior High School (SHS 3) Biology students in the Volta Region of Ghana. Two hundred and forty students were randomly chosen from six SHSs to respond to the research instruments. Additionally, six SHS 3 Biology teachers in the sampled schools also participated in the study. The main instruments used to collect data were science process skills assessment tasks, interview guides for students and teachers and guide for content analysis of Biology practical workbook of students. The research instruments were pilot tested on a representative sample to determine the reliability and validity of the instruments. The interrater reliability coefficient for the performance tasks on drawing, classifying, interpreting and hypothesising were found to be 82.50%, 85%, 2.50% and 80% respectively. Mixed methods research design was employed in this study and thus quantitative and qualitative methods were used in analysing data generated from the respondents. Prominent among the findings were that majority of the students performed poorly on the skills of drawing, classifying, interpreting and hypothesizing, Biology practical activities were not organized frequently in the schools and there was a significant difference between the categories of schools and the acquisition of science process skills of drawing, classifying, interpreting and hypothesizing. Based on the findings, it was recommended that Biology teachers at SHSs should organise practical activities frequently for students to acquire and master science process skills that are stipulated in the syllabus for meaningful learning of Biology.

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DEDICATION

I dedicate this work posthumously to the memory of my late father: Mr. Emmanuel Dah.

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CHAPTER ONE

INTRODUCTION

This chapter consists of background to the study, statement of the problem, purpose of the study, research questions and hypotheses, significance of the study, delimitation, limitation, definition of terms as well as the organisation of the study.

Background to the Study

Science is seen as both a process and a product in nature and, therefore, involves procedures such as observation, measuring, manipulation, communication, drawing, recording, interpreting, predicting, hypothesizing, experimenting to arrive at conclusions such as scientific facts, theories and laws (Ministry of Education Youth and Sports [MOEYS], 2004; Sadhana, 2017). Science process skills or processes are the activities that students carry out in scientific investigations to attain knowledge (Abungu, Okere & Wachanga, 2014; Jack, 2018; MOEYS, 2004; Rauf, Rasul, Mansor & Othman, 2013; Sadhana, 2017) and the knowledge, facts, theories and laws that are acquired by the students as a result of engaging in the processes of science, are the products of science (MOEYS, 2004; Sadhana, 2017).

Science education must, therefore, focus on activities that will enable students to see the processes and products of science as interdependent and geared towards promoting scientific literacy and technological advancement of the nation in this 21st century (Abungu, Okere & Wachanga, 2014; Dzidzinyo, 2011; Harlen, 1999; Ogunmade, 2005). This is because in science education, mastery of science process skills is not only important for students to produce knowledge in science but also be able to apply scientific skills to solve problems in their daily lives (Abungu, Okere & Wachanga, 2014; Al-Rsa'l, Al-Helalat & Ali Saleh, 2017; Aydogdu, 2015; Hernawati, Amin, Irawati, Indriwati & Aziz, 2018; Jack, 2018; Rauf, Rasul, Mansor, Othman & Lyndon, 2013; Samsudin, Haniza , Abdul-Talib & Ibrahim, 2015).

In contemporary society, there are many problems which need to be solved and hence students do not only need knowledge which dwells on recall of facts but also higher-order thinking skills which are science process skills to prepare them adequately for the real-world challenges. This is because knowledge obtained through higher-order thinking processes is easily transferable and enables students with deep conceptual understanding to apply the knowledge to solve new problems (Al-Rsa'l, Al-Helalat, & Ali Saleh, 2017; Jack, 2018; Ramos, Dolipas & Villamor, 2013). Practical work is thus essential for the development of transferable skills such as observing, measuring, predicting and inferring which can be applied to solve problems in life (Wellington, 1998).

In science education, there is the need for students to undergo practical activities in order to acquire science process skills (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Babalola, Lambourne & Swithenby, 2019; Chebii, 2011; Hofstein, 2004; Hofstein & Lunetta, 2003; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Kazeni, Baloyi & Gaigher, 2018; Lunetta, Hofstein & Clough, 2005; Musasia, Abacha & Biyoyo, 2012). When students engage in practical activities in the laboratory, they actively apply science processes to generate scientific knowledge (Abungu, Okere & Wachanga, 2014; Eshun, 2011; Jack, 2018; Musasia, Abacha & Biyoyo, 2012; Ongowo & Indoshi, 2013) which is assimilated more efficiently and understood at a much deeper level (Jack, 2018; Lunetta, Hofstein & Clough, 2005; Mwangu & Sibanda, 2017; Ongowo & Indoshi, 2013). Learning becomes meaningful as a result of students' active participation in science processes in a practical setting to construct their own knowledge during the teaching and learning process (Boateng, 2014; Hofstein & Mamlok-Naaman, 2007; Idiege, Nja & Ugwu, 2017; Rauf, Rasul, Mansor, Othman & Lyndon, 2013). By engaging students in an inquiry in the laboratory does not only develop psychomotor skills such as making observations, measuring, recording data and drawing but it also inculcates desirable attitudes such as curiosity, independence of mind and personal search for meaning about the world (Cimer, 2007) which are the prerequisites for learning science.

Acquisition of science process skills hinges on how science practical activities are organised in schools. This is because when students participate in practical activities, it facilitates the development of science process skills as they manipulate equipment, classify, interpret data and observe phenomena during science practical activities (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Chebii, 2011; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Musasia, Abacha & Biyoyo, 2012). However, a number of research works have documented that science students do not regularly undergo practical activities to acquire science process skills because of time constraints, overloaded science curriculum, large class size, lack of in-service training on practical activities and unavailability of laboratory equipment and materials (Abdul-Mumuni, 2005; Adu-Gyamfi, 2014; Ampiah, 2004; Awuku, 2014; Boateng, 2014; Dzah, 2014; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Mwangu & Sibanda, 2017; Said, Friesen & Al-Ezzah, 2014). For instance, Said, Friesen and Al-Ezzah (2014), asserted that because science teachers are pressurised to raise academic achievements of students by producing high grades in national and international examinations, they do not have enough time to implement high quality practical work towards the acquisition of science process skills of learners. If science practical activities that serve as the fulcrum for attainment of science process skills are not organised frequently for students, then there is no doubt that the level of acquisition of these skills in learners will be low and this will hamper meaningful learning of science concepts and ability to solve daily problems.

The development of practical and experimental skills in learners requires active learning through practical activities for students to gain higher order thinking skills. There is, therefore, the need for Biology teachers to adopt appropriate assessment modes for higher order thinking skills such as observing, planning, drawing, interpreting and hypothesising by learners. Teachers often desire to develop students' higher order thinking skills, however, the assessment modes adopted by these teachers do not reflect these global achievement goals (Al-Sadaawi, 2007). According to Connor-Greene (2000), "emphasizing active learning and problem solving in class but using tests that neither require nor allow students to demonstrate higher level thinking sends mixed messages to students" (p. 84). This is because what teachers assess has a significant influence on what and how students learn.

What is learned by students is determined by their decisions with regard to classroom assessment modes by their teachers (Cimer & Cimer, 2010). It is, therefore, essential that assessments demand and reflect the kind of learning that teachers want their students to develop (Cimer & Cimer, 2010).

Statement of the Problem

For students to acquire science process skills and to generate scientific knowledge, they must undergo practical activities in the laboratory or field (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Babalola, Lambourne & Swithenby, 2019; Chebii, 2011; CRDD, 2010; Gultepe, 2016; Hofstein, 2004; Hofstein & Lunetta, 2003; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Kazeni, Baloyi & Gaigher, 2018; Lunetta, Hofstein & Clough, 2005; Musasia, Abacha & Biyoyo, 2012). In order for students to develop and master science process skills, there is the need for them to carry out practical activities in a laboratory setting or field frequently (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Padilla, 1990) because teachers cannot expect students to excel at skills they have not been given ample opportunities to experience or practice (Padilla, 1990). Accordingly, mastery of science process skills is not only important for students to produce knowledge in science but also to be able to apply scientific skills to solve problems in their daily lives (Abungu, Okere & Wachanga, 2014; Al-Rsa'l, Al-Helalat & Ali Saleh, 2017; Aydogdu, 2015; Jack, 2018; Rauf, Rasul, Mansor, Othman & Lyndon, 2013; Samsudin, Haniza, Abdul-Talib & Ibrahim, 2015).

The necessity for Biology students to attain science process skills such as observing, drawing, classifying, measuring, recording, interpreting, planning, communicating, manipulating and hypothesising has demanded the inclusion of practical and experimental skills as one of the profile dimensions in the Biology syllabus at senior high schools. Additionally, the curriculum planners have made provisions for 3 periods (120 minutes) per week for students to undergo practical activities and have also suggested the availability of well-equipped laboratories as well as well-trained laboratory technicians/assistants to play complementary roles to the Biology teachers in organising practical activities (CRDD, 2010). Biology students are, therefore, supposed to be introduced to practical activities under the guidance of their teachers or laboratory technicians to promote acquisition of science process skills because teachers are very paramount in the inculcation of science process skills in learners as they interact with them during the teaching and learning process (CRDD, 2010; Kruea-In & Thongperm, 2013; Rauf, Rasul, Mansor, Othman & Lyndon, 2013; Sadhana, 2017; Wekesa, 2013; Wilunjeng & Suryadarma, 2017) as Biology practical skills are science process skills that can be acquired and developed during Biology practical sessions (Ongowo & Indoshi, 2013). Effective development of science process skills is necessary because it will enable students to acquire scientific knowledge, promote meaningful learning of science concepts and also solve their daily problems (Abungu, Okere & Wachanga, 2014; Aydogdu, 2015; Jack, 2018; MOEYS, 2004; Muangu & Sibanda, 2017; Rauf, Rasul, Mansor & Othman, 2013; Sadhana, 2017; Samsudin, Haniza, Abdul-Talib & Ibrahim, 2015). Nevertheless, it appears science practical activities are not organised regularly for students to attain their associated science process skills (Abdul-Mumuni, 2005; Adu-Gyamfi, 2014; Agyei, 2011; Ampiah, 2004; Awuku, 2014; Boateng, 2014; Dzah, 2014; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Mwangu & Sibanda, 2017) prominently due to time constraint, overloaded curriculum, lack of equipment and large class size. Researchers such as (Abdul-Mumuni, 2005; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Boateng, 2014, Dzah, 2014) and WAEC Chief Examiners' Reports (WAEC: 2012, 2013, 2014, 2015, 2016**)** have recommended that practical activities should be intensified by teachers among science students in senior high schools for the students to acquire science process skills and to study scientific concepts meaningfully. It seems that science teachers at senior high schools especially Biology teachers have not adhered to the suggestions by the various researchers and WAEC that they need to increase practical activities for students to attain science process skills. The Biology teachers have neither stuck to the allocation of 120 minutes for practical activities per week as stipulated in the Biology syllabus as most secondary schools do not have practical lesson periods on their teaching time table (Ampiah, 2004; Boateng, 2014). Meanwhile lack of adequate exposure to practical activities leads to poor development of science process skills in students (Idiege, Nja & Ugwu, 2017). Consequently, Biology students show weaknesses in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising as revealed by the Chief Examiners' Reports of Biology practical examinations conducted by West African Examinations Council (WAEC: 2011-2016). Some of the weaknesses listed in WAEC Chief Examiners' Reports include.

a. Inability of students to draw biological specimens according to rubrics (not drawing to given size, no title or wrong title, no magnification or poor magnification), inability to interpret biological data, inability to hypothesise from biological data (WAEC, 2011).
b. Inability of students to classify organisms into their taxa accurately, inability to draw biological specimens according to rubrics (WAEC, 2012).
c. Inability of students to draw biological specimens according to rubrics (not labelling accurately), inability to hypothesise from biological data (WAEC, 2013).
d. Inability of students to draw biological specimens according to rubrics (not drawing to given size, wrongly spelt labels, failure to indicate the magnification of the drawing), inability to classify given organisms into their taxa accurately (WAEC, 2014).
e. Inability of students to draw biological specimens according to given size (WAEC, 2015).
f. Inability of students to draw biological specimens according to rubrics (inappropriate heading, cut surface of specimen was not represented with double line), inability to interpret biological information, inability to hypothesise from an experiment (WAEC, 2016).

The weaknesses in the attainment of drawing, classifying, interpreting and hypothesising skills by Biology students as reported by the Chief Examiners cast serious doubts on Biology students' frequent involvement in practical activities during science course and subsequent assessment of science process skills acquired by students during the practical activities. Various researchers (Akani, 2015; Akinbobola & Afolabi, 2010; Al-Rsa'l, Al-Helalat & Ali Saleh, 2017; Anthony-Krueger, 2001; Chebii, 2011; Johnson, 2001; Karamustafaoglu, 2011; Ongowo & Indoshi, 2013; Shakibu, 2013; Zeidan & Jayosi, 2015) have assessed science process skills of students. However, there is no or few documentary evidences of assessment of science process skills of Biology students in the Volta Region of Ghana. It is, therefore, prudent to assess the science process skills of drawing, classifying, interpreting and hypothesising among SHS 3 Biology students in the Volta Region and to find out about the frequency as well as factors that inhibit effective organisation of Biology practical activities for the students to acquire science process skills.

Purpose of the Study

The purpose of this study was to use science process skills tasks to assess science process skills of drawing, classifying, interpreting and hypothesising of Biology students in selected senior high schools in the Volta Region. It was also intended to find out how frequent Biology practical lessons were organised and the factors that affect effective organisation of Biology practical activities for students to acquire science process skills.

Research Questions

The study was guided by the following research questions.

1. What are the levels of acquisition of drawing, classifying, interpreting and hypothesising skills among SHS 3 elective Biology students?

2. How frequent do SHS 3 Biology students engage in practical activities to acquire science process skills?
3. What are the factors that affect effective organisation of Biology practical activities for students to acquire science process skills?
4. Which science process skills do teachers expose SHS 3 Biology students to during practical activities?

Null Hypotheses

The following null hypotheses were formulated and tested.

1. There is no significant difference in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising among SHS 3 elective Biology students from the different schools.
2. There is no significant difference in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising of SHS 3 elective Biology students based on gender.
3. There is no significant difference in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising of SHS 3 elective Biology students based on categorisation of schools.

Significance of the Study

This study would enable Biology students to improve upon their skills in drawing, classifying, interpreting and hypothesising processes as stipulated in the Biology syllabus and will be able to take concrete steps to equip themselves with any of the science process skills that they have not well acquired. It would also help Biology teachers to use appropriate assessment tasks in assessing the science process skills of drawing, classifying, interpreting and hypothesising.

Secondly, the study would lay bare the factors that inhibit effective organisation of Biology practical lessons, and appropriate solutions would be suggested to help SHS Biology teachers organise practical lessons frequently for the students to acquire science process skills that are stipulated in the syllabus.

Furthermore, the research would serve as the basis for provision of in-service training to Biology teachers as part of the professional development process in order to equip them with the relevant skills for inculcating science process skills in students.

Finally, the study would help school administrators to increase their supervisory roles in ensuring that Biology students regularly engage in practical activities which would facilitate their development of science process skills.

Delimitations

There are a number of science process skills stipulated in the Biology syllabus but this research work focused on only drawing, classifying, interpreting and hypothesising skills.

The science process skills tasks administered to the SHS 3 Biology students concentrated on concepts in biological drawings, classification of organisms into taxonomic classes of *Monocotyledoneae* and *Dicotyledoneae,* photosynthesis and transpiration to the exclusion of other topics in the Biology syllabus. The SHS 3 Biology students were chosen because the concepts of biological drawings was in section one of the first year course work, concepts on classification of organisms into monocots and dicots was in section one of the second year course work, concepts on photosynthesis and transpiration were in section one of the third year course work (CRDD, 2010) and therefore at the time of data collection, it was expected that students in SHS 3 have studied theoretically and have also undergone practical activities on the stated topics.

In the Volta Region of Ghana, there are a number of senior high schools offering Biology as an elective subject. Nevertheless, this study focused on students pursuing Biology as a subject in the General Science programme in selected public SHSs in the Volta Region of Ghana.

Moreover, the sampled schools only constituted six conveniently selected SHSs in the Volta Region and therefore made the generalisations of the findings to the population difficult.

Limitations

All the public SHSs offering General Science programme in the Volta Region were not given equal opportunity to be included in the sample size because convenient sampling technique was used in the selection of the six schools in the region and, therefore, the findings of the study could not be pertaining to all the public SHSs offering General Science programme in the region.

The fact that students were put into an examination mood during the administration of the science process skills tasks created some apprehension and tension in them which possibly adversely affected their responses to the tasks.

There are many concepts in the Biology syllabus for students to learn theoretically and also carry out practical activities on them. However, the science process skills tasks were only set on concepts in biological drawings, classification of organisms into taxonomic classes of *Monocotyledoneae* and *Dicotyledoneae*, photosynthesis and transpiration.

There are many science process skills but the study explored only four of these science process skills. Also varied science process skills tasks were not used in assessing the levels of acquisition of each of the science process skills and, therefore, the outcomes of the research could not reflect the exact levels of acquisition of science process skills of drawing, classifying, interpreting and hypothesising and could not be generalised to all the science process skills specified in the Biology syllabus.

In the content analysis of Biology practical work books of students to determine the topics under which practical activities were carried out, practical activities that were undergone by students and the science process skills that they were exposed to in the course of carrying out the practical activities, practical activities that were carried out through computer simulations, demonstrations by both teachers and students and practical activities that were carried out on the field/environment without any documentation were not considered.

Definition of Terms

Profile dimension: The underlying behaviours for teaching, learning and assessment (CRDD, 2010).

Science Process skills: These include skills such as drawing, interpreting, manipulating and hypothesising which are manifested in the cognitive and psychomotor domains and are usually displayed by the students during scientific experiments.

Scaffolding: According to Tuckman and Monetti (2011) Vygotsky refers to scaffolding as the assistance provided by more competent adults, peers and teachers to enable students proceed through their zone of proximal development.

Zone of Proximal Development (ZPD): Vygotsky refers to zone of proximal development as between the levels of actual development and potential development in which students must be assisted by more skilled and competent peers, adults and teachers in order to successfully complete given tasks (Tuckman & Monetti, 2011).

SHSs: Second cycle institutions in Ghana where students are expected to offer various programmes based on their future career aspirations.

WAEC: West African Examinations Council

Between-class ability grouping: This refers to separate classes of students with different abilities for group work (Moore, 1998; Ornstein & Lasley, 2000).

Within-class ability grouping: This refers to mixed ability groups of students for group work (Moore, 1998; Ornstein & Lasley, 2000).

Organisation of the Study

The research work was organised into five chapters. Chapter One which was the Introduction entailed background to the study, statement of the problem, purpose of the study, research questions, significance of the study, delimitations, limitations and definition of terms.

Chapter Two talked about review of related literature. It included conceptual framework of the study, role of practical lessons and science education, science process skills, assessment of science process skills, performance assessment tasks and scoring rubrics, gender and science education, type of school and students' performance, the roles of in-service training and reflection in science education, barriers to organisation of science practical lessons in senior high schools in Ghana and summary of the review.

Chapter Three dealt with the Methodology which focused on research design, population, sample and sampling procedure, data collection instruments, data collection procedure, data analysis and chapter summary.

Chapter Four focused on results and discussions of the research work. This included the findings based on the research questions and the null hypotheses and Chapter Five focused on summary, conclusions, recommendations and suggestions for future research

CHAPTER TWO

LITERATURE REVIEW

This chapter consists of conceptual framework of the study, role of practical lessons in science education, science process skills, assessment of science process skills, gender and science education, type of school and students' performance, the roles of in-service training and reflection in science education, barriers to organisation of science practical lessons in senior high schools in Ghana and summary of the review.

Conceptual Framework of the Study

This research work is embedded in constructivist paradigm. Constructivism is a dynamic learning process in which students develop new thoughts in relation to their present knowledge (Alshalabi, Hamada & Elleithy, 2013). In constructivism, students construct their own understanding of concepts and phenomena through experiencing things and reflecting on those experiences (Mogashoa, 2014; Yadav, 2017). Two prominent perspectives of constructivism are psychological constructivism and social constructivism. The psychological or cognitive constructivism is based on the ideas of Jean Piaget who visualises knowledge acquisition as a process of continuous self-construction by the learner through experience and social constructivism which has its origin in the work of Vygotsky emphasises construction of knowledge through social interaction and cultural context of the individual (Yadav, 2017).

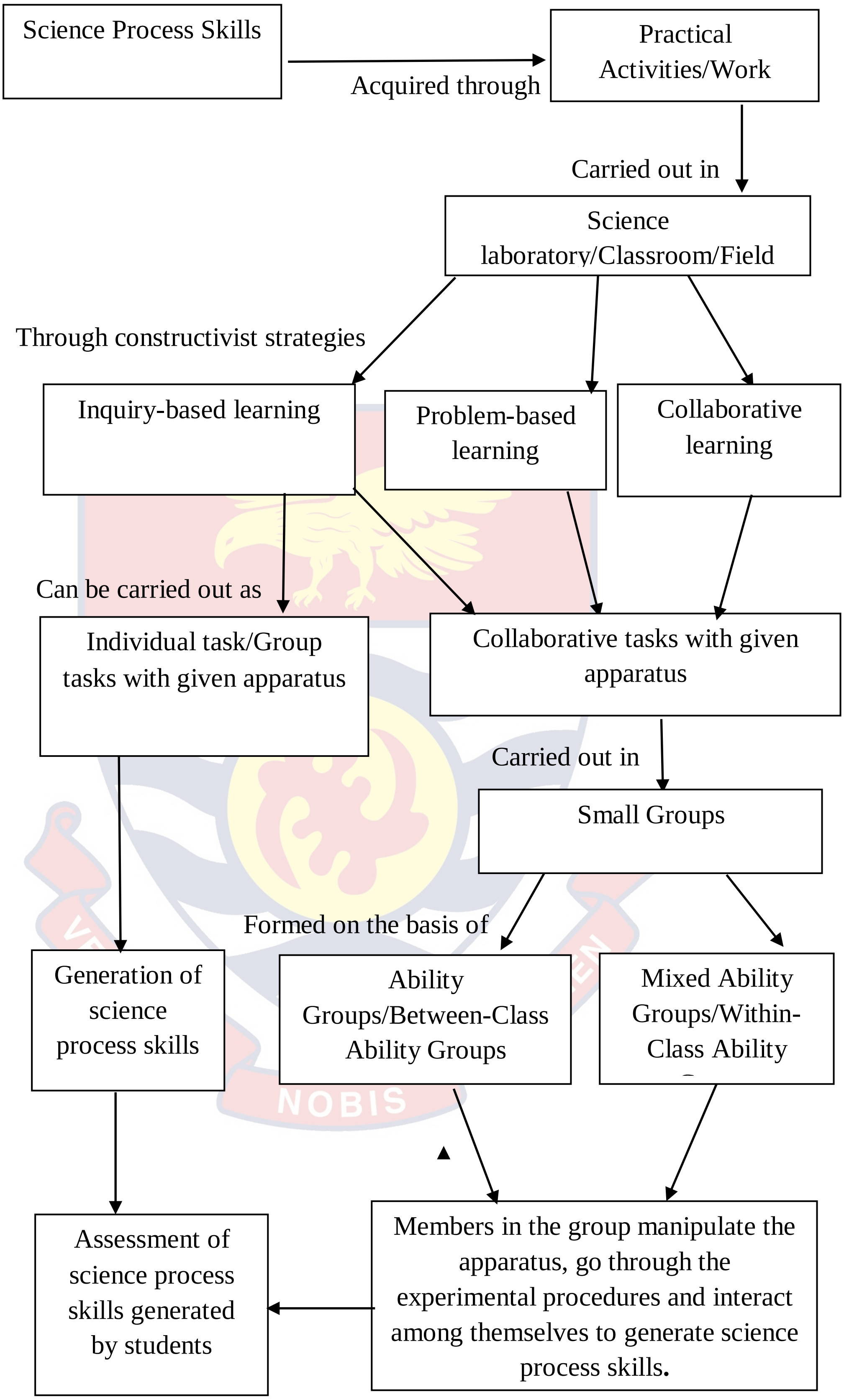

Figure 1: Framework for acquisition of science process skills by students.

Source: Framework developed by the researcher.

In constructivism, each learner plays an active role in the teaching and learning process in order to make learning meaningful (Mogashoa, 2014; Yadav, 2017). Mertens (2005) stated that in constructivist paradigm knowledge is socially constructed by students actively engaged in the teaching and learning process to make learning meaningful. Meaningful learning requires that students engage in systematic processes or strategies for coding and storing information in long term memory, retrieving it as well as organising and integrating it with their existing knowledge (Tuckman & Monetti, 2011). This means that according to Jean Piaget, students need to adapt to the teaching and learning environment by altering the new knowledge and skill to fit into already known knowledge and skill in what he termed as assimilation as well as adjusting existing knowledge or skill for a new one to be fitted into it in what he described as accommodation (Woolfolk, 2001).

If students are to learn science meaningfully, science teachers must be innovative and adopt student-centred approaches in the delivery of science concepts to students. This is because in student-centred approaches, students usually collaborate with one another to solve realistic problems, manipulate and interact with equipment and materials in the teaching and learning process which in turn promotes the grasping of scientific concepts by students. When students actively interact with the concrete objects during the teaching and learning process, they engage in science processes such as observing, classifying, measuring, predicting, interpreting and drawing which facilitates the acquisition of scientific concepts as a product of science. Learning through active participation by students facilitates the retention of scientific concepts as well as demystifies the study of science. It is in this vein that Cimer (2007) contended that much emphasis should be laid on participatory classroom activities because there is a general agreement that effective learning requires students to be active in the learning process.

The core constructivist perspectives in meaningful learning according to Tobin and Tippin as cited in (International Baccalaureate Organisation [IBO], 2012) are:

1. learning is a self-directed process: knowledge is constructed rather than directly received;
2. the instructor acts as a facilitator;
3. learning occurs as a sociocultural process (p. 5).

The fact that learners must construct their knowledge and understand the world by experiencing things and reflecting on those experiences (Meyer, 2009; Yadav, 2017) as well as learning occurring in sociocultural context (Mertens, 2005; Tuckman & Monetti, 2011) and teachers serving as facilitators (Mogashoa, 2014; Tuckman & Monetti, 2011) in a laboratory setting or field where practical activities are carried out for attainment of science process skills (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Babalola, Lambourne & Swithenby, 2019; Dadzie, 2011; Kasiyo, Denuga & Mukwambo, 2017; Musasia, Abacha & Biyoyo, 2012 Jack, 2018) demand that constructivist strategies such as inquiry-based learning, problem based learning and collaborative learning (Yadav, 2017) which are student-centred approaches be employed in the teaching and learning process in order to make learning meaningful (IBO, 2012). In student-centred approach, students are active participants in the learning process, learn at their own pace, use their own strategies and they are more intrinsically than extrinsically motivated (Mido, 2017) as they manipulate given apparatus, go through experimental procedures and interact among themselves to generate science process skills.

Anderson (2002) asserted that "scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from the work" (p. 2). In inquiry-based learning, students learn to solve real life problems by asking questions, analysing problems, conducting investigations, gathering and analysing data, making interpretations, creating explanations and drawing conclusions (IBO, 2012). In the science laboratory, students can participate individually in an inquiry to carry out a task, different tasks or as a group activity on a task or different tasks (Shakibu, 2013). When students participate in an inquiry by employing the processes of science in the laboratory, they generate scientific knowledge which is assimilated more efficiently and understood at a much deeper level (Ongowo & Indoshi, 2013). Accordingly, the findings of Roth and Roychoudhury (1994) revealed that students found laboratory work as an important aspect of leaning science because they became participants in generating knowledge and this knowledge could be expanded and linked to what they have learnt from their textbooks in order to make learning meaningful.

According to Hmelo-Silver (as cited in Tuckman and Monetti 2011) and Yadav (2017), problem-based learning is a student directed learning focusing on solving complex problems that do not have a single correct answer. Students work collaboratively in groups to acquire new skills which they use to solve real-world problems. In problem-based learning, the teacher's role is to facilitate the learning process rather than to provide knowledge. Students follow the problem-based learning cycle which follows the sequence below:

1. presentation of the problem scenario;
2. identifying the relevant facts associated with the scenario;
3. generating hypotheses as to possible solutions;
4. identifying knowledge deficiencies or learning issues, that is, self-directed learning necessary for solving the problem;
5. applying the new knowledge to test the hypotheses generated in the third step;
6. reflecting on the abstract knowledge gained (Tuckman & Monetti, 2011, p.316).

It is, therefore, worthy to agree with the Report of the President's Committee on Review of Education Reform in Ghana (2002) which pointed out that Ghana's educational system should help individuals to be innovative, adaptive and have the capacity to apply knowledge and skills acquired to solve problems in daily life.

Moore (1998) and Ampiah (2004) asserted that co-operative or collaborative learning method involves mixed-ability groups of students working together in terms of interaction and contribution of ideas to accomplish a set of tasks. Co-operative learning method is an interdependent learning, an accepted and often preferred instructional method at all levels of education (Johnson, Johnson & Smith, 2007). In co-operation, "the idea is to create interdependence in such a way that each individual's actions benefit the group and the group's actions benefit the individual" (Ornstein & Lasley, 2000, p. 324). Promoting increased use of co-operative learning in the classroom is of a central aim (Johnson & Johnson, 2003; Slavin, 1995). This is because in learning co-operatively on science practical activities, science process skills such as observing, classifying, measuring, predicting, inferring, interpreting, drawing, manipulating and hypothesising can be acquired among students. Subsequently, Yamarik (2007) found out that students taught by co-operative learning method achieved greater academic performance than students taught by traditional lecture format. However, Sherman, Tingle and Good as cited in Ampiah (2004) are of the view that co-operative learning does not always result in greater understanding of the subject matter. Co-operative groups work best when the rewards are given out on group basis so that low achievers will be motivated to seek help from the high achievers who will also be willing to provide the assistance (Webb, 1982). As pointed out by Vygotsky learners do not construct knowledge in isolation but through social interaction with their peers and this interaction among learners can affect each other's learning as they co-operate to perform a task (Cimer, 2007) and as students involve themselves in a co-operative setting to construct their own knowledge or teach their peers, they are motivated intrinsically and this results in greater confidence in their abilities for learning science (Roth & Roychoudhury, 1994). In competitive and individualistic situations, there will be little motivation for students to help one another (Tuckman & Monetti, 2011).

An important question that needs to be answered is how the groups should be formed by the instructor to promote effective interaction among students and subsequently facilitate improved learning/acquisition of science process skills by students. According to Ornstein and Lasley (2000), the most common means of dealing with heterogeneity is to assign students to classes and programmes according to their abilities thus between-class ability grouping which involves separate classes for students of different abilities and within-class ability grouping which is a mixed ability grouping are used by teachers. They further stated that researchers have found out that high ability students benefit from separate ability groups because the curriculum and instructions are usually tailored towards students' abilities. However, the critics of ability-grouping contend that "the gains made by high achievers do not compensate for the loss of self-esteem and achievement among low achievers" (Ornstein & Lasley, 2000, p. 316). Turney (as cited in Slavin, 1990) stated that advantages associated with between-class ability grouping include:

1. it permits students to make progress which commensurates with their abilities;
2. it makes possible an adaptation of the technique of instruction to the needs of the group;
3. it reduces failures;
4. it helps to maintain interest and serves as an incentive because bright students are not bored by the participation of the dull;
5. slower students participate more when not eclipsed by those much brighter;

6. it makes teaching easier;
7. it makes possible individualised instruction to small slow groups (Slavin, 1990, p. 473).

If teachers will be dedicated and commit appropriate resources, pedagogical strategies, enough time and energy to each of the ability groups especially the low achievers' group so that they can equally achieve the goals of the curriculum, then ability grouping will be of a desire to parents, curriculum developers and stakeholders. On the contrary, Slavin (1990) argued that in between-class ability grouping, there is a perceived damage to low achievers who receive a slower pace and low quality of instruction from teachers, have teachers who are less experienced and face low expectations for performance. Notwithstanding, the merits connected with between-class ability grouping and the fact that slow pupils need the presence of the able students to stimulate and encourage them learn, there is stigma attached to low achievers, inability of teachers to have time to differentiate the work for different levels of ability, and teachers objecting to slower groups as demerits associated with between-class ability groupings by Turney as cited by Slavin (1990), within-class ability group which is a mixed ability grouping has been assessed as effective for students as it tends to support low ability students (Ornstein & Lasley, 2000). According to Arends (1991) when teachers are to group students for instructional purposes, they can lean heavily on heterogeneous grouping and ability grouping and tracking. Argument in favour of within-class ability grouping is that it will allow teachers to adapt instruction to the needs of a diverse student body and give them an opportunity to provide more difficult material to high achievers and provide more support to low achievers (Slavin,

1990) by adopting appropriate pedagogical skills and modifying instructions to suit the level of the low achievers which will facilitate improved learning in them. According to Ornstein and Lasley (2000) the following benefits are associated with within-class groupings:

1. students proceed at different paces on different materials;
2. the tasks and assignments tend to be more flexible than those in between-class ability groups;
3. there is less stigma for students in within-class grouping than in between class grouping;
4. teachers also tend to increase the tempo of instruction and the amount of time for instruction in low achieving students in within-class groups to bring these students to the class mean (Ornstein & Lasley, p. 317).

Generally, co-operative learning requires that mixed-ability groups of students work together to accomplish a set of tasks (Ampiah, 2004; Moore, 1998) and the fact that students divide the tasks among themselves, help one another to complete the task, praise and critique one another's efforts and contributions (Ornstein & Lasley, 2000) as well as work interdependently (Johnson, Johnson & Smith, 2007; Ornstein & Lasley, 2000) stresses that members in a co-operative group need to interact and share ideas with one another to perform the tasks successfully and hence separate classes for homogeneous group of students will not be appropriate but rather students should be placed in task groups that are composed of high, middle and low learners in co-operative learning (Moore, 1998) for this interaction to be effective in constructing knowledge. As pointed out by Vygotsky learners do not construct knowledge in isolation but through social interaction with their peers and this interaction among learners can affect each other's learning as they co-operate to perform a task (cited in Cimer, 2007) and that this social constructivism: the idea that social interaction facilitates learning according to Vygotsky is more effective in students working together to construct knowledge than students working apart (Gauvain, 2001). According to Elliot, Kratochwill, Cook and Travers (2000) and Tuckman and Monetti (2011) Vygotsky pointed out that students can perform some tasks without help from their teachers, peers and parents which signifies their actual developmental level and can also perform some tasks with assistance from more competent adults, teachers and peers which portrays their potential developmental level. Vygotsky emphasised that between the levels of actual development and potential development lie the Zone of Proximal Development (ZPD) in which students must be assisted through social collaboration with more skilled and competent peers, adults or teachers in order to successfully complete tasks that lie within their zone of proximal development. Vygotsky further stated that in social construction of knowledge, when skilful parents, peers and teachers interact with students in a technique called scaffolding, it leads to meaningful learning. Tuckman and Monetti (2011) further stated that Vygotsky's idea can be applied to teaching in the following ways:

1. provide learners with challenging tasks. Students will not be placed in a zone of proximal development nor scaffolding made possible, if they are not confronted by tasks that initially require assistance to perform.

2. have learners work co-operatively on tasks. In this way, more competent peers will be able to assist those with less competence.

3. provide learners with cognitive models. These models can be teachers or peers who can be observed performing the task while providing verbal instructions.

4. provide learners with opportunities to work on tasks likely to be encountered in the real world. These opportunities help learners to relate what they are learning in school to real-life situations and provide additional opportunities for scaffolding.

5. relate your instructional style to the cultural background of learners. Vygotsky emphasises the relevance of learners' cultural context since learning does not occur in isolation from it (Tuckman & Monetti, 2011, p. 77).

For effective interaction in the classroom, it is necessary that students are properly arranged in the classroom space to promote effective interaction among learners. According to Bull and Solity (1987) teaching intentions will be conveyed to pupils by the way the total environment is organised. By arranging the furniture in particular ways, we can set the scene for interaction between students, and between students and teachers which are appropriate to learning on particular types of activity. It would be a relatively easy task to set out simply a series of classroom arrangements, which on the basis of research, would seem suited to different types of activity. The consistent use of room arrangement as an integral part of management in the classroom requires that a teacher can make informed choices and adapt arrangements to suit particular circumstances. Ornstein and Lasley (2000) asserted that traditional seating pattern of rows of students directly facing the teacher at the front in the classroom tend to reduce student-to-student interaction and rather increase teacher control and student passivity. Ornstein and Lasley (2000) further stated that even though, in the traditional formal seating pattern teachers normally engage in whole group instructions where they gear their teachings to the average students with the assumption that this level of presentation will meet the needs of the greatest number of students, critics of the whole group instruction contend that:

1. it fails to meet the needs and interests of individual students;
2. teachers who use this method tend to look upon students as a homogeneous group with common abilities, interests and style of learning;
3. instruction is geared towards a hypothetical average student: a concept that fits only a few students in the class;
4. learning is paced on the basis of the average group;
5. high achieving students eventually become bored and low achieving students eventually become frustrated;
6. the uniqueness of each student is often lost in the large group;
7. extroverted students tend to monopolise the teacher's time and passive students do not receive the necessary attention;
8. students sometimes act out their behavioural problems in teacher-centred whole group instructional format (Ornstein & Lasley, 2000, p. 302).

Bull and Solity (1987) stated that in co-operative working groups students will seat close together so that they can talk and share materials and ideas when working together. The preferred seating arrangement is that both students and children are to sit by side with friends with whom they are working co-operatively. Subsequently, informal seating patterns such as horse-shoe formation, circular patterns and rectangular/seminar patterns which results in greater student discussion and interaction, make students active learners and reduce teacher control (Ornstein & Lasley, 2000) will be a preferred seating pattern for students working co-operatively on a task.

Alesandrini and Larson as cited in Tuckman and Monetti (2011) offer the following tenets of constructivism:

1. learning results from exploration and discovery, that is, actively exploring new information and constructing meaning from it by linking it to previous knowledge and experience;
2. learning is a community actively facilitated by shared inquiry; it requires learners to reflect on and share their insights with the group;
3. learners play an on-going, active, and critical role in assessment; it is through the self-assessment activities of reflection and verbalisation that learners realize the meaning of what they have experienced;
4. learning results from participation in authentic activities, that is, it should be based on activities and problems that students might encounter in the real world;
5. learners create knowledge from new information in light of their previous experiences;

6. teachers should function as facilitators who coach learners as they create their own paths toward personally meaningful goals (Tuckman & Monetti, 2011, p. 313).

According to Muijs and Reynolds (2005), constructivist authors have developed a number of teaching strategies which, though varied and often subject-specific, have many common elements. The following elements are often present:

1. Connecting new ideas to prior knowledge: teacher finds out what pupils know about the topic before teaching starts.
2. Modelling: teacher carries out a complex task and shows pupils the processes needed to carry out that task.
3. Scaffolding: teacher gives assistance to pupils to achieve tasks that they cannot yet master on their own and then gradually withdraws support.
4. Coaching: motivating learners, analysing their performance and providing feedback on their performance.
5. Articulation: encouraging pupils to articulate their ideas and thoughts as they communicate their solutions or findings to the teacher.
6. Reflection: allowing pupils to think about the way they solve problems, the strategies they use and whether the strategies are effective or need a modification to solve the problem better.
7. Collaboration: pupils collaborate or work together with their peers to solve problems.
8. Exploration and problem-solving activities: allowing pupils to investigate and develop their thinking capabilities to solve problems.

9. Constructivist teachers give their pupils choices and options: pupils are allowed to have a say in what tasks, projects or assignments they do. Rather than the lessons and assignments being teacher-designed, teachers work with pupils to design projects that will facilitate learning.
10. Flexibility: rather than having a fixed, unvarying lesson plans, constructivist teachers are reactive in the sense that they let pupils guide the direction of the lesson. For example, if in the course of the teaching a pupil brings out a good idea or question that is outside the originally planned lesson, the teacher tries to explore the idea or question in full to the satisfaction of the pupil.
11. Constructivist teachers are adaptive: teachers take individual differences of pupils in terms of academic abilities and learning styles into consideration and vary their teaching strategies to appeal to pupils' academic abilities and learning styles.
12. Constructivist teachers stress existence of multiple realities: teachers move pupils away from the conception that there is always one right answer or solution to a question or problem and help them to become more thoughtful and engage in deeper learning (Muijs & Reynolds, 2005, p. 66).

Windschitl (2002) stressed that constructivist instruction is intended to cultivate understanding that is grounded in meaningful context in learners and to accomplish this, it requires assessments that focus on the processes as well as on the products of learning, and offer students the opportunity to be participants in determining criteria of excellence of the work, must be employed in assessing students' performance. In constructivism, learners actively construct their own knowledge rather than receive preformed information transmitted by others (Tuckman & Monetti, 2011). Teachers should as a result set up realistic contexts for assessments that enable students to apply their learning thoughtfully and flexibly, thereby demonstrating their understanding of the content standards. Authentic assessment methods such as essays, research projects, oral presentations, performance tasks and portfolios (Ornstein & Lasley, 2000) will be appropriate to assess students as they construct knowledge because emphasising active learning and problem solving in class but using assessment methods that do not require nor allow students to demonstrate higher level thinking sends mixed messages to students (Connor-Greene, 2000). According to Windschitl (2002), in constructivist instruction, paper-and-pencil tests in which learners recognise answers or give fact-based responses to questions that are devoid of meaningful context are not generally used as the assessment mode. Rather, assessment methods that are rich, complex, interpretive, potentially subjective and embedded in the learning activities are employed and to Mohammed (2010) since traditional paper-and-pencil test techniques do not prove effective in assessing higher level thinking skills, performance-based assessment techniques which improve students' skills by bringing into play complex functions of cognitive processing that necessitate higher level of thinking for problem-solving must be employed in rating the level at which students acquire these skills. In evaluating performance assessment tasks, well designed scoring rubrics are required and designing these rubrics with students makes explicit what is valued in the learning process (Windschitl, 2002). A rubric is a scoring tool that explicitly represents the performance expectations of an assignment or a piece of work and essentially a means of communicating expectations associated with a range of performance levels to students as a way of assessing their work (Grant, Hindman & Stronge, 2010). In conformity with the above idea Arter and McTighe, Busching as well as Perlman stated that rubrics tell both the instructors and students what is important and what to look for when assessing students (cited in Jonsson & Svingby, 2007) and can be used as a scoring or grading guide to provide formative feedback to support and guide on-going learning efforts by students.

Role of Practical Lessons in Science Education

Practical work plays an essential role in educating science students because it promotes development of science process skills (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Babalola, Lambourne & Swithenby, 2019; Chebii, 2011; Hofstein, 2004; Hofstein & Lunetta, 2003; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Lunetta, Hofstein & Clough, 2005; Musasia, Abacha & Biyoyo, 2012) and the laboratory or field is a place where students should be allowed to develop scientific skills such as observing, drawing, interpreting, and manipulating (Abungu, Okere & Wachanga, 2014; Dadzie, 2011; Eshun, 2011; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Musasia, Abacha & Biyoyo, 2012; Ongowo & Indoshi, 2013). This is because in the laboratory or field, students go through processes such as experimenting, observing, drawing, manipulating, hypothesising and interpreting to gain scientific knowledge and facts as the mastery of these science processes is important for students not only to produce knowledge in science but also to be able to apply scientific skills in their daily lives (Abungu, Okere & Wachanga, 2014; Al-Rsa'l, Al-Helalat & Ali Saleh, 2017; Aydogdu, 2015; Hernawati, Amin, Irawati, Indriwati & Aziz, 2018; Jack, 2018; Samsudin, Haniza , Abdul-Talib & Ibrahim, 2015). In the laboratory or field, students become participants in the teaching and learning process as they generate scientific knowledge through learning experiences (Abungu, Okere & Wachanga, 2014; Eshun, 2011; Lunetta, Hofstein & Clough, 2005; Musasia, Abacha & Biyoyo, 2012). Learning becomes meaningful as a result of students' active participation in the teaching and learning process to construct their own knowledge or interaction with peers to create knowledge. Students, therefore, see science laboratories or ecological fields as important aspects in learning science because as they involve themselves personally in constructing knowledge it gives them a greater degree of autonomy and confidence in learning science and this fulfils their needs for a meaningful integration of knowledge (Hernawati, Amin, Irawati, Indriwati & Aziz, 2018; Idiege, Nja & Ugwu, 2017; Rauf, Rasul, Mansor, Othman & Lyndon, 2013; Roth & Roychoudhury, 1994). By engaging students in an inquiry in the laboratory does not only develop psychomotor skills such as making observations, measuring, recording data, drawing and intellectual skills such as analysing data, making comparisons, evaluating results but it also inculcates in students desirable attitudes such as curiosity, independence of mind and an improvement personal search for meaning about the world (Cimer, 2007).

It is undeniable fact that in science classrooms both lower-order skills which mainly dwell on recall of facts and higher-order thinking skills which focus on application of knowledge to solve problems in unfamiliar situations have a role to play in the development of students (Wenglinsky, 2001). However, the type of thinking processes that students must develop to prepare them confront the real world must go beyond simple learning of facts and contents and emphasise more on higher-order thinking skills such as observing, interpreting and hypothesising. This is because knowledge obtained through higher-order thinking processes is easily transferable and enables students with deep conceptual understanding to apply the knowledge to solve new problems (Aydogdu, 2015; Jack, 2018; Ramos, Dolipas & Villamor, 2013). Practical work thus develops not only knowledge but also promotes higher level, transferable skills such as observation, measurement, prediction and inference which can be applied to solve problems in life by the students (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Aydogdu, 2015; Babalola, Lambourne & Swithenby, 2019; Kasiyo, Denuga & Mukwambo, 2017; Musasia, Abacha & Biyoyo, 2012; Samsudin, Haniza , Abdul-Talib & Ibrahim, 2015; Wellington, 1998).

It is in recognition of the important roles that practical activities play in developing both theoretical concepts and science processes in students that Curriculum Research and Development Division (CRDD) in Ghana, deems it fit for practical and experimental skills to be one of the profile dimensions in the Biology Syllabus. Students are, therefore, supposed to be engaged in practical activities in the laboratory or field under the supervision of their teachers or qualified laboratory assistants which will enable them to acquire practical and experimental skills such as planning, designing experiments, observing, manipulating, classifying, drawing, measuring, interpreting, recording and hypothesising (CRDD, 2010). Unfortunately, according to (Abdul-Mumuni, 2005; Adu-Gyamfi, 2014; Agyei, 2011; Ampiah, 2004; Awuku, 2014; Boateng, 2014; Dzah, 2014; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Mwangu & Sibanda, 2017) most teachers do not perform laboratory-based practical work due to lack of time, large class size, extensive nature of the science syllabus and lack of equipment. And if these practical activities are not performed, students cannot acquire the relevant science process skills because science process skills are mostly acquired by students during their participation in an inquiry in the science laboratory (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Babalola, Lambourne & Swithenby, 2019; Chebii, 2011; Hofstein, 2004; Hofstein & Lunetta, 2003; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Karamustafaoglu, 2011; Lunetta, Hofstein & Clough, 2005; Musasia, Abacha & Biyoyo, 2012). Additionally, Ampiah (2004, 2007) and Chief Examiners' Report (WAEC: 2012, 2013, 2014, 2015, 2016) also pointed out that a variety of students' weaknesses in the science practical examinations conducted by West African Examinations Council (WAEC) cast serious doubts about science students' involvement in practical activities in the course of their study to acquire the associated science process skills and they further advised science teachers to organise practical lessons for students to develop science process skills and to study the scientific concepts meaningfully.

Acquisition of science process skills hinges on how science practical activities are organised in schools. The major aim for engaging students in practical work is for them to acquire science process skills of observing, experimenting, recording results, making inferences and interpreting data (Abungu, Okere & Wachanga, 2014; Anthony-Krueger, 2007; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Babalola, Lambourne & Swithenby, 2019) and the laboratory or field is a place where students should be allowed to develop their scientific skills by carrying out science practical activities (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Babalola, Lambourne & Swithenby, 2019; Chebii, 2011; CRDD, 2010; Dadzie, 2011; Hofstein, 2004; Hofstein & Lunetta, 2003; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Lunetta, Hofstein & Clough, 2005; Musasia, Abacha & Biyoyo, 2012). The question that needs to be answered is how practical activities are organised to enhance effective learning of science concepts and attainment of science processes by students. According to Lazarowitz, Hertz-Lazarowitz and Baird (1994), experiments in the science laboratory many a time, required students to work in groups due to constraints of experimental processes and limited equipment and material supplies in the schools.

If students are to work groups in the laboratory or field to acquire science process skills due to constraints of experimental processes and limited supplies of equipment and materials, the composition of these groups is very paramount as the members in a group are expected to interact and share ideas with one another and by so doing, the above-average students will offer relevant assistance to the below-average students. Consequently, within-class ability grouping which is a mixed ability grouping and enables students of different ability groups to interact and share ideas in performing a task (Ampiah, 2004; Moore, 1998) as well as co-operative learning in which students divide the given task among themselves, assist one another, critique one another's efforts and contributions, give and receive feedbacks (Ornstein & Lasley, 2000; Yadav, 2017) should serve as the basis for group work in science practical lessons for effective acquisition of science process skills by students because in the views of Lazarowitz, Hertz-Lazarowitz and Baird (1994) there have been consistent reports that students perform better on a task when they learn through co-operative methods as opposed to individualised learning modes.

For effective interaction among members of co-operative groups, members should not be too many and on the average, five students can form a group. Nevertheless, since there are different types of learners in a classroom with specific needs and attention (Mido, 2017) and the fact that each student must turn out some kind of worksheet during science practical examinations (Ampiah, 2004, 2007) it behoves science teachers not only to resort to group work during science practical lessons as a way of addressing the challenge of inadequate laboratory equipment but also focus on individual practical activities which will cater for individual differences as well as promote effective acquisition of science process skills by each student. This is because according to Mido (2017) understanding learner differences in classrooms and finding ways to appropriately deal with each student to meet their needs must be pursued by teachers.

In the science laboratory, students can participate individually in an inquiry to carry out a task, different tasks or as a group activity on a task or different tasks (Shakibu, 2013). When students participate in an inquiry by employing the processes of science in the laboratory, they generate scientific knowledge which is assimilated more efficiently and understood at a much deeper level (Jack, 2018; Lunetta, Hofstein & Clough, 2005; Muangu & Sibanda, 2017; Musasia, Abacha & Biyoyo, 2012; Ongowo & Indoshi, 2013). If teachers truly value the development of knowledge, skills and attitudes that are unique to practical work in science laboratories, suitable methods for the assessment of these outcomes must be developed and implemented continuously by teachers in their own laboratories (Hofstein, 2004; Hofstein & Lunetta, 2003). Thus, authentic assessment methods such as essays, research projects, oral presentations, performance tasks and portfolios (Ornstein & Lasley, 2000) can be used to evaluate the knowledge and skills that are generated by students as they engage in practical work in the science laboratories.

Science Process Skills

Science process skills are a set of broadly transferrable abilities appropriate to many science disciplines and are reflective of the behaviours of scientists (Idiege, Nja & Ugwu, 2017; Jack, 2018; Mei, Kaling, Xinyi, Sing & Khoon, 2007; Padilla, 1990; Raj & Devi, 2014). In the opinions of Akinbobola and Afolabi (2010) science process skills are cognitive and psychomotor skills that are used in problem solving. They are the skills which scientists use in problem identification, data gathering, interpretation and communicating their findings.

Science process skills can be classified as basic and integrated process skills (Karamustafaoglu, 2011; Mei, Kaling, Xinyi, Sing & Khoon, 2007; Padilla, 1990). The basic science process skills include observing, inferring, measuring, communicating, classifying and predicting (Karamustafaoglu, 2011; Mei, Kaling, Xinyi, Sing & Khoon ,2007; Padilla, 1990) whilst the integrated science process skills entail controlling variables, defining operationally, formulating hypothesis, interpreting, experimenting and formulating models (Mei, Kaling, Xinyi, Sing & Khoon ,2007; Padilla, 1990). In addition to what (Mei, Kaling, Xinyi, Sing & Khoon ,2007; Padilla, 1990) stated as integrated process skills, Karamustafaoglu (2011) pointed out that collecting and transferring data, constructing tables of data and graphs, describing relationships between variables, manipulating materials and equipment, recording data, drawing conclusions from experiments and generalising are integrated process skills. The basic science process skills provide a foundation for learning the integrated science process skills which are more complex and terminal skills for solving problems or in carrying out scientific experiments (Karamustafaoglu, 2011; Mei, Kaling, Xinyi, Sing & Khoon ,2007; Padilla, 1990; Rauf, Rasul, Mansor, Othman & Lyndon, 2013).

Science is seen as both a process and a product in nature. Science as a process entails procedures such as observation, measuring, manipulation, communication, drawing, recording, interpreting, predicting, hypothesising, experimenting and the conclusions such as scientific facts, theories and laws that are arrived at when scientists engage in the processes of science is the product (MOEYS, 2004; Sadhana, 2017). Scientific phenomena can be fully understood by neither practice nor theory alone because the theoretical and empirical concepts are intertwined and cannot be separated from each other (Jokiranta, 2014; Karamustafaoglu, 2011). It is, therefore, essential that practical activities complement theoretical concepts for effective teaching and learning of science. Students are thus supposed to engage in scientific inquiry in the teaching and learning process of science to facilitate development of science process skills and the retention of the scientific concepts. Engaging students in an inquiry can help them develop psychomotor skills such as gathering and setting up apparatus, making observations and measurements, recording data and drawing graphs as well as academic and intellectual skills such as analysing data, making comparisons, evaluating results, preparing reports and communicating results to others and teachers (Cimer, 2007).

Practical work thus plays an essential role in educating science students to acquire science process skills (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Babalola, Lambourne & Swithenby, 2019; Chebii, 2011; Hofstein, 2004; Hofstein & Lunetta, 2003; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Lunetta, Hofstein & Clough, 2005; Musasia, Abacha & Biyoyo, 2012) and the laboratory or field is a place where students should be allowed to develop scientific skills such as observing, drawing and manipulating (Abungu, Okere & Wachanga, 2014; Dadzie, 2011; Eshun, 2011; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Musasia, Abacha & Biyoyo, 2012; Ongowo & Indoshi, 2013). This is because in the laboratory or field, students go through processes such as experimenting, observing, drawing, manipulating, hypothesising, and interpreting to gain scientific knowledge and facts as the mastery of these science processes is important for students not only to produce knowledge in science but also to be able to apply scientific skills in their daily lives (Abungu, Okere & Wachanga, 2014; Al-Rsa'l, Al-Helalat & Ali Saleh, 2017; Aydogdu, 2015; Jack, 2018; Samsudin, Haniza, Abdul-Talib & Ibrahim, 2015). It is, therefore, very necessary for science process skills to be inculcated in students during science practical lessons to ensure the acquisition of these skills and their subsequent use to solve problems in life (CRDD, 2010; Kruea-In & Thongperm, 2013; Rauf, Rasul, Mansor, Othman & Lyndon, 2013; Wilunjeng & Suryadarma, 2017). However, some researchers have found out that practical activities were not organised regularly for science students to acquire science process skills on the premises of time constraints, overloaded curriculum, lack of equipment, extensive nature of the science syllabus and large class sizes (Abdul-Mumuni, 2005; Adu-Gyamfi, 2014; Agyei, 2011; Ampiah, 2004; Awuku, 2014; Boateng, 2014; Dzah, 2014; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Mwangu & Sibanda, 2017). If practical activities that are supposed to be the fulcrum for acquisition of science process skills, are not performed regularly by students then there is no doubt that science students' level of acquisition of science process skills will be low. Teachers cannot expect students to excel at skills they have not been given ample opportunities to experience or practice (Padilla, 1990). If students are to master science process skills, there is the need for students to engage in more inquiry activities in the laboratory or field under the guidance of their teachers or qualified laboratory assistants and they must keep reflective journals of the skills acquired. According to Coil, Wenderoth, Cunningham and Dirks (2010) a more effective way to help students master science process skills is through explicit instruction of science process skills through practical lessons and helping students to acquire a repertoire of these skills by keeping reflective journals.

The development of science process skills in students during the process of teaching and learning of science must be pursued with all seriousness it deserves by science teachers. This is because science process skills are inseparable from the conceptual understanding involved in learning science (Jokiranta, 2014; Karamustafaoglu, 2011) and that mastery of science process skills is not only necessary for students to generate scientific knowledge but also apply the scientific skills in their daily lives (Abungu, Okere & Wachanga, 2014; Aydogdu, 2015; Babalola, Lambourne & Swithenby, 2019; Jack, 2018; Samsudin, Haniza, Abdul-Talib & Ibrahim, 2015). Studies in the United States of America pointed out that elementary pupils who were taught science process skills did not only learn to use those processes but retained them for future use (Mei, Kaling, Xinyi, Sing & Khoon, 2007). Subsequently, for the past four decades science educators have focused attention on the development of basic and integrated science process skills in students because these skills are crucial for meaningful learning and can be applied throughout the life-time of the individual (Jack, 2018; Karamustafaoglu, 2011; Mwangu & Sibanda, 2017).

The most effective person that enables students to gain science process skills is the teacher and hence teachers need to acquire these skills at the desired levels (Karamustafaoglu, 2011) and to effectively develop these science process skills in learners, it behoves teachers to make use of student-centred approaches by engaging students in activities that will enhance the development of their science process skills (Gurses, Cetinkaya, Dogar & Sahin, 2015). For the mastery of science process skills, teachers must provide students with multiple opportunities and ample time to develop and work with these skills in different content areas and contexts (Padilla, 1990; Sehie, 2001) and if teachers model these skills and provide appropriate feedback on the acquisition of science process skills to students, they will become more proficient and independent in practising science process skills (Sehie, 2001).

Assessment of Science Process Skills

The development of practical and experimental skills in learners requires active learning through practical activities for the students to gain higher order thinking skills. Al-Sadaawi (2007) stated that teachers often desire to develop students' higher order thinking skills, however, the assessment practices usually adopted by these teachers do not reflect these global achievement goals as science teachers appear to concentrate on assessing lower order skills to the detriment of science process skills (Zeidan & Jayosi, 2015). It is, therefore, essential that assessments focus on the kind of learning outcomes that teachers want their students to develop (Cimer & Cimer, 2010).

For acquisition and exhibition of adequate proficiency in skills of planning, observation, performing and reasoning the student must engage in performance-based assessment tasks (Ofori-Amanfo, 2001) and when students acquire skills during performance-based assessment tasks, there is the need to assess the extent to which these skills have been acquired. Since traditional testing models that involve paper-and-pencil test techniques have been under intense criticism for their inadequacy in measuring higher order thinking skills that are required in science curriculum (Sanders & Horn, 1995) performance-based assessment techniques which improve students' skills by bringing into play complex functions of cognitive processes that necessitate higher level of thinking for problem-solving must be employed in rating the extent to which students acquire these skills (Mohammed, 2010). According to Johnson (2001), performance assessment necessitates that students demonstrate mastery of specific skills and competencies by performing some tasks and to Moore (1998) these skills must be the behaviours that the assessor wants to measure in the given tasks.

The aim of performance assessment, therefore, is to measure learning or performance directly instead of using paper-and-pencil tests (Muijs & Reynolds, 2005) which is consistent with modern learning theory which emphasises that students should be actively involved in inquiry activities in order to construct meaning of knowledge for themselves (Seshie, 2001). Performance assessment tasks yield evidence that reveals understanding and when we call for authentic application, "we do not mean recall of basic facts or mechanical plug-ins of a memorized formula rather we want students to transfer knowledge—to use what they know in a new situation" (McTighe & O'Connor, 2005 p.10). According to Swan and Hofer as well as Ashford-Rowe, Herrington and Brown, teachers should as a result set up realistic contexts for assessments that enable students to apply their skills thoughtfully and flexibly, thereby demonstrating their transfer of these skills (cited in Villarroel, Bloxham, Bruna, Bruna & Herrera-Seda, 2018).

Performance assessments provide a means of assessing processes as well as products that result from performing a task (Johnson, 2001; Seshie, 2001). Thus, performance assessment gives teachers the opportunity to evaluate directly observing, classifying, interpreting, predicting, hypothesising, manipulating skills as well as knowledge that is generated by students when they engage themselves in scientific inquiry in the laboratory. Performance assessment should measure content outcomes as well as inquiry skills of learners (Wright, 2001). Performance-based assessment requires higher level of thinking for problem solving (Mohammed, 2010) because society develops faster if its people can solve problems through application of scientific and critical thinking skills (Dadzie, 2011).

In performance-based assessments, students are required to carry out performance tasks. For students to improve their performance skills and teachers to obtain a more comprehensive picture of students' skills, a substantial number of performance tasks are necessary (Dadzie, 2011) as this will afford the students to internalise the skills and apply them to solve real-life problems in different situations and hence showing mastery of these science process skills in the long run.

Students' involvement in the assessment of performance tasks contributes a lot to the acquisition of science process skills as performance assessments are designed to capture more elusive aspects of learning and they allow students to solve authentic or realistic problems which are often assessed with the guidance of scoring rubrics (Jonsson & Svingby, 2007; Mohammed, 2010). A well-designed performance assessment task with scoring rubrics can elicit a rich variety of student performances and offers the possibility of deeper understanding of cognitive processes and problem-solving strategies (Mohammed, 2010).

Various researchers around the world have assessed science process skills of students and have documented their findings. Zeidan and Jayosi (2015) found out that the level of acquisition of science process skills among Palestinian Secondary School students was low as they reported a mean value of 1.13 for classifying and 1.25 for hypothesizing out of a total of 2 marks from the descriptive statistics. Maranan (2017) affirmed that 38% of the students scored 9-10 points, 24% scored 7-8 points, 21% recorded 5-6 points, 9% scored 3-4 points and 8% recorded 0-2 points when their classifying skills were assessed. Thus, 38% of the students have mastered classifying skills, 24% are near mastery level, 21% are moving towards mastery level, 9% have low mastery level and 8% showed no mastery level. Sunyono (2018) asserted that 50.67% of students displayed moderate classifying skills and 39.33% demonstrated low interpreting skills when they were assessed on a 5-point rating scale. Rabacal (2016) assessed the science process skills of students on a 5-point rating scale of 4.01-5.00, 3.01-4.00, 2.01-3.00, 1.01-2.00 and 0.00-1.00 which correspond to very high, high, average, low and very low respectively in terms of acquisition of science process skills. She reported that majority of the students performed averagely in the skills of classifying and interpreting as most of them had a score range of 2.01-3.00 in the classifying and interpreting skills. She, however, reported that majority of the students showed low performance in the hypothesising skill as greater number of students had a score range of 1.01-2.00 out of a maximum of 5-points in the hypothesising skill. Yamtinah, Masykuri, Ashadi and Shidiq (2017) pointed out that 35.7% of the students interpreted data correctly when their interpreting skill was assessed with science process skills test. Anthony-

Krueger (2001) assessed interpreting, inferring and predicting skills of Biology students in the Central Region of Ghana and affirmed that majority of the students could only make partial interpreting, predicting and inferring with respect to the science process skills assessment tasks. Agyei (2011) found out that 46.5% of the students exhibited proficiency in observation skills, 27.9% of the students exhibited proficiency in the skill of reasoning and 62.8% of the students demonstrated proficiency in the skill of planning when he assessed the laboratory skills of Biology students in some selected senior high schools. Dzidzinyo (2011) reported that elective Biology students had difficulties in interpreting a graph as well as problems in drawing accurate features of a given specimen and making ruled guidelines when she investigated the weaknesses of Biology students during graph work and biological drawing. According to Wekesa (2013) and Akinjide, Olakanmi and Mulkah (2018) majority of Biology students exhibited low/poor drawing skills as they stated respectively that 84% of the students showed low drawing skills and 96.66% portrayed poor drawing skills when they were assessed during drawing of biological specimen achievement tests. Seshie (2001) reported that 16.33 % (49 out of a total number of 300) showed high level of proficiency in planning skills and majority of the students 71. 67% (215 out of 300 students) showed low level of proficiency in performing skills when he assessed laboratory skills of students in selected senior secondary school elective Chemistry topics in titrimetric analysis. Johnson (2001) affirmed that the overall achievement of students was satisfactory as the mean score for planning skill was 3.41 out of a total mark of 6 points, 4.5 out of a total mark of 9 points for performing skill and 5.98 out of a total mark of 10 points for reasoning task when he assessed laboratory skills of Physics students in selected senior secondary school topics in mechanics.

There appears to be a relationship between acquisition of science process skills and achievements of students in science. For example, Abungu, Okere and Wachanga (2014) reported that students' achievement in Chemistry was low and this could be attributed to lack of exposure to science process skills by teachers. This implied that if students had been constantly exposed to science process skills, their achievement in Chemistry would have been high. According to (Aydogdu & Ergin, 2008; Derilo, 2019), there is a positive correlation between students' mastery of science process skills and academic achievements in science by students which suggests that students' science process skills mastery leads to better performance in science.

Performance Assessment Tasks and Scoring Rubrics

A rubric is a scoring tool that explicitly represents the performance expectations of an assignment or a piece of work, and essentially a means of communicating expectations associated with a range of performance levels to students as a way of assessing their work (Grant, Hindman & Stronge, 2010). Arter and McTighe, Busching as well as Perlman stated that rubrics tell both the instructors and students what is important and what to look for when assessing students (cited in Jonsson & Svingby, 2007) and can be used as a scoring or grading guide to provide formative feedback to support and guide on-going learning efforts by students.

When used formatively, rubrics can help instructors get a clearer picture of the strengths and weaknesses of the class because when assignments are scored and returned with rubrics, students can more easily recognise the strengths and weaknesses of their work and seek ways to improve upon their weaknesses (Teaching Excellence and Educational Innovation [TEEI], 2015). Therefore, by using rubrics in scoring acquisition of science process skills, the student will incorporate the feedback into subsequent efforts in acquiring science process skills. Grant, Hindman and Stronge (2010) pointed out that teachers are not the sole dispensers of feedbacks in classrooms and therefore students' ownership of their learning is a vital component for success. Rubrics are a means to encourage ownership of knowledge by students as well as serving as a basis for students' evaluation of their work.

According to McTighe and O'Connor (2005) a rubric is a widely used evaluation tool which consists of criteria, a measurement scale and descriptions of the characteristics for each score point which if well developed, can communicate the important dimensions or elements of quality, in a product or performance to guide educators in evaluating students' work. Grant, Hindman and Stronge (2010) asserted that developing and using rubrics can have many positive effects in the classroom. These include:

1. increased student involvement in the assessment process, which makes assessment part of learning rather than a measure of the end result;
2. more reliable scoring of tasks as the teacher uses a rubric with specified criteria rather than scoring tasks without any specified criteria;
3. decreased time spent in grading by the teacher as the rubric focuses the grading (Grant, Hindman & Stronge, 2010, p.70).

According to McTighe and O'Connor (2005), rubrics also benefit students in the sense that when students know the criteria in advance of their performance, they have clear goals for their work. Because well-defined criteria provide a clear description of quality performance, students do not need to guess what is most important or how teachers will judge their work and, therefore, as pointed out by Jonsson and Svingby (2007), reliable scoring of performance assessments through the use of holistic or analytic rubrics will enhance acquisition of science process skills by students. In holistic scoring, the rater makes overall judgement about the quality of performance in the work while in analytic scoring, the rater assigns a score to each dimension being assessed in the task. Holistic scoring is usually used for large scale assessment because it is assumed to be easy whereas analytic scoring is useful in the classroom since the results can help teachers and students identify students' strengths and learning needs (Jonsson & Svingby, 2007). Even though, performance assessments to some extent lack the reliability and validity as associated with objective tests, and are by their nature somewhat subjective, their ability to measure behaviours in realistic contexts and to assess processes that cannot easily be measured on paper makes this form of assessment potentially very powerful (Muijs & Reynolds, 2005).

Gender and Science Education

The role of gender in determining students' interest and performance in science continues to attract attention from both scholars and the general public (Seshie, 2001). Gender differences still persist in terms of students' attitudes towards science and their participation in science related subjects (Archer, DeWitt, Osborne, Dillon, Willis & Wong, 2013). The reasons for the persistent differences in attitudes of males and females towards participation in science subjects are varied and can be attributed to the parents, students, teachers and the curriculum. People usually perceive scientists to be more like men than women (Archer, DeWitt, Osborne, Dillon, Willis, & Wong, 2013; Avraamidou, 2013; Carli, Alawa, Lee, Zhao & Kim, 2016; Wonch Hill, McQuillan, Talbert, Spiegel, Gauthier & Diamond, 2017). If gender stereotypes about successful scientists, favour men than women then people might view women as deficient in the traits needed to be effective scientists (Carli, Alawa, Lee, Zhao & Kim, 2016). In school textbooks, there is gender stereotyping where girls are portrayed as housewives, petty traders and the boys are depicted as doctors, engineers and accountants and thereby considering girls as less intelligent (Bardley, 2000). According to Potter and Rosser as well as Powell and Garcia, content analysis of representations of scientists in secondary school science textbooks has showed relatively few images of women (cited in Carli, Alawa, Lee, Zhao & Kim, 2016). The teaching, assessment modes and attitudes of science teachers can be gender biased and favouring males in many instances (Carlone, 2004; Warrington, Younger & Williams, 2000). For instance, Bardley (2000) reported that many girls did not opt for Mathematics and Science courses at secondary school level because their teachers told them that the course was too difficult for girls. Subsequently, Science and Mathematics courses were seen as a preserve for males and few girls who ventured to study Science and Mathematics faced discouragement from teachers, parents, male counterparts and society at large (Tachie, 2001). Many girls, therefore, have lower desire and confidence levels of studying science and becoming scientists in the future (Wonch Hill, McQuillan, Talbert, Spiegel, Gauthier, & Diamond, 2017).

The low representation of females as well as their under-performance in science courses received much attention in educational research (Seshie, 2001). To bridge the yawning gap between girls and boys in terms of enrolment and achievement in Science and Mathematics subjects, the government of Ghana through Ghana Education Service (GES) made an intervention by instituting Science Technology and Mathematics Education (STME) clinic for girls in 1987 to promote the interest and achievement of girls in Science, Technology and Mathematics education. The clinics were decentralised to the district levels in 1997 and has resulted in an increase in the number of girls pursuing science and technology related courses in the secondary schools as well as the universities (Ghana Education Service [GES], 2012; Tachie, 2001).

In schools, boys tend to manipulate scientific equipment more than girls and therefore mostly prefer career choices in the physical sciences whereas girls are more concerned about human dimensions of science than abstract scientific principles and hence desire professions in the life sciences (Seshie, 2001). This is in support of the evidence that at the tertiary institutions, many men pursue courses in the physical sciences and many women undergo courses in the biological sciences than the physical sciences (Chin-Fei, Ching-Sen, Guang-Jing & Chia-Ju, 2015). Robinson and Gillibrand (as cited in Eshun, 2011) are of the view that girls perform better in certain subject areas such as Mathematics and Science when boys are not in the class. This assertion could be due to inferiority complex among girls in co-educational institutions as a result of discrimination against girls in mixed-sex science classrooms by teachers in their teaching, assessment modes, attitudes, teachers' perception that Mathematics and Science are for boys, and stereotyping of gender roles in Mathematics and Science textbooks where females are portrayed as traders and nursing mothers and males are seen as doctors and engineers (Archer, DeWitt, Osborne, Dillon, Willis, & Wong, 2013; Avraamidou, 2013; Bardley, 2000; Carli, Alawa, Lee, Zhao, & Kim, 2016; Chin-Fei, Ching-Sen, Guang-Jing & Chia-Ju, 2015, Wonch Hill, McQuillan, Talbert, Spiegel, Gauthier & Diamond, 2017). Advocates of single sex schools claimed that the current co-educational system disadvantaged boys and that teaching boys and girls separately would boost boys' achievement in science (Eshun, 2011). Nonetheless, Shakibu (2013) asserted that there is no evidence that a particular boy or girl will perform better in a single-sex school than co-educational schools and thus the difference in performance may be due to hereditary or environmental factors such as teachers' approach to teaching, motivational factors and students' attitude towards the study of science (Tuckman & Monetti, 2011) and subsequently, Tachie (2001) pointed out that if girls are given equal opportunities as boys in the educational system, they will perform equally or even better than boys.

The achievements of male and female students in science have been reported by various researchers. The findings by the researchers send mixed feelings because whereas others reported of differences in performance of males and females, others talked about equal performance of both sexes on given tasks in science. For instance, Zeidan and Jayosi (2015) reported that the mean value for acquisition of science process skills by males was 10.31 and that of females was 12.75 and that there was a significant difference in the acquisition of science process skills in favour of females when they assessed science process skills of Palestinian students. Eshun (2011) testified that girls performed better than boys in the skill of interpreting as the girls had a mean rank of 62.24 and the males had 54.41 in the skill of interpreting. Dzidzinyo (2011) found out that females performed better than their male counterparts in drawing test and graph work when she investigated students' weaknesses in graph work and biological drawings. Some researchers reported that there was a statistically significant difference between the mean achievement scores of males and females on science process skills in favour of females (Raj & Devi, 2014; Tek, Tuang, Yassin, Baharom, Yahya & Said, 2012; Zeidan & Jayosi, 2015). Anthony-Krueger (2001) affirmed that sex of the students was independent of their performance on the tasks of interpreting, inferring, and predicting when he assessed their science process skills. He, however, stated that even though the performance of the students did not depend on their sex, a relatively higher percentage of females than males exhibited higher degrees of performance in the skills of interpreting, inferring and predicting. Johnson (2001) reported that males had mean scores of 3.21, 4.52 and 5.81 on planning, performing and reasoning tasks respectively whereas females had mean scores of 3.73, 4.78 and 6.28 on planning, performing and reasoning tasks correspondingly when he assessed the laboratory skills of Physics students. The females thus performed better than males on the skills of planning, performing and reasoning. On the contrary, Akani (2015) reported that males had a mean value of 3.62 and females had a mean value of 2.48 and, therefore, there was a statistically significant difference in the possession of science process skills in support of males when he assessed the levels of possession of science process skills by final year students in colleges of education in Nigeria. Addai (2001) reported that boys performed better than girls in planning, performing and reasoning tasks when he evaluated the practical skills of students in Mechanics in Physics. According to (Gurses, Cetinkaya, Dogar, Sahin, 2014; Tilakaratne, & Ekanayake, 2017), there was a statistically significant difference between the mean performance of males and females on science process skills in support of males. Some researchers also reported that both males and females achieved equally when they were assessed on performance tasks to determine their levels of acquisition of science process skills. For example, Shakibu (2013) reported that both male and female teacher trainees performed at similar levels in the skills of planning, performing and reasoning. Seshie (2001) also found out that both male and female students performed at the same level of proficiency in the skills of planning when he assessed their laboratory skills in titrimetric analysis. According to (Ekon & Eni, 2015; Mohamad & Ong, 2013), gender does not significantly influence the acquisition of science process skills. This implies that both males and females could perform better on science process skills if adequate equipment and materials are available for them to undergo practical activities regularly with competent and dedicated science teachers who constantly motivate and provide the right atmosphere for them in order to develop positive attitudes towards practical work for effective acquisition of science process skills.

Type of School and Students' Performance

Before 1990 in Ghana, the categorisations of secondary schools have been single-sex schools and co-educational institutions or urban and rural schools. Recently, however, there is a new categorisation of schools basically in terms of the resources and facilities that are available in the school. Ampiah (2004) reported that because of significant inequities in the facilities and equipment in the science laboratories and depending on the financial standing of the secondary schools, they are being classified into well-endowed and less-endowed schools. Lately, there has been a slight modification in the well-endowed and less-endowed secondary schools to encompass the third status of endowed secondary schools. According to Ghana Education Service (2015), Senior High Schools (SHSs) in Ghana have been grouped into three options on the basis of endowment of resources and equipment as well as their performance in final examinations conducted by WAEC. Consequently, we have Option 1 SHSs which are less-endowed, Option 2 SHSs which are averagely endowed and Option 3 SHSs which are well-endowed. Most of the endowed and well-endowed SHSs are located in urban areas and most of the less-endowed SHSs are located in rural areas.

There have been research findings on the type of school and availability of laboratory facilities and students' achievement in science. For instance, Anthony-Krueger (2001) reported that more students from the urban schools than students from the rural schools made accurate interpretation, and none of the students from the rural schools made accurate prediction with full reasons whereas some students from urban schools made accurate prediction with full reasons. Gurses, Cetinkaya, Dogar and Sahin (2014) found out that significant differences exist on the performance of students from different high schools with respect to science process skills. Raj and Devi (2014) affirmed that there was a statistically significant difference in the mean scores of rural and urban students on science process skills in favour of urban students. Zeidan and Jayosi (2015) stated that the mean achievement score of village students was 13.04 and that of city students was 10.53 on science process skills and thus the village students performed better on the science process skills than city students. Soyibo and Johnson (as cited in Naah, 2011) analysed students' performance on integrated science process skills based on school type and location and observed that students could perform better when they receive better facilities and services of teachers of better quality. Adeyemo (2013) and Bello (2012) found out that there was a significant relationship between availability and optimal utilisation of laboratory facilities and academic achievement of Physics students in Nigeria. Ihejiamaizu and Ochui (2016) asserted that availability and effective use of laboratory equipment result in higher academic achievement in Biology and according to Johnson (2016), exposure of students to laboratory apparatus during practical activities facilitates acquisition of science process skills.

The Roles of In-service Training and Reflection in Science Education

The art of teaching and instruction is dynamic and, therefore, for teachers to be abreast of the new trends, they need regular professional development in pedagogy and instructional techniques (Buabeng, Owusu & Ntow, 2014). It is thus appropriate that in recent years, there is the need to ensure that teachers are competent and meet the required standards in the knowledge and skills for effective teaching of subject matter and skills to students (Pollard & Triggs, 1997) and they can achieve this through constant professional development to upgrade and update their content knowledge and skills that are necessary to be competent in the classroom for improved learning by students.

According to Osamwonyi (2016), teachers must be provided with opportunities through in-service programmes to update their knowledge, skills and experiences for their professional competence in the classroom because there is documentary evidence that in-service training programmes lead to improvement in the professional competencies of teachers in terms of knowledge and skills for effective delivery of lessons to students (Cossa & Vamusse, 2015; Rahman, Jumani, Akhter, Chisthi & Ajmal, 2011). Science teachers therefore need to constantly develop their knowledge and practical organising skills through in-service programmes in order to be competent in the classroom (Khatoon, Alam, Bukhari & Mushtaq, 2014) as some teachers do not feel confident to perform laboratory-based practical activities for students to observe because of lack of training on these practical activities (Cossa & Vamusse, 2015). Subsequently, in Ghana, Anthony-Krueger (2007) found out that 85.7% of Biology teachers never had any in-service training in teaching practical laboratory skills in Biology when he conducted a study into factors militating against laboratory practical work in Biology among Ghanaian senior secondary school students.

Meanwhile teacher professional interventions are designed to increase teachers' content knowledge and pedagogical content knowledge (Schieb & Karabenick, 2011). Van Driel, Beijaard and Verloop (2001) stated that lack of success in many innovative curricula is attributed to the failure of teachers to implement the innovations in a way corresponding to the intentions of the curriculum developers. They further stated that long term professional development programmes are needed to achieve lasting changes in teachers' content and practical knowledge. Accordingly, Department of Education and Training (2005), stated that if we are to realise continuous improvement in the quality of teaching and learning in our classrooms, we must build the capacity of our teachers to meet these expectations. Building the capacity of teachers for quality teaching can be achieved through pre-service and in-service training programmes and as stated by Van Driel, Verloop and Devos (1998) both pre-service and in-service training programmes have resulted in changes in the participants' conception of teaching and learning science. Because in-service training programmes are capital intensive (Osamwonyi, 2016), there is the need for school authorities to support teachers in developing themselves professionally in order to meet the expected standards. Through effective leadership, teachers are provided with opportunities to develop their skills, knowledge and attitudes necessary to teach to higher professional standards by engaging in professional development sessions (Department of Education and Training [DET], 2005).

One of the most important attitudes by both teachers and students towards teaching and learning of practical science is reflection. Reflection means critically reviewing the way an experiment had been carried out, noting the possible flaws associated with it and thinking about ways to improve upon it subsequently (CRDD, 2007). Teachers and students must therefore reflect on practical activities in science to promote meaningful learning by students. According to Prabha (2016) science students should be given opportunities to reflect on their laboratory experiences because it leads to greater understanding of practical activities and concepts, acquisition of skills and assessment of their own learning (Cengiz & Karatas, 2015; Denton, 2018; Lew & Schmidt, 2011). Reflective practice by teachers enables them to learn from their own professional experiences, analyse these experiences and change their practice where necessary (Goker, 2016; Priya, Prassanth & Peechattu, 2017) towards an improvement in learning by students because "reflective teachers are constantly engaged in thoughtful observation and analysis of their actions in the classroom before, during, and after interactions with their students" (Snowman & Biehler, 2000 p. 15).

For effective reflection to occur during science lessons, there is the need for reflective journals to be written by both students and teachers during the teaching and learning process. Reflective journals about laboratory activities reveal students' level of acquisition of knowledge, science process skills, attitudes, motivation, self-assessment, experimental processes, active learning mode and feedback on the practical activities (Al-Rawahi & Al-Balushi, 2015; Cengiz, Karatas & Yadigaroglu, 2013; Farrah, 2012; Lew & Schmidth, 2011; Thorpe, 2004; Towndrow, Ling & Venthan, 2008). Through writing of reflective journals about laboratory activities, students' attitudes towards the practical work, self-assessment of the practical work, science process skills learnt from the practical work, experimental procedures of the practical work and their opinions about the practical work can be determined (Cengiz, Karatas & Yadigaroglu, 2013). According to Al-Rawahi and Al-Balushi (2015), self-reflection through journal writing on hands-on activities allows students to think back on the activities, reveal their judgements and feelings with respect to the activities, suggest alternative methods for conducting these activities and note down questions for further exploration. Reflective journals can be used to facilitate science students' curiosity and engagement in laboratory work (Towndrow, Ling & Venthan, 2008). Reflective journals also promote active learning among students, enhances their motivation and builds up their confidence for learning science (Cengiz & Karatas, 2015; Farrah, 2012; Thorpe, 2004). Furthermore, reflective journals help students to write about their manipulative, observation, prediction, hypothesising and interpretive skills, enables students to assess their work formatively and to produce feedback on their learning process (Al-Rawahi & Al-Balushi, 2015). Writing of reflective journals by students during practical activities is very essential because documentary evidence shows that there is a positive correlation between students' laboratory achievement and reflective journals. For instance, it was reported that positive correlation exists between students' laboratory achievement in Chemistry and writing of reflective journals (Cengiz & Karatas, 2015; Cengiz, Karatas & Yadigaroglu, 2013). Science teachers should, therefore, encourage science students to write reflective journals (Al-Rawahi &Al-Balushi, 2015). It is not only science students that derive benefits from writing reflective journals but also science teachers. Reflective journals permit teachers to learn from their own professional experiences and to critically analyse what they do in class and discover alternative approaches to their practices (Goker, 2016; Priya, Prassanth & Peechattu, 2017) for effective learning by students. Subsequently, Benade (2015) suggested that in addition to the use of digital technologies for teaching and learning in this 21st century, teachers must as well be reflective practitioners during the teaching and learning process.

For reflective journals to promote meaningful learning among students, there is the need for teachers to guide learners through the process of writing and they must provide feedback on students' reflective journals. According to Towndrow, Ling and Venthan (2008), teachers must guide their students during writing of reflective journals in the form of reflective questions and they must also provide students with appropriate and timely feedback because research has found out that when Chemistry students were provided with appropriate and timely feedback on their reflective journals, it increased their achievement in Chemistry laboratory work (Cengiz & Karatas, 2015).

Students and teachers need to reflect on their practices as they occur in order to find solutions to them. Schon (as cited in Smith 1999) believes that professionals need to reflect in action and on action of their practices. Reflection in action describes the teacher's ability to resolve situations while they are happening and they are done instinctively, while drawing on previous experiences. This reflection does not happen after the in-class occurrence, rather the teacher tries out several solutions till the most appropriate solution is found. It involves a mixture of knowing and doing. Reflection on action takes place after the event has taken place and it involves developing a repertoire of experience and forces teachers to think about what they would ideally do if the situation happened again. Schon believes that both types of reflection are necessary to become an effective practitioner (cited in Bilash, 2011) because to become an expert teacher, you must continuously examine your own attitudes, practices and outcomes (Tuckman & Monetti, 2011). Snowman and

Biehler (2000) stated that reflective teachers continuously engage in thoughtful observation and analysis of their actions in the classroom before, during, and after interactions with their students. This means that teachers should constantly evaluate their classroom practices to see if they result in an improved learning by the students. If their actions do not result in effective learning by the students, then there will be the need to adopt more appropriate teaching and learning strategies to help their students learn effectively. Larrivee (2000) highlights the importance of reflection, believing that when teachers become reflective practitioners, they move beyond a knowledge base of discrete skills to a stage where they integrate and modify skills to fit specific contexts and eventually to a point where the skills are internalised, enabling them to invent new strategies. Arends (1991) and Moore (1998) asserted that reflective teaching means teachers must ask self-evaluative questions with regard to the appropriateness and success of their teaching. If students are not successful in learning what they teach, they must change their teaching styles or classroom behaviours in order to improve students' learning. Subsequently (Cengiz, Karatas & Yadigaroglu, 2013; Mei, Kaling, Xinyi, Sing & Khoon, 2007) stated that keeping a scientific journal is an effective strategy to enhance students' science process skills and that reflection can be carried out through writing of reflective journals which would help enhance the acquisition of science process skills. For instance, if a student keeps a reflective journal on the venation of a particular dicotyledonous leaf, it will help in acquisition of science process skills such as observing, drawing, recording and communicating in the student.

Barriers to Organisation of Science Practical Lessons in Senior High Schools in Ghana

Scientific phenomena are such that the empirical and theoretical concepts should be intertwined in order to promote meaningful learning by students (Jokiranta, 2014). Laboratory work in science is, therefore, essential for science students in the acquisition of practical and theoretical knowledge which will help them understand the nature and methods of science (Eshun, 2011). Boateng (2014) and Tobin (1990) asserted that meaningful learning occurs in the laboratory if students are given opportunities to manipulate equipment and materials in order to construct knowledge about scientific phenomena. Science educators in Ghana are thus supposed to engage their students in practical activities for the learning of science to be meaningful to students (CRDD, 2010).

However, research findings in Ghana revealed that the organisation of science practical activities is confronted with some challenges and, therefore, making attainment of science practical skills in Ghanaian SHSs difficult. According to (Abdul-Mumuni, 2005; Adu-Gyamfi, 2014; Agyei, 2011; Ampiah, 2004; Awuku, 2014; Boateng, 2014; Dzah, 2014), most teachers do not perform science practical work regularly due to lack of time, large class size, extensive nature of the science syllabus and lack of laboratory equipment. Dzah (2014) found out that among the factors that inhibit effective organisation of science practical activities, 64.7% was attributed to large class size, 56.4% was credited to faulty equipment and 38.9% was ascribed to time constraint when he investigated into Physics practical lessons in senior high schools in the Cape Coast Metropolis. The problem of laboratory equipment appeared to be prevalent not only in Ghana but also in other developing countries. Awuku (2014) pointed out that in many developing countries of which Ghana is of no exception, poor state of laboratory equipment creates a situation where expected influence of science practical activities is not achieved. Additionally, Anthony-Krueger (2007), reported that irregular professional development sessions by science teachers is a hindrance to effective organization of science practical activities because science teachers need to constantly update and upgrade their knowledge and skills to teach science effectively (Boateng, 2014). Furthermore, in most SHSs qualified laboratory assistants were not available (Anthony-Krueger, 2007), funds were also not readily made available to science teachers by school authorities for organisation of science practical activities (Ampiah, 2004) and science teachers usually organise practical work on predicted topics or areas of the syllabus that WAEC sets practical questions on. Accordingly, Boateng (2014) reported that Biology teachers were of the view that they organised practical activities on drawing, interpretation of data, identification and classification of organisms and food tests because they form the major aspects of the practical activities that come in the final exams by WAEC.

Summary of the Review

Students usually construct their knowledge socially and, therefore, students must be allowed to engage actively with their peers in an inquiry about scientific phenomena during the teaching and learning process for effective acquisition of science process skills.

From the literature, if students are to learn science meaningfully, science teachers must be innovative and adopt student-centred approaches by providing hands-on activities for students in the teaching and learning process so that they can construct their knowledge actively.

It will be appropriate if students work collaboratively in mixed-ability groups to solve problems so that they can interact and share ideas and by so doing, the above average students can assist the below average students so that they can also be brought to the required standards with regard to the attainment of science process skills and understanding of scientific concepts.

If students are working on a task and they get stuck, there is the need for more skilful peers, parents or teachers to interact with them and assist them so that they can overcome their difficulties.

Practical work plays an important role in science education because it affords students to acquire scientific knowledge through the processes such as observing, drawing, interpreting, inferring, manipulating, classifying and hypothesising.

When science teachers develop science process skills such as observing, classifying, measuring, inferring, predicting, interpreting, hypothesising in learners, they must use appropriate assessment modes or techniques to assess these higher-order thinking skills in learners.

Males and females should be given equal opportunities in science classrooms so that they can develop their potentials to the fullest. Because from the literature it is clear that gender is independent of students' performance in science and if males and females are given equal treatments in terms of quality teaching, motivation and provision of facilities, they will excel in science.

Teacher qualities such as reflective practices, updating and upgrading of knowledge and skills through in-service training programmes are necessary for science teachers to be effective in inculcating science process skills in students and to assist them study theoretical concepts meaningfully.

CHAPTER THREE

RESEARCH METHODS

This chapter consists of research design, population, sample and sampling procedure, data collection instruments, data collection procedure, data processing, data analysis and chapter summary.

Research Design

The research design adopted for the study was mixed methods research design. A mixed methods study combines or integrates quantitative and qualitative approaches as components of the research (Creswell, 2014; Ponce & Pagan-Maldonaldo, 2015). A convergent parallel mixed method was employed in this study thus quantitative and qualitative techniques were employed simultaneously in this study to generate and interpret data. Mixed methods design was adopted in this study because it provides an avenue to merge the quantitative and qualitative results of the study and thus provides a comprehensive analysis of the research problem for a more holistic understanding than employing either quantitative or qualitative approach alone (Creswell, 2014; Ponce & Pagan-Maldonaldo, 2015). The quantitative phase for the study involved using science process skills assessment tasks to assess the level of acquisition of science process skills of drawing, classifying, interpreting and hypothesising by SHS 3 elective Biology students. The qualitative phase dwelt on focus group interviews for the students on the frequency of acquisition of science process skills and the factors that affect effective organisation of practical lessons for the students to acquire science process skills. The Biology practical workbooks of the students were also analysed to ascertain the level of acquisition of science process skills by the students. Additionally, there were individual interview sessions for SHS 3 Biology teachers on the frequency of organisation of practical lessons and the factors that affect effective organisation of Biology practical activities for the acquisition of science process skills by students in order to triangulate the information with that of the students.

The problem under study involved assessing the science process skills of drawing, classifying, interpreting and hypothesising among elective Biology students of SHS 3 in selected secondary schools in the Volta Region. In assessing these science process skills, quantitative data were generated through the administration of science process skills assessment tasks on drawing, classifying, interpreting and hypothesising to SHS 3 elective Biology students in order to answer Research Question 1 and to test the Null Hypotheses. However, for the students to acquire, master and apply science process skills to solve problems in their daily lives, they must engage in practical activities frequently in the laboratory or field and hence these experiences or underlying factors which contributed to the performance of the students in the science process skills were measured qualitatively through interviews and document analysis. Consequently, the mixed methods design was selected because the research problem could not be addressed holistically from the unique perspective of only a quantitative or qualitative study. There was, therefore, the need to generate quantitative and qualitative data towards a clear and deep understanding of the research problem being addressed in order for the problem to be solved in its entirety.

Population

The population for the research consisted of all Biology students at SHS 3 in the 2017/2018 academic year from 30 public SHSs that offer General Science programmes with an estimated population of 1620 students and all the Biology teachers in the 30 SHSs in the Volta Region. These 30 SHSs have been categorised by Ghana Education Service (2015) into three options on the basis of endowment of resources and equipment as well as their performance in West African Senior Secondary Certificate Examinations (WASSCE). Consequently, we have Option 1 SHSs which are less-endowed, Option 2 SHSs which are averagely endowed and Option 3 SHSs which are well-endowed in terms of facilities and resources as well as on the basis of their performance in the final examinations conducted by WAEC. These 30 public SHSs which offer General Science programme in the Volta Region comprised of 14 less-endowed, 10 endowed and 6 well-endowed schools (Source: Volta Regional Directorate of Education).

Sampling Procedure

The sample size comprised 240 SHS 3 elective Biology students within the age range of 17 to 19 years from six SHSs in the Volta Region. These students were made up of 120 males and 120 females in order to cater for gender equality in the sample size. Also, 80 respondents each were sampled from well-endowed, endowed and less endowed schools for the study. This meant that equal proportions of the number of students were used from all categories of schools for the study. In addition, Biology teachers in SHS 3 in the sampled schools were purposively selected and thus six Biology teachers at SHS 3 in the selected schools responded to the research instruments.

In selecting the sample, the list of all the SHSs offering Biology in the General Science programme in the Volta Region was obtained from the Volta Regional Directorate of Education. From the list obtained, stratified random method which is a probability sampling technique was used to form three strata of less-endowed, endowed and well-endowed schools. Six SHSs which comprised two schools from each of the stratum were conveniently selected depending on their geographical locations in the region and thus two schools each were selected from southern, central and northern zones of the Volta Region in order to make comparisons of the levels of acquisition of science process skills among the categories of the schools possible. Two single sex schools which consisted of one male institution and one female institution were selected from the well-endowed school category. The other four SHSs which fell into the categories of endowed and less-endowed schools were mixed SHSs. The well-endowed schools were coded A and B, averagely endowed schools were coded C and D and the less-endowed schools were coded E and F.

Stratified Random Sampling technique was used in selecting students from the mixed sex SHSs. In selecting the students, two strata of boys and girls were formed. The total list of boys offering Biology at SHS 3 in each of the mixed SHSs was obtained from their teachers. Likewise, the total list of girls pursuing Biology in each of the mixed SHSs was also obtained. Computer generated random numbers were used to select 20 students from each stratum. Computer generated random numbers were used because it gave each student equal opportunities of being included in the sample size. The essence of the stratification was to increase precision, representativeness and to ensure gender equality in the sample. For the single sex schools, Simple Random Sampling technique was employed to select 40 students from each school using computer generated random numbers. The Simple Random Sampling technique provided the subjects with equal chance of being included in the study.

The participants in the study did not use their names but were given identification numbers for the purpose of easy identification and to ensure anonymity of the participants. Every male student was given Y and every female student was given X and hence in School A which was a male single sex school, the respondents were identified as AY_1 to AY_{40}, in School B which was a female single sex school, the subjects were labelled BX_1 to BX_{40}. Schools, C, D, E and F were mixed SHSs and, therefore in School C, the males had identification numbers of CY_1 to CY_{20} and the females had CX_1 to CX_{20}, in School D, the males were coded DY_1 to DY_{20} and the females were coded DX_1 to DX_{20}, in School E, the males were identified as EY_1 to EY_{20} and the females were identified as EX_1 to EX_{20} and in School F, the males were labelled as FY_1 to FY_{20} and the females were labelled as FX_1 to FX_{20}.

Data Collection Instruments

The instruments used for the study included science process skills assessment task, interview guide and guide/framework for analysing Biology practical workbooks of the students.

Science Process Skills Assessment Task in Biology (SPSATB) whose format in terms of instruction, scenario and problem for students as well as the scenario on interpreting graph which was modified from Process Skills Assessment Task in Biology (PSATB) by Anthony-Krueger (2001) to assess science process skills of elective Biology students was developed by the researcher to assess the science process skills of drawing, classifying, interpreting and hypothesising. The science process skills assessment tasks were based on concepts in biological drawings, classifying plants into taxonomic classes of *Monocotyledoneae* and *Dicotyledoneae*., photosynthesis and transpiration. These concepts are part of the Biology syllabus at SHS and hence students were supposed to learn these topics theoretically and also carry out practical activities on them to acquire the necessary science process skills. For instance, the concept on biological drawings is found in Year 1, Section 1 and Unit 6 of the Biology syllabus and students were required to learn the guidelines on biological drawings and also draw a number of biological specimens. The concept on classifying plants into monocots and dicots is located in Year 2, Section 1 and Unit 3 of the Biology syllabus and students were supposed to classify plant species into taxonomic classes of *Monocotyledoneae* and *Dicotyledoneae* based on the observed characteristics of the plants. The concept on photosynthesis is found in Year 3, Section 1 and Unit 4 of the Biology syllabus and students were required to learn about the factors that affect the rate of photosynthesis and also carry out experiments to show the effects of the factors that affect the rate of photosynthesis. Finally, the concept on transpiration is located in Year 3, Section 1 and Unit 6 of the Biology syllabus and students were supposed to learn about transpiration and also carry out experiments to demonstrate the factors that affect the rate transpiration in plants (CRDD, 2010). The science process skills assessment tasks were appropriate because science process skills were being assessed and objective tests could not be used to appropriately assess these higher order thinking skills but students need to engage themselves in tasks that will enable them construct their thoughts subjectively.

The science process skills assessment tasks were coded A, B, C, and D since four science process skills were involved. Tasks A and B were experimental in nature where biological specimens were provided to students in order to assess the skills of drawing and classifying. Task A was on the concept of biological drawings in flowering plants and students were given *Hibiscus rosasinensis* flower which was labelled as specimen A for them to draw in line with some specifications and guidelines for biological drawings to ascertain their level of acquisition of drawing as a science process skill (Refer to Appendix A for Task A). Task B was centred on the concept of classifying biological specimens where four plant specimens were provided to students to classify them into the taxonomic classes of *Monocotyledoneae* and *Dicotyledoneae* based on observed features of the specimens. The specimens included *Cyperus rotundus*, *Sida acuta*, *Commelina sp* and *Talinum triangulare* which were labelled B, C, D and E respectively (Refer to Appendix C for Task B). Task C dwelt on factors necessary for photosynthesis to occur in plants. It was modelled on two maize plants of the same species to which one of the plants was supplied with all the conditions necessary for photosynthesis to occur and to the other plant, a factor necessary for photosynthesis to occur was limiting. Measurements of the growth rate in the lengths of the two plants at periodic intervals were recorded and a graph was plotted for students to interpret the graph (See Appendix E for Task C). Task D which focused on hypothesising encompassed the biological concept of stomata transpiration in plants. It consisted of two balsam plants of almost the same number of leaves and height which were placed in different environments. One of the balsam plants was placed in an environment with high light intensity coupled with adequate soil moisture and air currents and the other balsam plant was placed in an environment with high humidity coupled with adequate soil moisture and air currents as found in the environment of the first plant for the same period of time. Students were asked to comment on how the two plants would lose water into the atmosphere with reasons (Refer to Appendix G for Task D). Each science process skills assessment task was thus structured into instructions for respondents, scenarios based on the skills being assessed and the problem for the respondents.

The interview guides for the teachers and students were developed by the researcher as well. The interview guides for both teachers and students were semi-structured and included three sections. Section A of the interview guides was on background information, Section B was on frequency of Biology practical lessons and Section C was on factors that affect effective organisation of Biology practical lessons. The teachers and students were interviewed because it enabled the researcher to gather primary data with respect to how often Biology practical lessons were organised and the challenges that were associated with the organisation of Biology practical activities for the students to acquire science process skills (See appendix I for teachers' interview guide and appendix J for the students' interview guide).

The guide/framework for analysing Biology practical workbook which was designed by the researcher was used to analyse Biology practical workbooks of students in terms of the topics under which practical activities were carried out, practical activities that were carried out under those topics and the science process skills that students were exposed to by their teachers as they carried out those practical activities (Refer to Appendix K for the Guide/Framework for analysing Biology practical workbook). The contents of the Biology practical workbooks of students were analysed to provide evidence in terms of the frequency of practical activities in the selected schools and to find out the type of science process skills and the rate of acquisition of these skills by the students in the various schools since practical activities serve as the fulcrum for the attainment of science process skills. The guide/framework for analysing Biology syllabus and the government approved textbook for Biology which was developed by the researcher was used to analyse the Biology syllabus and the government approved textbook in terms of the total number of units to be covered within a three-year period (Refer to Appendix L for the Guide/Framework for analysing Biology syllabus and government approved Biology textbook). The Biology syllabus and the government approved Biology were analysed in order to provide data in relation to the overloaded nature of the Biology syllabus.

The Science Process Skills Assessment Task in Biology (SPSATB), the interview guides and the guides/frameworks for analysing Biology practical workbooks, syllabus and textbook which were developed by the researcher were subjected to expert judgement by the thesis supervisors to determine the content validity of the instruments.

The research instruments were pilot tested on a representative sample in one of the endowed SHSs which was not included in the sampled schools on 6th December, 2017 to help reshape and modify the instruments as well as ensure the validity and reliability of the instruments. After the pilot testing, ambiguous phrases were removed from the science process skills assessment tasks, the interview guides and the frameworks for analysing Biology practical workbook, syllabus and textbook. It also led to the modification of the response format table for science process skills assessment task on classifying and an alteration in terms of the content of the task on hypothesising as a way of finalizing the research instruments. The instruments were again tested on another representative sample in one of the endowed SHSs after they have been modified on 15th January, 2018 before the commencement of data collection.

The work sheets of the pilot study on the science process skills assessment tasks were scored independently by the researcher and another expert in science education who was trained using the scoring rubrics. The researcher and the other assessor sat on two distant furniture pieces with each person bearing the scoring/assessment sheets with the codes/identification numbers of students. After the researcher had finished assessing the science process skills tasks of each student with the scoring rubrics and had finished recording the marks against the codes/identification numbers of each student, the science process skills tasks were passed to the other assessor for him to measure the performance of the students on the various tasks and record their scores against their codes/identification numbers on the scoring/assessment sheet. The two assessors sat on distant furniture pieces in order to make the scores of the assessors independent. Consistency in the scores of the two assessors was calculated in order to determine the interrater/intercoder reliability for the various tasks. Thus, the interrater/intercoder reliability for Task A was 82.50%, Task B was 85%, Task C was 82.50% and Task D was 80% (Refer to Appendix M for the interrater reliability tables). According to Miles and Huberman (1994) the criterion for determining interrater/intercoder reliability is 70% and above and therefore the science process skills assessment tasks A, B, C, and D were reliably scored.

Data Collection Procedure

The researcher collected data personally with the science process skills assessment tasks, interview guides and guides/frameworks for analysing Biology practical workbooks, syllabus and textbook. Before the collection of data, an introductory letter from the Department of Science Education at the University of Cape Coast was given to the researcher (Refer to appendix P for the introductory letter). The letter explained the purpose of the study by the researcher and sought for assistance from the headmasters/headmistresses of SHSs, teachers, students in the sampled schools and any other person or institution. The introductory letter was first sent to the Volta Regional Directorate of Education to enable me get the list of SHSs offering General Science programme and their categorisations into less-endowed, endowed and well-endowed status.

After the list of the SHSs offering science and the degree of their categorisations were obtained, the researcher stratified the schools into less-endowed, endowed and well-endowed and then conveniently selected six schools which comprised of two schools from each stratum depending on their geographical locations in the Volta Region to constitute the sample schools for the study. After the selection of the sample schools, the researcher first visited the schools with the introductory letter from the department together with a permission letter to make his intention known to the school authorities and to acquaint himself with the students and Biology teachers in the chosen schools. The researcher was then given two days to collect data from each school and these were agreed upon after the headmasters/headmistresses have consulted the Heads of Department for General Science programme in the chosen schools. The data collection period spanned from 26th March, 2018 to 13th April, 2018.

On the days that were set for the collection of data, the researcher went to the schools with the research instruments. He met the students and their Biology teachers and highlighted the purpose of the research and assured them of the anonymity of their responses and confidentiality of the data that would be gathered from them. The participants were made to sit in an arranged pattern of five columns by eight rows and in mixed SHSs, the columns of males and females alternated. The science process skills assessment tasks were given to the students to read through and seek any clarifications on the tasks. For Task A which was on drawing, *Hibiscus rosasinensis* flower which was labelled specimen A was provided to each student. However, for Task B which was on classifying, the four plant species: *Cyperus rotundus*, *Sida* *acuta*, *Commelina sp* and *Talinum triangulare* which were labelled B, C, D and E respectively were placed on tables at both ends of each row for students to observe their characteristics and classify them into the taxonomic classes of *Monocotyledoneae* and *Dicotyledoneae.* At the end of the entire period which lasted for 1hour, 25minutes, the science process skills assessment tasks were taken from the students.

The students were made to stretch out for 20 minutes and after that a focus group interview for 12 students from each school was conducted. In totality, 72 students were involved in the focus group interview. Gender equity was the main criterion considered in selecting students for the interview in the mixed sex SHSs. Thus, in each of the mixed sex SHSs, the students were made up of six boys and six girls. The focus group interview for the students lasted for about 1 hour and it dwelt on the frequency of Biology practical lessons and factors that affect effective organisation of Biology practical lessons. The Biology teachers in SHS 3 in the sampled schools were later interviewed individually in order to triangulate the information gathered from the students. The students were made to write their identification numbers/codes on pieces of papers which they clipped to their Biology practical workbooks.

On the second day, the Biology practical workbooks of students were analysed in terms of topics under which practical activities were carried out, practical activities carried out under these topics the science process skills that students were exposed to by teachers in the course of carrying out the practical activities with reference to the guide/framework for analysing Biology practical workbook.

The science process skills assessment tasks were rated using a scoring rubric which ranged from 0 to 5 points. A score of 5 points indicated excellent level of skill, 4 points indicated very good level of skill, 3 points showed good level of skill, 2 points indicated fair level of skill, 1 point showed poor level of skill and 0 showed no acquisition level of skills (Refer to appendices B, D, F and H for the scoring rubrics). The science process skills assessment tasks of each student were rated by two expert assessors using the scoring rubrics. In rating the tasks, the two assessors sat on two distant furniture pieces with each person bearing the scoring/assessment sheets with the codes/identification numbers of students. After the researcher had finished assessing the science process skills tasks of each student with the scoring rubrics and had finished recording the marks against the codes/identification numbers of each student, the science process skills tasks were passed to the other assessor for him to measure the performance of the students on the various tasks and record their scores against their codes/identification numbers on the scoring/assessment sheet. The scores of the two assessors for each task were averaged to determine the score for the students in that task and where decimal fractions resulted, it was rounded off to the nearest whole number. This was done to reduce the degree of subjectivity that might be associated with the ratings of one assessor. Redesigning the 0-5 points scale into three classes, a score range of 0 to 2 points would be deemed low acquisition level of the science process skills, 3 points was considered as average in the acquisition level of the skills and a score range of 4 to 5 was judged as high in terms of the achievement level of the science process skills.

Data Processing and Analysis

The researcher employed both quantitative and qualitative analysis in the study. The research questions and the null hypotheses served as a guide in analysing data. For Research Question 1, descriptive statistics was used in the analysis of data and the percentage values of students on the various tasks were compared to see their levels of performance on the various science process skills. One-way Multivariate Analysis of Variance (One-way MANOVA) was used to test Null Hypothesis 1 to see if significant differences existed in the attainment of science process skills of drawing, classifying, interpreting and hypothesising among SHS 3 elective Biology students from the different schools. One-way Multivariate Analysis of Variance (One-way MANOVA) was used to test Null Hypothesis 2 to see whether significant differences existed in the achievement of males and females on the science process skills of drawing, classifying, interpreting and hypothesising and One-way Multivariate Analysis of Variance (One-way MANOVA) was used to verify whether significant differences existed in the attainment of the chosen science process skills of students based on the categorisations of the schools as less-endowed, endowed and well-endowed

The data collected with the interview guides from the teachers and students were transcribed and coded into themes and analysed qualitatively to answer Research Questions 2 and 3. The outcome of the content analysis of the Biology practical workbook of students generated data in answering Research Question 4 and also supported in answering Research Question 2 as it was used in combination with the interview guides for students and teachers as a means of triangulating data. This was done in order to verify the frequency of Biology practical lessons in SHSs as well as science process skills that students were exposed to by teachers during Biology practical activities.

CHAPTER FOUR

RESULTS AND DISCUSSION

The purpose of the study was to assess science process skills of drawing, classifying, interpreting and hypothesising of Biology students in selected senior high schools in the Volta Region of Ghana. It was also intended to find out the regularity of Biology practical activities and the factors that affect effective organisation of Biology practical activities.

The study used a mixed method research design, thus qualitative and quantitative research techniques were used to gather and analyse data. A sample size of 240 SHS 3 Biology students which were randomly selected from six schools responded to the research instruments. Additionally, six SHS 3 Biology teachers from the sampled schools also responded to the research instrument. The results have been presented and discussed according to the research questions and hypotheses that guided the study.

Research Question One

What are the levels of acquisition of drawing, classifying, interpreting and hypothesising skills among SHS 3 elective Biology students?

To investigate SHS 3 elective Biology students' levels of acquisition of drawing, classifying, interpreting and hypothesising science process skills in Biology, participants were made to answer science process skills assessment tasks on drawing, classifying, interpreting and hypothesising which were based on concepts in biological drawings, classification of plants into taxonomic classes of *Monocotyledoneae* and *Dicotyledoneae,* photosynthesis and transpiration respectively. The science process skills assessment tasks were rated using a scoring rubric which ranged from 0 to 5 points. The scoring rubrics for all the tasks were discussed in Chapter Three of this study. To answer Research Question 1, the researcher and another Biology teacher who was trained on the scoring rubrics rated the performances of the students on drawing, classifying, interpreting and hypothesising tasks using a scoring rubric. In rating the tasks, the two assessors sat on two distant furniture pieces with each person bearing a scoring/assessment sheet with the codes/identification numbers of students. After the researcher had finished assessing the science process skills tasks of each student with the scoring rubrics and had finished recording the marks against the codes/identification numbers of each student, the science process skills tasks were passed to the other assessor for him to measure the performance of the students on the various tasks and record their scores against their codes/identification numbers on the scoring/assessment sheet. The scores of the two assessors for each task were averaged to determine the score for the students in that task and where decimal fractions resulted, it was rounded off to the nearest whole number. This was done to reduce the degree of subjectivity that might be associated with the ratings of one assessor. The levels of acquisition of science process skills of drawing, classifying, interpreting and hypothesising are presented on Table 1 using descriptive statistics in terms of frequency and percentage counts of the science process skills. Table 1 shows science process skills acquisition levels of SHS 3 Biology students in drawing, classifying, interpreting and hypothesising.

Table 1: Levels of acquisition of science process skills among SHS 3 Biology students

Process Skills	Performance Criteria											
	No skills		Poor		Fair		Good		Very Good		Excellent	
	F	%	F	%	F	%	F	%	F	%	F	%
Drawing	14	5.8	103	42.9	74	30.8	43	17.9	6	2.5	0	0.0
Classifying	16	6.7	42	17.5	74	30.8	50	20.8	46	19.2	12	5.0
Interpreting	13	5.4	29	12.1	68	28.3	81	33.7	41	17.1	8	3.3
Hypothesising	24	10.0	95	39.6	78	32.5	29	12.1	13	5.4	1	0.4

Source: Field Work, 2018.

With regard to drawing skills of students from Table 1, none of the students had excellent drawing skills. This means that no student was able to draw to match with all the given dimensions. In addition, only 6 students representing 2.5% had a very good drawing skill, while 14 students representing 5.8% showed no skills on drawing. Majority of the students (103) which represents 42.9% however showed poor skills on drawing. It appeared the students had difficulties with the drawing task. The weaknesses of not drawing to rubrics exhibited by majority of the students in the drawing task is in conformity with the findings of Dzidzinyo (2011) and the Chief Examiners Report in Biology practical examinations conducted by WAEC (WAEC: 2011, 2012, 2013, 2014, 2015 & 2016) as they reported of inability of students to draw biological diagrams according to rubrics such as providing appropriate title to the drawing, providing appropriate ruled guidelines and drawing to given dimensions/size. Reducing the five-point performance criteria of the scoring rubrics into three which are low (0-2 points), average (3 points) and high (4-5 points), it could be deemed that 191 students (79.5%) exhibited low acquisition of drawing skills, 43 students (17.9%) showed average level in the acquisition of drawing skills and 6 students (2.5%) displayed high level in terms of attainment of drawing skills. The finding of 191 students (79.5%) displaying low drawing skill is in conformity with that of Wekesa (2013) and Akinjide, Olakanmi and Mulkah (2018) as they reported respectively that 84% and 96.66% which constituted majority of the Biology students exhibited low/poor drawing skills when they were assessed during drawing of biological specimens achievement tests.

With respect to classifying, 16 students which represent 6.7% showed no skills on classifying. Also 42 students (17.5%) had poor classification skills. This implied that the students only met one of the 5-points performance criteria of the scoring rubrics for the classifying task. In addition to classifying, 74 students representing 30.8% had fair acquisition skills on classifying specimens. This outcome connotes that the students satisfied two performance criteria on the scoring rubrics for the classifying task. Moreover, 12 (5.0%) students had excellent acquisition skills in the classification of specimens provided. This indicated that the students were able to fulfil all the five performance criteria set for the classifying task. These 12 students were able to classify the specimens provided as monocotyledons and dicotyledons and stated correctly three corresponding observable characteristic features between the specimens classified as monocots and dicots to be considered as having excellent classifying skills. Reducing the five-point performance criteria of the scoring rubrics into three which are low (0-2 points), average (3 points) and high (4-5 points), it could be deduced that 132 students (55%) portrayed low classifying skills, 50 students (20.8%) exhibited average skill in classifying and 58 students (24.2%) displayed high classifying skills. Majority of the students (55%) portraying low classifying skills was supported by Zeidan and Jayosi (2015) and Maranan (2017) as they reported of low classifying skills among secondary school students as well as inability of students to classify organisms into their taxa accurately as reported by the Chief Examiners in Biology (WAEC, 2012, 2014).

Consequently, regarding the interpreting skills of the students, 81 students representing 33.7% exhibited good interpreting skills of the graph drawn. This implied that students were able to interpret that plant A increased in height more than plant B within the 25 days period because plant A was exposed to all the conditions necessary for photosynthesis to occur and plant B was put into a dark room where sunlight was absent/limiting factor for photosynthesis to occur. Also, 8 students which represent 3.3% exhibited excellent acquisition skills on the interpretation of the graph provided for them. This indicated that the students were able to interpret that photosynthesis results in the growth rate of plants and had occurred at a higher rate in plant A which was exposed to sunlight than plant B, hence the increase in height of Plant A more than Plant B within the 25 days period. Besides, 13 students representing 5.4% showed no skills in interpreting the graph provided for them. This meant that they either provided wrong interpretation or no response for the graph drawn for them. They were unable to indicate that plant A had increased in height more than plant B within the 25 days interval because plant A was exposed to all the conditions necessary for starch to be produced or photosynthesis to occur in a plant. Reducing the five-point performance criteria of the scoring rubrics into three which are low (0-2 points), average (3 points) and high (4-5 points), it could be seen that 110 students (45.8%) exhibited low interpreting skills, 81 students (33.7%) showed average interpreting skills and 49 students (20.4%) showed high interpreting skills. One hundred and ten students which constituted majority of the students showing low interpreting skills was in conformity with (Anthony-Krueger, 2001; Dzidzinyo, 2011; Sunyono, 2018; WAEC, 2011 & 2016) as they reported of weaknesses of students in interpreting biological data and graphs leading to low interpreting skill among secondary school students.

Finally, considering hypothesising skill of the students, majority of the students 95 which represents 39.6% had poor hypothesising skills. This indicated that the students were only able to hypothesise that plant F will lose water in the form of water vapour at a faster rate into the atmosphere than plant G. Also, only 1 student representing 0.4% exhibited excellent hypothesising skills. This meant that it was only one student who was able to hypothesise that plant F will lose water in the form of water vapour into the atmosphere at a faster rate than plant G because plant F was placed in an environment of high light intensity and plant G was placed in a humid environment and in a humid environment, the stomata tend to close and thus reduce the exit of water in the form of water vapour from the plant into the atmosphere. Reducing the five-point performance criteria of the scoring rubrics into three which are low (0-2 points), average (3 points) and high (4-5 points), it could be estimated that 197 (82.1%) of the students exhibited low hypothesising skills, 29 (12.1%) showed average skill in hypothesising and 14 (5.8%) students portrayed high hypothesising skills. Majority of the students exhibiting low hypothesising skill is buttressed by the findings of (Rabacal, 2016; Zeidan & Jayosi, 2015) as they reported of low acquisition level of hypothesising skill among secondary school students. Also, the Chief Examiners' Report outlined weaknesses of students with respect to the skill of hypothesising (WAEC, 2011, 2013, 2016).

The low performance rate of students with respect to drawing (79.5%), classifying (55%), interpreting (45.8%) and hypothesising (82.1%) could be attributed to the fact that Biology practical activities were not carried out frequently for the students to acquire science process skills and where practical activities were carried out, appropriate feedback on the practical activities were not provided to students and reflective journals on the practical lessons were not kept by students to enhance their acquisition of science process skills subsequently. This finding was supported by (Abdul-Mumuni, 2005; Adu-Gyamfi, 2014; Ampiah, 2004; Awuku, 2014; Boateng, 2014; Cengiz, Karatas & Yadigaroglu, 2013; Coil, Wenderoth, Cunningham & Dirks ,2010; Dzah, 2014; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Mwangu & Sibanda, 2017). If practical activities were to be regular to provide teachers with their expertise to model as well as coach students on acquisition of science process skills, they would have performed better than seen in Table 1. This is because the teachers serve as master craftsmen in the domains of science process skills and the students act as the apprentice learning from the master craftsmen.

In a nutshell, it was observed from Table 1 that quite a large number of students performed better on the science process skills of interpreting and classifying as compared to drawing and hypothesizing. The better performance of students in the classifying and interpreting skills as compared to hypothesising skill is in conformity with the findings of Rabacal (2016) that majority of the students performed averagely in the skills of classifying and interpreting as most of them had a score range of 2.01-3.00 in the classifying and interpreting skills and that majority of the students showed low performance in the hypothesising skill as greater number of students had a score range of 1.01-2.00 when they were assessed on a 5-point rating scale.

Research Question Two

How frequent do SHS 3 Biology students engage in practical activities to acquire science process skills?

To answer this question, SHS 3 Biology teachers from the sampled schools were interviewed individually and 12 students from each of the selected schools were engaged in a focus group interview on how frequent Biology practical activities were organised. Additionally, the Biology practical workbooks of students were analysed to provide evidence in support of the answer to the question.

On the frequency of Biology practical activities, three of the Biology teachers from Schools A, D and F admitted that practical activities were not organised often for the students while two teachers from Schools B and E stated that practical activities were quite often and one teacher from School C stated that the regularity of practical activities was dependent on the topic being treated and the availability of the materials and equipment in the laboratory. When the teachers were asked to approximate the number of practical activities they organised for the students in a term, three of the Biology teachers from Schools A, D and F said that approximately, one major practical activity was organised for the students in a term, the Biology teacher from School B said approximately four practical activities were organised for the students in a term, the Biology teacher from School E said that approximately eight practical activities were organised for the students in a term and the Biology teacher from School C said that approximately, either one or two practical activities were organised for the students in a term. For instance, it was reported by the Biology teacher in School C that: "I usually organise one major practical activity for the students in a term but at times two practical activities and it depends on the topic. If the things needed are available in the laboratory, I organise it." It could thus be implied that the teacher deemed some topics as less important for practical activities to be organised on them and if materials and equipment are not available in the laboratory, the teacher would not make any concrete effort to get that practical organised for the students to acquire its associated science process skills.

From the focus group interviews of the students, it emerged that practical activities were not organised often for the students. With respect to approximate number of practical activities that were organised in a term, it came to light that practical activities were organised once in a term for Schools A, C, D, and F and students from School B affirmed that approximately two practical activities were organised in a term. Students from

School E however stated that approximately four practical activities were organised in a term. There appeared to be contradictions in the responses that were given by Biology teachers in Schools B and E, the responses by their students and what the document analysis revealed with respect to the number of Biology practical activities. For instance, in School B, the Biology teacher confirmed that approximately four practical activities were organised for the students in a term and the students from School B affirmed that approximately two practical activities were organised in a term and from the document analysis, it was discovered that students undertook a maximum of six practical activities. This meant that on the average one practical activity was organised in a term.

From the responses of the Biology teachers and the students interviewed coupled with the analysis of the Biology practical workbooks of the students as highest number of documented practical activities was six and the lowest number was four, it became apparent that practical activities were not regularly organised for the students. This is because if Biology teachers had stuck to the time allocation of 3 periods (120 minutes) per week for practical activities as stipulated in the syllabus, students would have recorded more practical activities in their Biology practical workbooks than seen by the researcher. This finding of irregularity of practical activities among science students is in line with (Abdul-Mumuni, 2005; Adu-Gyamfi, 2014; Ampiah, 2004; Awuku, 2014; Boateng, 2014; Dzah, 2014; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Mwangu & Sibanda, 2017) that practical work was not organised regularly for students in SHSs prominently due to constraint of time, overloaded curriculum, lack of equipment and large class.

If practical activities were not organised regularly for students, then it would be difficult for them to acquire science process skills. Meanwhile, it is necessary for science process skills to be inculcated in students by teachers during practical lessons (CRDD, 2010; Kruea-In & Thongperm, 2013; Rauf, Rasul, Mansor, Othman & Lyndon, 2013; Wilunjeng & Suryadarma, 2017) to ensure the acquisition of these skills (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Babalola, Lambourne & Swithenby, 2019; Chebii, 2011; Hofstein, 2004; Hofstein & Lunetta, 2003; Jack, 2018; Kasiyo, Denuga & Mukwambo, 2017; Kazeni, Baloyi & Gaigher, 2018; Lunetta, Hofstein & Clough, 2005; Musasia, Abacha & Biyoyo, 2012) and their subsequent use to solve problems in life (Abungu, Okere & Wachanga, 2014; Al-Rsa'l, Al-Helalat & Ali Saleh, 2017; Aydogdu, 2015; Jack, 2018; Rauf, Rasul, Mansor, Othman & Lyndon, 2013; Samsudin, Haniza, Abdul-Talib & Ibrahim, 2015) and for mastery of the science process skills, teachers must provide students with multiple opportunities and ample time to develop these skills (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Padilla, 1990). It is in this vein that the Curriculum Research and Development Division included practical and experimental skills in the Biology curriculum for students to perform practical activities and thereby develop science process skills such as drawing, predicting, inferring, classifying, communicating, interpreting, manipulating and hypothesising (CRDD, 2010). However, the regularity with which practical activities were being organised for the students implied that their level of acquisition of science process skills would be low and subsequently, the application of these science process skills by the students to solve real-life problems would be limited.

Research Question Three

What are the factors that affect effective organisation of Biology practical activities for the students to acquire science process skills?

Biology teachers were interviewed individually and the students were interviewed in a focus group interview with respect to the factors that affect effective organisation of Biology practical activities for acquisition of science process skills by students. In connection with the responses from the Biology teachers and students, the following themes: time constraints for Biology practical activities, overloaded Biology curriculum, large class size of Biology students, qualified Biology laboratory assistants, equipment and materials for Biology practical work, funds for Biology practical activities, Biology practical guide book, professional development of Biology teachers and reflective journals on Biology practical activities were revealed as factors that affect effective organisation of Biology practical activities for acquisition of science process skills for discussion.

Time Constraint for Biology Practical Activities

It seemed that time was a limiting factor when it came to organisation of Biology practical activities. When the SHS 3 Biology teachers were asked whether they had separate periods for practical activities and theory lessons, five of the teachers from Schools A, C, D, E and F disclosed that they had no separate periods for practical activities and theory lessons while one teacher from School B agreed that there were separate periods for practical and theory lessons. From the focus group interview of the students, there was a confirmation to the responses of the teachers that Schools A, C, D, E and F had no separate periods for practical and theory lessons while Biology periods on Fridays in School B were designated for practical activities. This finding was supported by (Ampiah, 2004; Boateng, 2014) that in some SHSs in Ghana there were no periods for practical activities on the school time table and science teachers conducted practical work whenever they deemed it fit. Meanwhile, the curriculum planners had allocated a total of 6 periods a week consisting of 40 minutes each to the teaching of Biology. Out of these 6 periods, 3 periods were to be used for the theoretical concepts and 3 periods for practical concepts (CRDD, 2010). It was, therefore, surprising that the time allotted to the practical work did not reflect on the teaching time table for Biology teachers to adhere to in the teaching and learning process. When the five Biology teachers who had no separate periods for practical activities and theory lessons were asked about the periods they then used for practical activities, three of the Biology teachers from Schools A, C and E confirmed that they used one of the theory periods within the week. The Biology teacher from School D said the theory period was being alternated with practical sessions and the teacher from School F said practical activities were organised for the students on Saturdays. The Biology teacher from School B said that even though there were separate periods for practical and theory lessons, the practical periods were not followed rigidly as theoretical concepts were presented to students during some of the times meant for practical sessions in order to complete the syllabus on time. It could be construed that even in SHSs where time was allotted for practical activities on the time table, Biology teachers did not organise practical activities for students on each of the time allotted for practical activities but rather alternated these practical periods with teaching of theoretical concepts possibly for the completion of the syllabus on time. Confirming this from the students, students from School A affirmed that practical activities were mainly organised after they had written their mock examinations and were preparing for the final examinations. Students from Schools C and E said their teachers at times used the theory sessions for practical activities. Students from School D said that theory periods were being alternated with the practical sessions and students from School F said at times Saturdays were being used for practical activities. There seemed to be a contradiction in the response by the teacher in School A and the students in School A. While the teacher confirmed that one of the theory periods within the week was been used for practical activities, the students stated that practical activities were being organised mainly after mock examinations towards the final examinations by WAEC. Could it be that the students had lost sight of the practical activities that were organised by the teacher during theory periods as they were not frequent as the practical sessions after mock examinations? Or the normal practice of the teacher had been to wait till the students had finished writing their mock examinations for practical activities to be intensified in preparation towards the final examinations? It could be deduced from the findings that Biology teachers did not constantly organise practical activities for students to acquire science process skills and to foster better understanding of biological concepts but rather intensified practical activities as a way of preparing students towards the final practical examination by the West African Examinations Council (WAEC).

Overloaded Biology Curriculum

All the six Biology teachers interviewed reported that they were not able to organise Biology practical activities based on most topics in the syllabus because of the extensive nature of the syllabus as this had compelled them to concentrate on teaching theoretical concepts for early completion of the syllabus for the students to pass the final examinations by WAEC to the detriment of practical activities. This finding is supported by Abdul-Mumuni (2005). For instance, analysis of the Biology syllabus and the government approved Biology textbook at SHSs by the researcher revealed that there are 79 units to be covered within a 3-year period. In Form 1, students are supposed to cover 24 units, in Form 2, students are supposed to complete 34 units and in Form 3, a total of 21 units must be covered by the students (CRDD, 2010; Yeboah, Owusu, Adjibolosoo, Agamloh & Meteku, 2010). If there are 6 periods each of 40 minutes out of which 3 periods totalling 120 minutes or 2 hours is to be used in teaching theoretical concepts and another 2 hours for practical activities in a week (CRDD, 2010) for an average of 40 weeks in a year (Source: Statistic Unit of Central Regional Directorate of Education), could the syllabus be deemed too loaded for Biology teachers to adequately cover the theoretical and practical activities on 79 units within a 3-year period which is never devoid of interference from co-curricula activities? If this analysis could not affirm the Biology syllabus as overloaded, then the Biology teachers inability to organise practical work on most of the topics was not due to overloaded nature of the Biology syllabus but in support of Ampiah (2004) that science teachers held the belief that students to some extent would be able to perform the practical activity in the final examinations with little exposure and to enable these students get that exposure, practical activities were organised as a way of preparing students for the final examination. As pointed out by students in School A "Practical activities are mainly organised after mock examinations when we are approaching our final exams" If Biology teachers could wait for practical activities to be intensified after mock examinations in preparation for the final practical examinations by WAEC, then Biology teachers would definitely not be able to organise practical activities on most topics in the syllabus. Subsequently, if practical activities could not be carried out under most topics in the syllabus, students would not be able to develop the relevant science process skills as well as get deep understanding of the theoretical concepts underpinning those topics and hence lower their academic achievement in Biology in the final analysis.

Large Class Size of Biology Students

All the six Biology teachers agreed that practical activities were either carried out in groups or individually and this was supported by the evidence from the focus group interview conducted with the students. Apparently, practical activities were organised in groups due to large class size, insufficient materials and equipment and this is in support of (Awuku, 2014; Dzah, 2014; Kasiyo, Denuga & Mukwambo, 2017; Lazarowitz, Hertz-Lazarowitz & Baird, 1994; Mwangu, & Sibanda, 2017; Said, Friesen & Al-Ezzah, 2014). For example, Lazarowitz, Hertz-Lazarowitz and Baird (1994) stated that experiments in the science laboratory many a time, required students to work in groups due to constraints of experimental processes and limited equipment and material supplies in the schools. Consequently, the Biology teacher in School A said that: "Because of the difficulty of class sizes of about 50 to 60 students and inadequate materials and equipment, I organise practical activities in groups", the Biology teacher in School B admitted that: "I organise practical work in groups because the number of students is too large" the Biology teacher in School C reported that: "we do the practical in groups because the students are many and the equipment and materials will not be sufficient for individual work". And the Biology teacher in School D stated that: "It depends on the number of materials and equipment available for the practical. We do individual practical at times and group practical at times if the materials and equipment are enough to be used" the Biology teacher in School E reported that: "we do practical work in groups due to lack of some materials and equipment" and the Biology teacher in School F stated that: "My major difficulty is having to deal with large class size. Due to large class size, some classes have to be put into groups with each group having a specified time to use the laboratory" Indeed, Biology practical activities must not only be organised in groups but also individually to enable students acquire science process skills personally for deeper understanding of theoretical concepts and also to be able to solve real-life problems that they would be confronted with and this is buttressed by the fact that there are different types of learners in a classroom with specific needs and attention (Mido, 2017) and each student must turn out some kind of worksheet during science practical examinations (Ampiah, 2004, 2007). Therefore, Biology teachers must not only resort to group work during Biology practical lessons as a way of addressing the challenge of inadequate laboratory equipment and large class size but also focus on individual practical activities which will

Cater for individual differences as well as promote effective acquisition of science process skills by each student.

The composition of groups for practical activities is very vital as the members in a group are expected to interact and share ideas with one another and by so doing, the above-average students will offer relevant assistance to the below-average students. When the teachers and students were asked about how the groups were formed for practical activities, it came to light that students mainly formed groups without concern for gender equity and mixed ability groupings. As testified by students from Schools A, B and D, "our teacher asks us to form a group of 5 members for practical work and we also form the groups" and as supported by the Biology teacher from School A, "I ask students to form a group of 4 to 5 members for practical work" and the Biology teachers from Schools B and D stated that: "I usually ask the students to form a group of 5 members for practical work". It became evident that the students formed groups based on friendships without consideration for gender equity and mixed ability groupings for practical work. For effective interactions to occur between students, there is the need for mixed ability groups to be formed when students are to carry out practical activities in groups and also in mixed SHSs, gender equity should be considered in forming groups for practical work. This is because in friendship groups, between-class ability groups may result where high achievers may be in one group and low achievers in the other group because as the saying goes "birds of the same feathers flock together" and if this so happens, friendship groups in which all the members are low achievers may be at a disadvantage. Consequently, within-class ability grouping which is a mixed ability grouping and enables students of different ability groups to interact and share ideas in performing a task (Ampiah, 2004; Moore, 1998) as well as co-operative learning groups in which students divide the given task among themselves, assist one another, critique one another's efforts and contributions, give and receive feedbacks (Ornstein & Lasley, 2000) should serve as the basis for group work in Biology practical lessons. In this way the below average students would be helped to achieve the curriculum goals as the above average students. Nevertheless, if the groups are just composed based on between-class ability groupings, then the students in the below average groups may not achieve the desired curriculum goals.

The number of members that constitute a group must also be of concern because when the members are too many effective interactions which would lead to improved learning by students may not occur. From the interview with the Biology teachers and students on the composition of groups in terms of number of students, it was discovered that group sizes ranged from 3 to 10 students and the group sizes to a large extent were dependent on class sizes and availability of equipment and materials. For example, Biology teachers in School C and F testified that students form groups of about 5 to 10 members depending on class size and insufficient materials. In reality, if members in a group should exceed 5 members then the group will be deemed large for practical activities. This is because each member may not be given equal opportunity to manipulate the apparatus and also undergo the experimental processes in order to develop the relevant science process skills which will equally facilitate the comprehension of the knowledge, facts and theories in science. This assertion was confirmed by the Biology teachers and the students during the interview sessions granted them. It was evident from the interview with the Biology teachers that when students are too many in a group for practical activities, they tend to be crowded around the apparatus and many of them do not get the ample chance and time to manipulate the equipment and to go through the experimental procedures to effectively acquire the science process skills. For instance, as reported by the Biology teacher in School A,

> *When students are too many in a group, at times some of them try to sit idle and allow few of their colleagues to manipulate the apparatus and go through the experimental procedures and whenever I spot this behaviour, I usually encourage those who try to sit idle to participate in the experimental processes as well*

Focus group interview with the students revealed that when students are too many in a group for practical activity, some of the students do not participate fully in the manipulation of the equipment and the experimental processes for effective development of their science process skills. For example, as confirmed by the students in School A, “when we are too many in a group for practical activity, some of us do not get enough opportunity to practise with the apparatus”.

Qualified Biology Laboratory Assistants

The views of Biology teachers and students were sought on the availability of qualified laboratory assistants in SHSs in the progression of this study. It was revealed from the responses of the six Biology teachers and the focus group interview of the students that qualified laboratory assistants were not available to help in the organisation of practical work. This finding was supported by Anthony-Krueger (2007) that most of the senior secondary schools in Ghana did not have trained Biology laboratory assistants. The Biology teachers cited various reasons for the absence of qualified laboratory assistants in their schools. For example, the Biology teacher from School E affirmed that: “We don’t have a qualified laboratory assistant due to lack of personnel to occupy the position”. The students could, however, not cite reasons for the absence of qualified laboratory assistants in their schools because they might not be aware of the necessity of these qualified laboratory assistants and their recruitment processes. Meanwhile, these qualified laboratory assistants will help the Biology teachers in organising Biology practical activities through activities such as collecting specimens, setting up apparatus for practical activities and serving as a guide together with the Biology teacher for students during practical activities. For instance, if a practical work is to be organised on classification of living organisms into their various taxa, this qualified laboratory assistant could go and collect the relevant specimens for the practical activity to be carried out by the students. It could be deduced that the absence of these qualified laboratory assistants in SHSs militates against effective organisation of Biology practical lessons for the students to acquire science process skills. For example, as pointed out by the Biology teacher in School C,

> *The lack of a qualified Biology laboratory assistant makes it so difficult for me to organise practical work due to the fact that sometimes my day is packed with so many classes such that there is insufficient time to practise or do the practical to see the results before allowing my students to do it.*

According to Anthony-Krueger (2007), the absence of trained laboratory assistants which would place a dual responsibility of setting the laboratory for practical activities and teaching theoretical concepts on the teacher would obviously be too demanding for the Biology teacher and a teacher in such a situation would find the easier way out which would be to ignore laboratory practical work. If practical work is neglected by a teacher on the premises of absence of Biology laboratory assistants, it would be detrimental to the students in terms of acquisition of science process skills and getting in-depth understanding of biological concepts.

In order to avert the absence of qualified laboratory assistants in SHSs, there is the need for Ministry of Education (MOE) to liaise with the universities for personnel to be trained with laboratory skills that would enable them function as qualified laboratory assistants to science teachers especially Biology teachers at SHSs. In this way, the qualified laboratory assistants would not only lessen the workload of the Biology teachers but also facilitate the organisation of practical work under most topics in the syllabus which would help the students to develop science process skills and to be able to understand the theoretical concepts meaningfully. Subsequently, the excuses of Biology teachers in terms of time constraint, large class size and overloaded curriculum to effective organisation of practical activities would be minimised if not eliminated completely because the qualified laboratory assistants could be directed to organise a particular practical activity for the students at a specified time as the teacher was engaged in teaching theoretical concepts to another class.

Equipment and Materials for Biology Practical Work

In order for students to develop science process skills, the crucial role of science laboratories cannot be underestimated since the laboratory is a place where students should be allowed to develop scientific skills such as observing, drawing and manipulating (Abungu, Okere & Wachanga, 2014; Agyei, 2011; Ampiah, 2004; Ampiah, Tufuor & Gadzekpo, 2004; Babalola, Lambourne & Swithenby, 2019; Chebii, 2011; CRDD, 2010; Dadzie, 2011; Gultepe, 2016; Hofstein, 2004; Hofstein & Lunetta, 2003). And for students to display scientific inquiry skills such as observing, drawing, manipulating, classifying and hypothesising, it is essential that laboratories are well equipped with adequate and proper functioning apparatus and materials for students to carry out practical activities for acquisition of science process skills and meaningful learning of theoretical concepts in science. This study, therefore, saw it appropriate to seek the views of Biology teachers and students on the state of laboratory equipment and materials in SHSs towards organisation of practical activities for the students to acquire science process skills.

All the six Biology teachers and the focus group interviews from the students revealed that they had laboratories for Biology practical work and this could be testified to by the researcher. The problems with the laboratories, however, appeared to be unavailability, inadequate and mal-functioning laboratory equipment. When the teachers were interviewed on whether the laboratories were equipped for practical work or not, it was discovered that the laboratories were not fully equipped for practical activities. For example, the Biology teacher in School A reported that: "Some permanent slides are not available and the microscopes and hand lens are few meanwhile the number of students is large”. The Biology teacher from School B stated that: “I don’t have sufficient microscopes, dissecting kits, Fehling’s and Benedict’s solution, as well as Millon’s reagent for practical work”. The Biology teacher in School D said that: “The microscopes are few and some are also not functioning properly” In addition to inadequate microscope, hand lens, dissecting kits, Fehling’s/Benedict’s solution and millon’s reagent, the Biology teachers from Schools C, E and F stated that barometer, photometer, light intensity probe and maximum-minimum thermometers were unavailable and this made ecological studies difficult. This finding was supported (Awuku, 2014; Kasiyo, Denuga & Mukwambo, 2017; Mwangu & Sibanda, 2017; Said, Friesen & Al-Ezzah, 2014). For instance, Awuku (2014) stated that in many developing countries of which Ghana is no exception, poor state of laboratory equipment creates a situation where the expected influence of science practical activities is not achieved.

On the part of students, it was revealed from all the schools that microscopes were in short supply with respect to the number of Biology students. Additionally, students from School B reported that there were few biological specimens and stools in their laboratory. It was this unavailability, inadequate and mal-functioning of the materials and equipment that necessitated that group work should be adopted for some practical activities. For example, the Biology teacher in School A said that: “Because of the difficulty of class size of about 50 to 60 students and inadequate materials and equipment, I organise practical activities in groups”, and the Biology teacher in School E reported that: “we do practical work in groups due to lack of some materials and equipment”.

Funds for Biology Practical Activities

In carrying out Biology practical activities, certain equipment and materials are needed for the students to perform the practical activities effectively. This study, therefore, sought the opinions of Biology teachers on the release of funds by school authorities for the purchase of materials and equipment for Biology practical activities. From the interview with the Biology teachers, five of the teachers from Schools A, C, D, E and F stated that funds were not regularly made available by the school authorities for the purchase of materials and equipment for Biology practical activities and one of the Biology teachers from School B affirmed that funds were made available by the school authorities for Biology practical activities. In response to the question on whether funds were made available for Biology practical activities or not, the Biology teacher from School A reported that: "No, funds were only made available during the final exams". The Biology teacher from School C stated that: "Sometimes, especially when it is for WASSCE examinations and mock. So, I always take advantage of these situations to buy extra things that are not in our stores". The Biology teacher in School D said that: "No, funds are only given during WASSCE practical". The Biology teacher from School E affirmed that: "No, always they do not have enough funds to give for the purchase of the materials and some of the equipment" and the Biology teacher in School F confirmed that: "No, funds are only made available for mock practical exams and WASSCE practical exams". From the responses of the teachers, it could be realised that in most SHSs, funds were not readily made available for the purchase of materials and equipment for Biology practical activities. This finding is in support of Mwangu and Sibanda

(2017) that lack of funds affects effective organisation of practical activities in secondary schools.

When the teachers were asked about what they do when funds are not readily made available by the school authorities? Two of the teachers from Schools D and E reported that they improvised equipment at times to enable the students carry out the practical activities. Teachers from Schools C and F said that they asked their students at times to contribute money towards the practical work. The teacher from School B affirmed that the teacher would have to sacrifice with his or her resources to get the practical materials for the students. The teacher from School A reported that if funds are not made available, we ignore the practical, students are asked to read about it or they watch a video on the practical activity. If practical lessons are not conducted by the teachers due to lack of funds, the Biology students would be adversely affected in the long run because these students would be denied the opportunities of acquiring science process skills as well as learning biological concepts meaningfully.

However, the findings revealed that funds were made available by the school authorities to the Biology teachers to purchase materials and equipment for practical activities during the final practical examinations conducted by WAEC. This finding is supported by Ampiah (2004) that science teachers asserted that they found it easier getting the school authorities to release money for practical exams conducted by WAEC than normal school activities.

Biology Practical Guide Book

In the development of this study, the researcher sought to find out about the existence of Biology Practical Guide Book at the SHSs. The Biology teachers were thus interviewed on the existence of the Biology Practical Guide Book. The Biology teacher from School A asserted that: "The GES approved practical guide book on Biology is not available but I have a pamphlet on Biology practical activities". The Biology teachers from Schools B, C and D stated that they depended on pamphlets on Biology practical activities, past Biology practical questions and activity sections of the Biology textbook as reference materials for their practical activities. The Biology teacher from School E reported that: "Yes, I have my own practical guide book but not government copy. I think practical guide book is necessary as it enhances teaching of the practical lesson" and the Biology teacher from School F affirmed that: "I use the activity section of the Biology GAST as my reference book"

From the responses of the six teachers, it appeared that Biology teachers relied on pamphlets on Biology practical lessons, activity sections of Biology textbook and Ghana Association of Science Teachers (GAST) as well as past Biology questions as their reference materials for Biology practical lessons. Since there was no approved practical guide book for Biology teachers at SHSs, it meant that practical activities were conducted on topics at the discretion of the Biology teachers and this is supported by (Ampiah, 2004; Boateng, 2014). Subsequently, Ampiah (2004) stated that the use of different manuals for practical activities by science teachers in various SHSs suggested that there were no standard practical activities undertaken by students in the various secondary schools. Meanwhile, a harmonised practical guide book can serve as a yardstick in assessing Biology teachers' performance on organisation of practical activities for students at SHSs.

Professional Development of Biology Teachers

The art of teaching and instruction is dynamic and, therefore, for teachers to be abreast of the new trends, they need regular professional development in pedagogy and instructional techniques (Buabeng, Owusu & Ntow, 2014) and they can achieve this through constant professional development to upgrade and update their content knowledge and skills that are necessary to be competent in the classroom for improved learning by students.

From the interview with the Biology teachers with respect to participation in professional development sessions, four of the teachers from Schools A, B, D and E reported that they have ever attended in-service training programmes to update and upgrade their knowledge and skills for effective teaching of biological concepts to students. Two of the Biology teachers, however, stated that they never had the opportunity to undertake any in-service training programme. This finding is supported by Anthony-Krueger (2007) when he found out that 85.7% of Biology teachers never had any in-service training in teaching practical laboratory skills in Biology when he conducted a study into factors militating against laboratory practical work in Biology among Ghanaian senior secondary school students. For example, the Biology teacher in School C reported that: "No, I have not got the opportunity yet" and the Biology teacher from School F reported that: "No, I haven't heard of any in-service training for science practical lessons. The General Science training programme by GAST is also not financially covered by the school". Meanwhile, Science teachers need to constantly develop their knowledge and practical organising skills through in-service programmes in order to be competent in the classroom (Khatoon, Alam, Bukhari & Mushtaq, 2014) as some teachers do not feel confident in performing laboratory-based practical activities for students to observe because of lack of training on these practical activities (Cossa & Vamusse, 2015). If Biology teachers have not attended in-service training programme to update and upgrade the practical skills they have acquired from the universities, then as time progresses their practical skills will remain dormant and they will not be able to teach practical skills effectively to the students.

When asked about the last time the Biology teachers had the opportunity to attend professional development programme, the Biology teacher from School A stated 2015, the Biology teacher from School B stated 2009, the Biology teacher from School D stated 2011 and the Biology teacher from School E stated 2013. It could be deduced that professional development programmes were not a regular venture for the Biology teachers. For instance, Biology teachers from Schools C and F taught for 6years and 11years respectively but never had the opportunity to attend in-service training programme in order to update and upgrade their knowledge and skills for effective teaching of biological concepts and practical activities to students. Meanwhile, according to (DET, 2005) if we are to realise continuous improvement in the quality of teaching and learning in our classrooms, we must build the capacity of our teachers through in-service training programmes to meet these expectations. There is, therefore, the need for Biology teachers to constantly attend professional development sessions so that they will be well equipped with the knowledge and skills required to impart theoretical concepts as well as practical lessons which involves science process skills to students.

Reflective Journals on Biology Practical Activities

Biology teachers and students must reflect on the challenges that they face during and after Biology practical activities and how to overcome these challenges in order to promote acquisition of transferrable skills by students. Because when students reflect on their laboratory experiences, it leads to greater understanding of practical activities and concepts, acquisition of skills and assessment of their own learning (Cengiz & Karatas, 2015; Denton, 2018; Lew & Schmidt, 2011) and reflective practice by teachers enables them to learn from their own professional experiences, analyse these experiences and change their practice where necessary (Goker, 2016; Priya, Prassanth & Peechattu, 2017) towards an improvement in learning by students. For effective reflection, Biology teachers and students need to keep a reflective journal on the practical activities so that it would serve as a benchmark for the effectiveness of the practical activity and its subsequent acquisition of science process skills. For instance, when students keep reflective journals during practical sessions, it reveals students' level of acquisition of knowledge, science process skills, attitudes, motivation, self-assessment, experimental processes, active learning mode and feedback on the practical activities (Al-Rawahi & Al-Balushi, 2015; Cengiz, Karatas & Yadigaroglu, 2013; Farrah, 2012; Lew & Schmidth, 2011; Thorpe, 2004; Towndrow, Ling & Venthan, 2008).

From the interviews with the Biology teachers and students, it emerged that reflective journals on practical activities were not kept by teachers and students. Teachers and students tried to reflect on the challenges encountered during the organisation of practical activities but they did not document any evidence for future reference. For example, the Biology teacher from School A said that: "During drawing of a biological specimen, some students held the pencil tightly and I taught them that the pencil should be held flexibly which they did in the subsequent practical involving drawing", the Biology teacher from School B stated that: "Some students found it difficult to manipulate the coarse and fine adjustments of the light microscope during practical activity and I taught them how to manipulate the coarse and fine adjustments of the microscope and they had no problems again", the Biology teacher in School C reported that: "Few students were shading biological drawings and I hinted them that biological drawings must not be shaded and they heeded to it in subsequent drawings", and the Biology teacher in School F reported that: "During classification of organisms into their various taxa, some students did not observe the organisms carefully to identify their characteristic features to make classification easy but when I stressed on that, they overcame the problem". On the part of students, it was revealed that students had challenges with drawing biological specimens, identification of biological specimens, classification of organisms into their various taxa and interpretation of biological data. Students resorted to various means such as seeking solutions from their teachers, researching into the problem and practising on their own for possible solutions. For example, students from School A reported that: "We have challenges with drawing, classification of organisms, interpreting of graphs and identification of specimens and we research into the challenges for solutions", students from School C reported that: "We have problems with drawing, how to identify some of the specimens if you are not familiar with them and we go to our teachers for clarification and sometimes, we discuss among ourselves for clarification", students from School D reported that: "We have challenges in classifying organisms and drawing specimens and we refer to our teachers and Biology textbooks for solutions", students from School E said that: "At times, drawing the specimen is difficult and we practice on our own to overcome the problem" and students from School F stated that: "classification of organisms into their various taxa is our problem" Teachers and students need to resolve the challenges as they occur or find solutions to the problems after they have occurred. For instance, as students found the manipulation of the coarse and fine adjustments of the light microscope difficult to bring the specimen to a clearer view, the Biology teacher reflected in action by teaching them how to manipulate the coarse and fine adjustments to bring the specimen to a clearer view. The Biology teacher could have also reflected on action which would have meant that the Biology teacher would have thought about what he or she would have done if the difficulty of manipulating coarse and fine adjustments of the microscope recurred. In other words, the challenge of manipulating the coarse and fine adjustments of the microscope would have been taught by the teacher after the students have viewed the first specimen so that students would appropriately apply the knowledge in viewing subsequent specimens. In either of these situations, both the teacher and the students could keep reflective journals on how the challenge was resolved for future reference. This would enable the teacher and students to fall on their repertoire of experience in the reflective journals to resolve such challenges when they reoccur in the future. And if these reflective journals are kept on practical activities by students, it would facilitate acquisition of science process skills. According to (Cengiz, Karatas

& Yadigaroglu, 2013; Mei, Kaling, Xinyi, Sing & Khoon, 2007), keeping a scientific journal on practical lessons is an effective strategy to enhance students' science process skills and that reflection can be carried out through writing of reflective journals which would help enhance the acquisition of science process skills.

Research Question Four

Which science process skills do teachers expose SHS 3 Biology students to during practical activities?

To answer this question, the Biology practical workbooks of students were analysed in terms of the topics under which practical activities were carried out, possible practical activities that were carried out under the various topics and the science process skills students were exposed to during practical activities.

From the content analysis of the Biology practical workbooks, students from School A carried out practical work on classification of living organisms into their various taxa, *Tilapia sp,* fruits, osmosis and cells. Students from School B performed practical work in classification of organisms into their various taxa, cockroach, human skeletal system, cells, plant physiology and osmosis. Students from School C carried out practical work on cells, plant physiology, classification of organisms into their various taxa, soil and photosynthesis. Students from School D performed practical activities in classification of organisms into their various taxa, cells, soil and weevil. Students from School E carried out practical activities on cells, cockroach, soil and classification of living organisms into their various taxa. Students from School F performed practical activities on classification of organisms into their various taxa, grasshopper, osmosis and cells. Table 2 shows the topics under which practical activities were carried out, practical activities and the science process skills students were exposed to during practical sessions.

Table 2: Science process skills SHS 3 Biology students were exposed to during practical activities

Topics	Practical activities	Science process skills
Classification of organisms into their various taxa	a. Observation of organisms b. Identification of features of organisms c. Grouping of organisms	observing, classifying, recording, communicating, manipulating
Tilapia sp	a. Observing the features of *Tilapia sp* b. Drawing and labelling the features of *Tilapia sp*	observing, drawing, communicating, recording, manipulating
Fruits	a. Cutting longitudinal section of orange b. Cutting transverse section of orange c. Drawing longitudinal and transverse sections of orange	observing, drawing, recording, communicating, manipulating

Source: Field Work, 2018.

Table 2 Cont'D

Topics	Practical activities	Science process skills
Osmosis	a. Experimenting osmosis with a living yam tuber	experimenting, planning, observing, measuring, hypothesising, recording, communicating, inferring, manipulating, predicting, interpreting
Cells	a. Observation of temporary and permanent slides under the microscope b. Drawing and labelling of cells observed under the microscope	observing, drawing, recording, manipulating, communicating

Source: Field Work, 2018

Table 2 Cont'D

Topics	Practical activities	Science process skills
Cockroach	a. Observing the characteristic features of cockroach b. Drawing and labelling parts of cockroach	observing, drawing, recording, manipulating, communicating
Human Skeletal System	a. Observing human skeletal system b. Drawing and labelling parts of the human skeletal system	observing, drawing, recording, manipulating, communicating
Plant Physiology	a. Observing the external features of flowering plants b. Drawing and labelling the external features of flowering plants	observing, drawing, recording, manipulating, communicating

Source: Field Work, 2018.

Table 2 Cont'D

Topics	Practical activities	Science process skills
Soil	a. Demonstrating porosity of water in the three soil samples	observing, measuring, recording, manipulating, drawing, inferring, communicating, predicting, planning, experimenting, interpreting, hypothesising,
Photosynthesis	a. Experiment to show that starch is produced during photosynthesis	experimenting, planning, measuring, inferring, recording, predicting, observing, communicating, manipulating, hypothesising, interpreting

Source: Field Work, 2018.

Table 2 Cont'D

Topics	Practical activities	Science process skills
Weevil	a. Observation of characteristic features of weevil b. Drawing and labelling parts of a weevil	observing, drawing, recording, manipulating, communicating
Grasshopper	a. Observation of characteristic features of grasshopper b. Drawing and labelling parts of a grasshopper	observing, drawing, recording, manipulating, communicating

Source: Field Work, 2018.

From Table 2, with respect to the practical activities carried out by the students, science process skills that students were exposed to by their teachers during practical lessons included observing, classifying, inferring, predicting, communicating, measuring, drawing, recording, manipulating, interpreting, experimenting, planning and hypothesising. The science process skills of observing, recording, communicating and manipulating permeated all the topics and hence the skills learners were exposed to most frequently. From Table 2, the basic science process skills that students were introduced to comprised of observing, classifying, communicating, measuring, inferring and predicting whereas the integrated science process skills teachers familiarised students with encompassed manipulating, interpreting, drawing, recording, hypothesising, planning and experimenting. It could be deduced that students were not exposed to some science process skills such as defining operationally and controlling variables. Moreover, the regularity with which the students were introduced to the other science process skills by their teachers was below expectation in connection with the requirements of the Biology syllabus. For instance, in School B, six practical activities were documented which had fallen below anticipation if Biology teachers were to adhere to 3 periods (120 minutes) per week for practical activities in the syllabus (CRDD, 2010). It, therefore, meant that SHS 3 Biology students would not attain mastery levels of the science process skills for problem solving in life and also for meaningful learning of biological concepts to promote higher academic achievement in Biology since there is a positive correlation between acquisition of science process skills and academic performance by students (Aydogdu & Ergin, 2008; Derilo, 2019). Evidently, the Biology practical examination that is set by WAEC based on science process skills is rated over 80 marks, the objective test scored over 50 marks and the subjective is assessed over 70 marks (Source: WAEC). And if students could not perform well in the practical examination as a result of inadequate or lack of exposure to hands-on activities for acquisition of science process skills, these students to a greater extent would attain low quality grades in Biology in the final analysis because the marks that students get in the practical test complement that of the theory test for the determination of grades by students.

Null Hypothesis One

There is no significant difference in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising among SHS 3 elective Biology students from the different schools

The objective of this research hypothesis was to investigate difference in the mean scores of acquisition of process skills of drawing, classifying, interpreting and hypothesising among SHS 3 elective Biology students from the different schools. The study required SHS 3 Biology students to answer questions concerning drawing, classifying, interpreting and hypothesising on the science process skills assessment tasks. The independent variable represented the six different schools and the dependent variable was the scores students had on science process skills assessment tasks in drawing, classifying, interpreting and hypothesising which was rated on maximum of 5 points. The data generated from the assessment tasks of students was analysed using one-way multivariate analysis of variance (one-way MANOVA) and the results were presented in Table 3.

Prior to conducting the MANOVA, a series of Pearson correlations were performed between the scores of all of the dependent variables in order to test the MANOVA assumption that the dependent variables would be correlated with each other in the moderate range. A meaningful pattern of correlations was observed amongst most of the dependent variables, suggesting the appropriateness of a MANOVA. Additionally, the Box's M value of 99.988 was associated with a *p*-value of .009, which was interpreted as non-significant based on Huberty and Petoskey's (2000) guideline. Thus, the covariance matrices between the groups were assumed to be equal for the purposes of the MANOVA. To further confirm that the assumption of homogeneity of variance (covariance matrices) has not been violated, the Levene's Test was run for each dependent variable (drawing, classifying, interpreting and hypothesising). The results of Levene's Test for homogeneity for each of the dependent measure are as: drawing, $F(5, 234) = 2.054$, $p = 0.072$, classifying, $F(5, 234) = 3.470$, $p = 0.051$, interpreting, $F(5, 234) = 1.092$, $p = 0.366$ and hypothesising, $F(5, 234) = 2.093$, $p = 0.067$. This means that all the four dependent variables do not violate the assumption at an alpha level of 0.05. Table 3 shows one-way MANOVA of the performance of the students from different schools on the science process skills.

Outcomes of the descriptive statistics from Table 3 indicates evidently that students' performance on the four science process skills among the six SHSs was below average with exception of classifying and interpreting skills where School A performed above average with mean scores of 3.30 and 3.25 respectively. These results indicate that students from the various schools showed fair knowledge in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising.

Additionally, in Table 3, the descriptive statistics shows that the students in School B appeared to acquire the highest drawing skills (M=2.15; SD=1.051). This was followed by School F (M=1.95; SD=1.061) and the lowest drawing skills was acquired by the students in School E (M=1.30; SD=0.758). Also, concerning acquisition of classifying skills among the students, it appeared that the students in School A acquired the highest (M=3.30; SD=1.018), followed by School B (M=2.80; SD=1.506) and the least classifying skills was acquired by the students in School E (M=1.58, SD=0.903).

Table 3: One-Way MANOVA showing acquisition of science process skills by SHS 3 Biology students from different schools

Science process skills	Schools	Mean	SD	Tests of Between-Subjects Effects			
				F-value	df	P-value	partial η^2
Drawing	School A	1.80	.791	5.878	5(234)	0.000	0.112
	School B	2.15	1.051				
	School C	1.50	.716				
	School D	1.40	.810				
	School E	1.30	.758				
	School F	1.95	1.061				
Classifying	School A	3.30	1.018	11.527	5(234)	0.000	0.198
	School B	2.80	1.506				
	School C	2.73	1.086				
	School D	2.28	1.339				
	School E	1.58	.903				
	School F	1.92	1.095				
Interpreting	School A	3.25	1.056	6.700	5(234)	0.000	0.125
	School B	2.83	1.238				
	School C	2.62	1.275				
	School D	2.20	.992				
	School E	2.00	1.132				
	School F	2.40	.871				
Hypothesising	School A	2.12	1.202	4.180	5(234)	0.000	0.082
	School B	1.83	1.035				
	School C	1.80	1.091				
	School D	1.45	1.037				
	School E	1.35	.770				
	School F	1.33	.730				
	Wilk's Lambda			= 0.654			
	F-value			= 5.247			
	df			= 20(767)			
	P-value			= 0.000)			
	partial η^2			= 0.101			

Source: Field Work, 2018

Regarding interpreting skills, the results show that students in School A appeared to have the highest score of interpreting (M=3.25; SD=1.056) and students in School B had the second highest of interpreting skills (M=2.83; SD=1.238) while students in School E had the lowest interpreting skills (M=2.00; SD=1.132). Similarly, students in School A seemed to acquire the highest hypothesising skills (M=2.12; SD=1.202). This was followed by students in School B (M=1.83; SD=1.035) while students in School F acquired the lowest hypothesising skills (M=1.33; SD=0.730). From these results, it appears that there is difference in the mean scores of students in the four science process skills (drawing, classifying, interpreting and hypothesising) from the different schools.

In Table 3, the result of the One-Way MANOVA reveals that there was a statistically significant difference in the performance of students on the science process skills of drawing, classifying, interpreting and hypothesising from the different schools, $F(20, 767.090) = 5.247$, $p < 0.001$; Wilk's $\Lambda = 0.654$, partial $\eta 2 = 0.101$. This explained that there was a difference in the performance of students from the different schools with respect to the science process skills of drawing, classifying, interpreting and hypothesising. The multivariate effect size was estimated at 0.101, which implied that 11.1% of the variance in the dependent variables (drawing, classifying, interpreting and hypothesising) was accounted for by the different schools. Therefore, we can conclude that these students’ level of attainment of science process skills (drawing, classifying, interpreting and hypothesising) was significantly contingent on which school type they had attended ($p < 0.001$).

To determine how the scores of students on the dependent variables (drawing, classifying, interpreting and hypothesising) differ with respect to the independent variable (type of school), the Univariate ANOVAs (Tests of Between-Subjects Effects) was performed (Refer to Table 3). The results of Univariate ANOVAs show that students' school type has a statistically significant effect on drawing skills ($F(5, 234) = 5.878$; $p < 0.001$; partial $\eta^2 = 0.112$), classifying skills ($F(5, 234) = 11.527$, $p < 0.001$; partial $\eta^2 = 0.198$), interpreting skills ($F(5, 234) = 6.700$; $p < 0.001$; partial $\eta^2 = 0.125$), hypothesising skills ($F(2, 234) = 4.180$; $p < .0001$; partial $\eta^2 = 0.082$). From these results, it is important to make an alpha correction to account for multiple ANOVAs being run, such as a Bonferroni correction. As such, in this case, I accept statistical significance at p < 0.0125 (0.05 / 4 = 0.0125).

Since the Univariate ANOVAs result was significant, the results were followed with Tukey's HSD post-hoc tests, as shown in the Multiple Comparisons table (see Appendix N). The result of multiple comparisons shows that the mean scores for drawing skills were statistically significant difference between School B and School C (p = 0.013), School B and School D (p = 0.002), School B and School E (p < 0.0001), School E and School F (p = 0.013) but not between School A and School B (p = 0.476), School A and School C (p = 0.644), School A and School D (p = 0.321), School A and School E (p = 0.113), school A and School F (p = 0.973) and School B and School F (p = 0.910), School C and School D (p = 0.0996), School C and School E (p = 0.910) and School C and School F (p = 0.199), School D and School E (p = 0.996) and School D and School F (p = 0.059).

Regarding classifying skills, the result of multiple comparisons shows that there were statistically significant difference of the mean scores between School A and School D ($p = 0.002$), School A and School E ($p < 0.0001$), School A and School F ($p < 0.0001$), School B and School E ($p < 0.0001$), School B and School F ($p = 0.013$), School C and School E ($p < 0.0001$) and School C and School F ($p = 0.31$) but not between the other schools. In connection with interpreting skills, the result of multiple comparisons shows that there were statistically significant difference of the mean scores between School A and School D ($p < 0.0001$), School A and School E ($p < 0.0001$), School A and F ($p = 0.009$) and School B and School E ($p = 0.012$). Finally, concerning hypothesising skills, the result of multiple comparisons shows that there was a statistically significant difference of the mean scores between School A and School D ($p = 0.031$), School A and school E ($p = 0.007$) and School A and School F ($p = 0.005$).

From these results, it could be concluded that students' level of attainment of science process skills of drawing, classifying, interpreting and hypothesising was dependent on the different types of schools. Thus, the different kinds of schools attended by the students (school type) had a statistically significant influence or affected their level of acquisition of science process skills of drawing, classifying, interpreting and hypothesising and hence the null hypothesis which states that This meant that the null hypothesis that "There is no significant difference in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising among SHS 3 elective Biology students from the different schools" was rejected.

The result of the study is a confirmation of the findings of Gurses, Cetinkaya, Dogar and Sahin (2014) that significant differences exist on the performance of students from different high schools with respect to science process skills. And this differences in the performance of the students on the science process skills could be due to the fact that schools that are well resourced in terms of equipment and materials for practical activities, receive services of better teachers and are located in urban centres perform better in attainment of science process skills than schools that lack many science equipment and materials and are located in rural areas (Adeyemo, 2013; Anthony-Krueger, 2001; Raj & Devi, 2014; Soyibo & Johnson as cited in Naah, 2011). For instance, Soyibo and Johnson (as cited in Naah, 2011) stated that students could perform better in science process skills when they receive better facilities and services of teachers of better quality. Adeyemo (2013) found out that there was a significant relationship between the provision of laboratory facilities and academic achievement of Physics students in Nigeria and Raj and Devi (2014) affirmed that there was a statistically significant difference in the mean scores of rural and urban students on science process skills in favour of urban students.

Null Hypothesis Two

There is no significant difference in the acquisition of science process skills of *drawing, classifying, interpreting and hypothesising* of SHS 3 elective Biology students based on gender.

The objective of this research hypothesis was to investigate the difference in mean scores of acquisition of science process skills of drawing, classifying, interpreting and hypothesising among SHS 3 elective Biology students based on gender. The data obtained from the assessment of science process skills tasks of students was analysed using one-way multivariate analysis of variance (one-way MANOVA) and the results were presented in Table 4.

Prior to conducting the MANOVA, a series of Pearson correlations were performed between all the scores of the dependent variables in order to test the MANOVA assumption that the dependent variables would be correlated with each other in the moderate range. A meaningful pattern of correlations was observed amongst most of the dependent variables, suggesting the appropriateness of a MANOVA. Additionally, the Box's M value of 21.292 was associated with a p-value of .062, which was interpreted as non-significant based on Huberty and Petoskey's (2000) guideline. Thus, the covariance matrices between the groups were assumed to be equal for the purposes of the MANOVA.

To further confirm that the assumption of homogeneity of variance (covariance matrices) has not been violated, the Levene's Test was run for each dependent variable (drawing, classifying, interpreting and hypothesising). The results of Levene's Test for homogeneity for each of the dependent measure are as: drawing, $F(1, 238) = 1.598$, $p = 0.207$, classifying, $F(1, 238) = 0.053$, $p = 0.819$, interpreting, $F(1, 238) = 0.366$, $p = 0.366$ and hypothesising, $F(1, 238) = 2.792$, $p = 0.096$. This means that all the four dependent variables do not violate the assumption at an alpha level of 0.05.

Table 4: One-Way MANOVA showing difference in students' science process skills based on gender

Science process skills	Gender	Mean	SD	Tests of Between-Subjects Effects			
				F-value	df	P-value	partial η^2
Drawing	Male	1.68	.869	0.000	1(238)	1.000	0.000
	Female	1.68	.970				
Classifying	Male	2.62	1.265	4.862	1(238)	0.028	0.020
	Female	2.25	1.311				
Interpreting	Male	2.71	1.133	4.484	1(238)	0.035	0.018
	Female	2.39	1.183				
Hypothesising	Male	1.74	1.104	2.109	1(238)	0.148	0.009
	Female	1.55	.934				

Wilk's Lambda	= 0.969
F-value	= 1.892
df	= 4(235)
P-value	= 0.113
partial η^2	= 0.031

Source: Field Work, 2018

From Table 4, concerning the drawing science process skills among the students, it appears that both male students (M=1.68; SD=0.869) and female students (M=1.68; SD=0.970) acquired drawing skills at the same level. This finding contradicted Dzidzinyo (2011) that female students performed better than their male counterparts on the drawing test. This could be attributed to the fact that the regularity at which the male and female students were exposed to the science process skill of drawing was almost at the same level and hence their parallel level in the attainment of drawing skill. Also, concerning acquisition of classifying skills among the students, it appears that the male students (M=2.62; SD=1.265) acquired high classifying science process skills than the female students (M=2.25; SD=1.311). Regarding interpreting skill, it seems that male students (M=2.71; SD=1.133) acquired more interpreting science process skills than the female students (M=2.39; SD=1.183). Similarly, about hypothesising skill among students, it was observed that male students (M=1.74; SD=1.104) acquired more hypothesising science process skills than the female students (M=1.55; SD=0.934). From these results, it appears that there is difference in the mean scores of the four science process skills (drawing, classifying, interpreting and hypothesising) of the students based on their gender.

In Table 4, the result of the One-Way MANOVA reveals that there was no statistically significant difference in the science process skills (drawing, classifying, interpreting and hypothesising) of the students based on gender, $F(4, 235) = 1.892$, $p = 0.113$; Wilk's $\Lambda = 0.969$, partial $\eta^2 = 0.031$. This explains that there is no difference between the four dependent variables (drawing, classifying, interpreting and hypothesising). Furthermore, the multivariate effect size was estimated at 0.031, which implies that only 3.1% of the variance in the dependent variables (drawing, classifying, interpreting and hypothesising) was accounted for by gender**.** Therefore, it can be concluded that the students' science process skills (drawing, classifying, interpreting and hypothesising) were not significantly contingent on gender of the students ($p = 0.113$).

However, to determine whether the dependent variables (drawing, classifying, interpreting and hypothesising) differ with respect to the independent variable (gender), the Univariate ANOVAs (Tests of Between-

Subjects Effects) was performed (Refer to Table 4). The results of Univariate ANOVAs show that gender has a statistically significant effect on classifying skills ($F(1, 238) = 4.862$, $p = 0.028$; partial $\eta^2 = 0{,}020$) and interpreting skills ($F(1, 238) = 4.484$; $p = 0.035$; partial $\eta^2 = 0.018$) in favour of males. Thus Table 4 portrays the mean score of males (M=2.62; SD=1.265) and females (M=2.25; SD=1.331) on the classifying skill and mean score of males (M=2.71; SD=1.133) and females (M=2.39; SD=1.183) on the interpreting skill. The influence of gender in the acquisition of science process skills of classifying and interpreting in favour of males is conformity with the findings of (Gurses, Cetinkaya, Dogar, Sahin, 2014; Tilakaratne, & Ekanayake, 2017) that there was a statistically significant difference between the mean performance scores of males and females on science process skills in support of males. However, gender has no statistically significant effect on drawing skills ($F(1, 238) = 0.000$; $p = 1.000$; partial $\eta^2 = 0.000$) and hypothesising skills ($F(1, 238) = 2.109$; $p = 0.148$; partial $\eta^2 = 0.009$). Therefore, Table 4 reveals the mean score of males (M=1.68; SD=.869) and females (M=1.68; SD=.970) on the drawing skill and a mean score of males (M=1.74; SD=1.104) and females (M=1.55; SD=.934) on the hypothesising skill. Absence of statistically significant influence of gender on the attainment of science process skills of drawing and hypothesising is in line with the findings of (Ekon & Eni, 2015; Mohamad & Ong, 2013) that gender does not significantly influence the acquisition of science process skills. This means that both male and female students could perform at similar levels with respect to attainment of science process skills if adequate science equipment and materials are available for them to undergo practical activities regularly with competent, dedicated and well-motivated science teachers who will provide the right atmosphere for them in order to develop positive attitudes towards acquisition of science process skills. From these results, it is important to make an alpha correction to account for multiple ANOVAs being run, such as a Bonferroni correction. As such, in this case, I accept statistical significance at $p < 0.0125$ ($0.05 / 4 = 0.0125$). From these results, it is concluded that students' science process skills (drawing, classifying, interpreting and hypothesising) depend on gender. Thus, gender of students has a statistically significant influence or affect the level of science process skills, hence, the null hypothesis which states that "There is no significant difference in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising of SHS 3 elective Biology students based on gender" was rejected.

Null Hypothesis Three

There is no significant difference in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising of SHS 3 elective Biology students based on categorisation of schools

The objective of this research hypothesis was to investigate difference in the mean scores of acquisition of science process skills of drawing, classifying, interpreting and hypothesising among SHS 3 elective Biology students based on categorisation of schools. The data was analysed using one-way multivariate analysis of variance (one-way MANOVA) and the results were presented in Table 5.

Prior to conducting the MANOVA, a series of Pearson correlations were performed between the scores of all the dependent variables in order to test the MANOVA assumption that the dependent variables would be correlated with each other in the moderate range. A meaningful pattern of correlations was observed amongst most of the dependent variables, suggesting the appropriateness of a MANOVA. Additionally, the Box's M value of 41.733 was associated with a p-value of .0051, which was interpreted as non-significant based on Huberty and Petoskey's (2000) guideline. Thus, the covariance matrices between the groups were assumed to be equal for the purposes of the MANOVA.

To further confirm that the assumption of homogeneity of variance (covariance matrices) has not been violated, the Levene's Test was run for each dependent variable (drawing, classifying, interpreting and hypothesising). The results of Levene's Test for homogeneity for each of the dependent measure are as: Drawing, F(2, 237) = 2.581, p = 0.078, Classifying, F(2, 237) = 3.685, p = 0.027, Interpreting, F(2, 237) =0.466, p = 0.628 and Hypothesising, F(2, 237) = 4.196, p = 0.016. This means that all the four dependent variables do not violate the assumption at an alpha level of 0.05.

From Table 5, the descriptive statistics indicates that the students in well-endowed school (M=1.97; SD=0.941) appears to acquire high drawing science process skills than students in endowed school (M=1.45; SD=0.76) and less-endowed school (M=1.62; SD=0.973). Also, concerning acquisition of classifying science process skills among the students, it appears that the students in well-endowed school (M=3.05; SD=1.301) acquired more classifying process skills than students in endowed school (M=2,50; SD=1.232) and less-endowed school (M=1.75; SD=1.013).

Table 5: One-Way MANOVA showing difference in students' science process kills based on categorisation of schools

Variables	Cat. of schools	Mean	SD	Tests of Between-Subjects Effects			
				F-value	df	P-value	partial η^2
Drawing	Well-endowed	1.97	.941	7.112	2(237)	0.001	0.057
	Endowed	1.45	.761				
	Less endowed	1.62	.973				
Classifying	Well-endowed	3.05	1.301	24.115	2(237)	0.000	0.169
	Endowed	2.50	1.232				
	Less endowed	1.75	1.013				
Interpreting	Well-endowed	3.04	1.163	12.178	2(237)	0.000	0.093
	Endowed	2.41	1.155				
	Less endowed	2.20	1.024				
Hypothesising	Well-endowed	1.97	1.125	8.238	2(237)	0.000	0.065
	Endowed	1.63	1.072				
	Less endowed	1.34	.745				
	Wilk's Lambda			= 0.744			
	F-value			= 9.343			
	df			= 8(468)			
	P-value			= 0.000			
	partial η^2			= 0.138			

Source: Field work, 2018

Concerning interpreting science process skills, the results show that students in well-endowed school (M=3.04; SD=1.163) seems to acquire more interpreting science process skills than the students in endowed school (M=2.41; SD=2.20) and less-endowed school (M=2.20; SD=1.024). Similarly, it looks like students in well-endowed schools (M=1.97; SD=1.125) acquire more hypothesising science process skills than students in endowed schools (M=1.63; SD=1.072) and less-endowed schools (M=1.34; SD=0.745). From these results, it appears that there is difference in the mean scores of the four science process skills (drawing, classifying, interpreting and hypothesising) of the students based on categorisation of schools.

In Table 5, the result of the One-Way MANOVA reveals that there was a statistically significant difference in the mean score of students' science process skills (drawing, classifying, interpreting and hypothesising) based on categorisation of schools, $F(8, 468) = 9.343$, $p < 0.001$; Wilk's $\Lambda = 0.744$, partial $\eta^2 = 0.138$. This explains that there is a difference between the four dependent variables (drawing, classifying, interpreting and hypothesising) but which one. The multivariate effect size was estimated at 0.138, which implies that 13.8% of the variance in the dependent variables (drawing, classifying, interpreting and hypothesising) was accounted for categorisation of schools. Therefore, it can be concluded that students' science process skill (drawing, classifying, interpreting and hypothesising) was statistically significantly contingent on the categorisation of schools attended by the students ($p < 0.001$).

To determine how the dependent variables (drawing, classifying, interpreting and hypothesising) differ for the independent variable (categorisation of schools), the Univariate ANOVAs (Tests of Between-Subjects Effects) was performed (Refer to Table 5). The results of Univariate

ANOVAs show that categorisation of school has a statistically significant effect on drawing science process skills ($F(2, 237) = 7.122$; $p < 0.001$; partial $\eta^2 = 0.057$), classifying science process skills ($F(2, 237) = 24.115$, $p < 0.001$; partial $\eta^2 = 0.169$), interpreting science process skills ($F(2, 237) = 12.178$; $p < 0.001$; partial $\eta^2 = 0.093$), hypothesising science process skills ($F(2, 237) = 8.238$; $p < .0001$; partial $\eta^2 = 0.065$). From these results, it is important to make an alpha correction to account for multiple ANOVAs being run, such as a Bonferroni correction. As such, in this case, I accept statistical significance at $p < 0.0125$ ($0.05 / 4 = 0.0125$).

Since the Univariate ANOVAs result was significant, the results were followed with Tukey's HSD post-hoc tests, as shown in the Multiple Comparisons table (see Appendix O). The result of multiple comparisons shows that the mean scores of drawing science process skills were statistically significantly different between students in well-endowed school and endowed school ($p = 0.001$), well-endowed school and less-endowed school ($p = 0.38$), however, no significant difference was found between students in endowed school and less-endowed school ($p = 0.434$). Regarding classifying science process skills, the result of multiple comparisons shows that the mean scores were statistically significantly different between students in well-endowed school and endowed school ($p = 0.010$), well-endowed school and less-endowed school ($p < 0.0001$) and endowed school and less-endowed school ($p < 0.0001$). Regarding interpreting science process skills, the result of multiple comparisons shows that the mean scores were statistically significantly different between students in well-endowed school and endowed school ($p = 0.001$), well-endowed school and less-endowed school ($p < 0.0001$), however, there is no statistically significant difference in the mean score between student in endowed school and less-endowed school ($p = 0.452$). Finally, concerning hypothesising process skills, the result of multiple comparisons shows that the mean scores were statistically significantly different between students in well-endowed school and less-endowed school ($p < 0.0001$), however, there is no statistically significant difference in the mean score between student in well-endowed school and endowed school ($p = 0.069$) and endowed school and less-endowed school ($p = 0.163$). From these results, it is concluded that students' science process skills (drawing, classifying, interpreting and hypothesising) depend on categorisation of school. Thus, the kind of school attended by the students (well-endowed school, endowed school and less-endowed school) statistically significantly influence or affect their level of process skills, hence, the null hypothesis which state that "There is no significant difference in the acquisition of process skills of drawing, classifying, interpreting and hypothesising of SHS 3 elective Biology students based on categorisation of school" is rejected. The findings of this research was confirmed by the fact that there was a significant relationship between availability and optimal utilisation of laboratory facilities and academic achievement of science students (Adeyemo, 2013; Bello, 2012; Ihejiamaizu & Ochui, 2016) and that exposure of students to laboratory apparatus during practical lessons facilitates acquisition of science process skills (Johnson, 2016). And that the significant differences in the achievement of science process skills between the well-endowed schools and the less-endowed schools could be due to the availability and effective use of more laboratory equipment and materials during practical activities in the well-endowed schools than less-endowed schools.

Integration of the Findings from the Qualitative and Quantitative Studies

The purpose of this study was to assess science process skills of drawing, classifying, interpreting and hypothesising of Biology students and to find out how frequent Biology practical lessons were organised as well as factors that affect effective organisation of Biology practical activities for the students to acquire science process skills. Mixed methods design was adopted in this study because it provides an avenue to merge the quantitative and qualitative results of the study and thus provides a comprehensive analysis of the research problem for a more holistic understanding of the research problem than employing either quantitative or qualitative approach alone (Creswell, 2014; Ponce & Pagan-Maldonaldo, 2015).

From the analysis of the quantitative data, none of the students had excellent drawing skills, 14 students representing 5.8% showed no skills on drawing and majority of the students (103) which represents 42.9% showed poor skills on drawing. In connection with classifying skills, 16 students which represent 6.7% showed no skills on classifying, 42 students (17.5%) had poor classification skills, 74 students representing 30.8% had fair acquisition skills on classifying specimens and 12 students (5%) had excellent classification skills. Additionally, 13 students (5.4%) exhibited no interpreting skills, 29 students (12.1%) showed poor interpreting skills and only 8 students (3.3%) portrayed excellent interpreting skills. Moreover, 24 students (10.0%) showed no hypothesising skills, 95 students (39.6%) exhibited poor hypothesising skills and only one student (0.4%) displayed excellent hypothesising skills (Refer to Table 1). Outcomes of the descriptive statistics from Table 3 indicates evidently that students' performance on the four science process skills among the six SHSs was below average with exception of classifying and interpreting skills where School A performed above average with mean scores of 3.30 and 3.25 respectively. From Table 4, both males and females performed below average on the science process skills of drawing, classifying, interpreting and hypothesising. The results in Table 5 revealed that, there was a statistically significant difference between the well-endowed schools and the less-endowed schools which meant that the well-endowed schools performed better on the science process skills of drawing, classifying, interpreting and hypothesising than the less-endowed schools.

Evidence from the qualitative data showed that Biology practical activities were not organised regularly for the students to acquire science process skills as three out of the six Biology teachers admitted that practical activities were not organised often for the students and one major practical activity was organised for the students in a term. The focus group interviews of the students revealed that practical activities were not organised often for the students as four out of the six schools affirmed that practical activities were organised once in a term. Time for practical activities was not allocated on the time table for the teachers to adhere to as five of the teachers from Schools A, C, D, E and F disclosed that they had no separate periods for practical activities and theory lessons and this was confirmed by their students. Content analysis of the Biology practical workbook revealed that students from School A carried out practical work on classification of living organisms into their various taxa, *Tilapia sp*, fruits, osmosis and cells. Students from School B performed practical work in classification of organisms into their various taxa, cockroach, human skeletal system, cells, plant physiology and osmosis. Students from School C carried out practical work on cells, plant physiology, classification of organisms into their various taxa, soil and photosynthesis. Students from School D performed practical activities in classification of organisms into their various taxa, cells, soil and weevil. Students from School E carried out practical activities on cells, cockroach, soil and classification of living organisms into their various taxa and students from School F performed practical activities on classification of organisms into their various taxa, grasshopper, osmosis and cells. Thus, six maximum documented practical activities were undergone by the students. The Biology laboratories were not fully equipped with equipment as Biology teachers reported of inadequate number of microscopes, permanent slides and unavailability of dissecting kits, Fehling's/Benedict's solution, millon's reagent, barometer, photometer, light intensity probe and maximum-minimum thermometer. Qualified laboratory assistants were not available in the various schools to help in the organisation of Biology practical activities as it was revealed from the responses of the six Biology teachers and the focus group interview of the students that qualified laboratory assistants were not available to help in the organisation of practical work. Funds were also not readily made available by school authorities for the purchase of equipment and materials for Biology practical activities as five out of the six Biology teachers interviewed revealed that funds were not regularly made available by the school authorities for the purchase of materials and equipment for Biology practical activities. Professional development sessions were not a regular venture for the Biology teachers as the interview revealed that two Biology teachers from Schools C and F taught for 6years and 11years respectively but never had the opportunity to attend in-service training programme in order to update and upgrade their knowledge and skills for effective teaching of biological concepts and practical activities to students and the last time Biology teachers in Schools A, B, D and E respectively had the opportunity to attend in-service training programmes were 2015, 2009, 2011 and 2013

Majority of the students (103) which represents 42.9% showing poor drawing skills, none of the students attaining level of excellent drawing skills, 42 students (17.5%) portraying poor classification skills, 13 students (5.4%) exhibiting no interpreting skills, 29 students (12.1%) showing poor interpreting skills, 24 students (10.0%) portraying no hypothesising skills, 95 students (39.6%) exhibiting poor hypothesising skills and only one student

(0.4%) displaying excellent hypothesising skills as well as students' performing below average on the four science process skills among the six SHSs with exception of classifying and interpreting skills where School A performed above average with mean scores of 3.30 and 3.25 respectively could be attributed to the fact that practical activities were not carried out frequently in the various schools for the students to acquire science process skills as three out of the six Biology teachers admitted that practical activities were not organised often for the students and one major practical activity was organised for the students in a term and this was confirmed by the students in a focus group interview. Moreover, content analysis of the Biology practical workbook revealed that students undergone a maximum of six documented practical activities. The inability of Biology teachers to constantly engage their students in practical lessons might be ascribed to factors such as non-allocation of practical periods on the school time table for the Biology teachers to adhere to in organising practical activities for the students to acquire science process skills, inadequate and unavailability of laboratory equipment and materials for practical work, unavailability of qualified laboratory assistants to help the teachers in organising hands-on activities for the students, non-release of funds by school authorities for the purchase of equipment and materials for Biology practical activities and irregular professional development sessions by the Biology teachers in order to update and upgrade their knowledge and skills in organisation of practical work to students. In line with the Biology syllabus, a total of 3 periods (120 minutes) per week should be allotted to the organisation of practical activities (CRDD, 2010) to enable students acquire science process skills and to learn theoretical concepts meaningfully. If this period had reflected on the school time table for the Biology teachers to be supervised by the school authorities to follow, they would have organised sufficient number of practical activities for the students in order to enhance their acquisition of science process skills. The non-allocation of practical periods on the time table is backed by the interview result as five of the teachers from Schools A, C, D, E and F disclosed that they had no separate periods for practical activities and theory lessons and this was confirmed by their students. Inadequate and unavailability of laboratory equipment and materials was one of the factors that affected effective organisation of practical lessons for the students to acquire science process skills. From the interview with the Biology teachers, teachers from the well-endowed schools reported of inadequate number of microscopes, hand lens, permanent slides and unavailability of dissecting kits, Fehling's/Benedict's solution and millon's reagent for practical activities and teachers from the less-endowed schools stated that inadequate number of microscopes, hand lens and unavailability of dissecting kits, Fehling's/Benedict's solution, millon's reagent, barometer, photometer, light intensity probe and maximum-minimum thermometer for hands-on activities. If the Biology laboratories were not fully equipped with science equipment and materials, it would be difficult for Biology teachers to organise practical activities for the students. Because improvisation of equipment and materials cannot be adopted in all instances as it cannot be used for equipment like microscope and hand lens/magnifying glass for microscopic studies. For example, unavailability of barometer, photometer, light intensity probe and maximum-minimum thermometer would make ecological studies difficult by the students and unavailability of dissecting kits would make dissection of small mammals impossible. The ill-equipped laboratories violate the vision of curriculum planners for the provision of well-equipped laboratories for practical activities and meaningful study of theoretical concepts (CRDD, 2010). Non-release of funds by school authorities for the purchase of equipment and materials for Biology practical activities was another hindrance to effective organisation of practical lessons for the students to acquire science process skills. From the interview with the teachers, five out of the six Biology teachers interviewed revealed that funds were not regularly made available by the school authorities for the purchase of materials and equipment for Biology practical activities. If funds were not released by the school authorities for the purchase of equipment and materials for Biology practical activities, it would be difficult for teachers to organise practical lessons on most of the topics in the syllabus. Unavailability of qualified laboratory assistants to help the teachers in organising hands-on activities for the students was one of the barriers to attainment of science process skills. The interview with the teachers and students revealed that qualified laboratory assistants were not available to help in the organisation of practical work. The unavailability of qualified laboratory assistants in the schools violates the dream of curriculum developers that well-trained laboratory assistants/technicians should be posted to the various schools to play complementary roles to the teachers in the organisation of practical activities for students (CRDD, 2010). Furthermore, irregular professional development sessions by the Biology teachers was another contributory factor towards ineffective organisation of practical activities for the students to acquire science process skills. From the interview with the teachers, two

Biology teachers from Schools C and F taught for 6years and 11years respectively but never had the opportunity to attend in-service training programme in order to update and upgrade their knowledge and skills for effective teaching of biological concepts and practical activities to students and the last time Biology teachers in Schools A, B, D and E respectively had the opportunity to attend in-service training programmes were 2015, 2009, 2011 and 2013. This portrayed that professional development sessions were not a regular venture for the Biology teachers. If Biology teachers did not attend in-service regularly to update and upgrade their knowledge and practical skills they have acquired from the universities, these skills will become dormant with time and they would not be able to use it effectively during practical lessons to the benefit of the students as some teachers do not feel confident to perform laboratory-based practical activities for students to observe because of lack of training on these practical activities (Cossa & Vamusse, 2015). Practical work which served as the fulcrum for attainment of science process skills was not organised regularly for students due to factors such as non-allocation of practical periods on the time table, inadequate and unavailability of laboratory equipment and materials, unavailability of qualified laboratory assistants, non-release of funds for the purchase of equipment and materials for practical work and irregular professional development sessions by the Biology teacher. This infrequent exposure of students to practical activities had culminated in the low attainment rate of students on the science process skills of drawing, classifying, interpreting and hypothesising. To avert the trend of low acquisition of science process skills by students, competent, dedicated and well-motivated Biology teachers must constantly expose students to practical activities in the right environment in order for the students to develop positive attitude towards practical work which would promote their acquisition of science process skills.

The results in Table 5 revealed that, there was a statistically significant difference between the well-endowed schools and the less-endowed schools in the attainment of science process skills of drawing, classifying, interpreting and hypothesising. According to Ghana Education Service (2015), Senior High School have been categorised less-endowed, endowed and well-endowed on the basis of endowment of resources and equipment as well as their performance in West African Senior Secondary Certificate Examinations (WASSCE). Consequently, we have Option 1 SHSs which are less-endowed, Option 2 SHSs which are averagely endowed and Option 3 SHSs which are well-endowed in terms of facilities and resources and portraying better performance in the final examinations conducted by WAEC. From the interview with the teachers, the well-endowed schools reported of inadequate number of microscopes, hand lens, permanent slides and unavailability of dissecting kits, Fehling's/Benedict's solution and millon's reagent for practical activities and teachers from the less-endowed schools stated that inadequate number of microscopes, hand lens and unavailability of dissecting kits, Fehling's/Benedict's solution, millon's reagent, barometer, photometer, light intensity probe and maximum-minimum thermometer for hands-on activities. This had clearly confirmed the well-endowed and less-endowed status of the schools as it could be seen from the results of the interview that, well-endowed schools have more equipment and materials than less-endowed schools. The better performance on the science process skills of drawing, classifying, interpreting and hypothesising by the well-endowed schools as compared to the less-endowed schools could be attributed to the availability and utilisation of more equipment and materials by students during practical lessons. This is confirmed by (Johnson, 2016) that exposure of students to laboratory apparatus during practical lessons facilitates acquisition of science process skills.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to assess science process skills of drawing, classifying, interpreting and hypothesising among elective Biology students using science process skills assessment tasks in some selected SHSs in the Volta Region.

The research design employed for the study was mixed methods design and thus qualitative and quantitative methods were used in analysing data gathered from the respondents. Two hundred and forty elective Biology students constituted the sample size for this study. Additionally, six SHS 3 Biology teachers from the sampled schools responded to the research instruments.

The study sought answers to the following research questions.

1. What are the levels of acquisition of drawing, classifying, interpreting and hypothesising skills among SHS 3 elective Biology students?

2. How frequent do SHS 3 Biology students engage in practical activities to acquire science process skills?

3. What are the factors that affect effective organisation of Biology practical activities for students to acquire science process skills?

4.Which science process skills do teachers expose SHS 3 Biology students to during practical activities?

Moreover, the following null hypotheses were formulated and tested.

1.There is no significant difference in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising among SHS 3 elective Biology students from the different schools.

2.There is no significant difference in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising of SHS 3 elective Biology students based on gender.

3.There is no significant difference in the acquisition of science process skills of drawing, classifying, interpreting and hypothesising of SHS 3 elective Biology students based on categorisation of schools

Summary

From Research Question 1, it was revealed that majority of the students performed low/poorly on the science process skills of drawing, classifying, interpreting and hypothesising. Additionally, no student had excellent drawing skills and only 1 student portrayed excellent hypothesising skills.

From Research Question 2, the responses of the Biology teachers and the students in connection with the interview, coupled with the analysis of the Biology practical workbooks of the students, it became apparent that practical activities were not regularly organised for the students and, therefore, the probability that Biology students would perform poorly on assessment of science process skills was high.

With respect to Research Question 3, the factors that affect effective organisation of Biology practical activities were time constraints for Biology practical activities, overloaded Biology curriculum, large class size of Biology students, unavailability of qualified Biology laboratory assistants, unavailability, inadequate and mal-functioning equipment and materials for Biology practical work, unavailability of or non-release of funds for Biology practical activities, unavailability of Biology practical guide book, irregular or absence of professional development sessions for Biology teachers and absence of reflective journals on Biology practical activities.

In connection with Research Question 4, the analysis of Biology practical workbook of students revealed science process skills that students were exposed to during practical lessons included observing, classifying, inferring, predicting, communicating, measuring, drawing, recording, manipulating, interpreting, experimenting, planning and hypothesising. However, students were not introduced to science process skills of defining operationally and controlling variables. Moreover, the students were not introduced to the other science process skills regularly.

In line with Null Hypothesis 1, the results of one-way MANOVA revealed that students in the six SHSs performed differently on the various science process skills and that there was a statistically significant difference among the schools on the drawing, classifying, interpreting and hypothesising science process skills.

With respect to Null Hypothesis 2, one-way MANOVA showed that there was no statistically significant difference between the mean scores of male and female students on the drawing and hypothesising science process skills. However, there was a statistically significant difference between the mean scores of male and female students on the classifying and interpreting science process skills.

The one-way MANOVA result with respect to the acquisition of science process skills of drawing, classifying, interpreting and hypothesising and the categorisation of schools showed that there was a statistically significant difference between the categories of schools on the drawing, classifying, interpreting and hypothesising science process skills. This suggested that students performed differently on the various science process skills in connection with the categorisation of the schools as less-endowed, endowed and well-endowed.

Conclusions

The following deductions were made from the research findings. In connection with Research Question 1, majority of the students performing poorly on the science process skills of drawing, classifying, interpreting and hypothesising could be due to the fact that practical activities were not regular in the selected schools for students to acquire and master science process skills.

In line with Research Question 2, Biology practical activities were not frequently organised for the students to acquire science process skills due to large class size, overloaded Biology curriculum, time constraints, inadequate and malfunctioning equipment and failure of school authorities to release funds for Biology practical activities. The irregularity of practical work had culminated in the poor performance of the majority of students on the science process skills of drawing, classifying, interpreting and hypothesising.

With respect to Research Question 3, time for Biology practical activities was not allocated on the school time table and, therefore, most Biology teachers could not organise practical activities for their students. Teachers could not organise practical work on most topics in the Biology syllabus because of the extensive nature of the Biology syllabus which compelled them to concentrate on teaching theoretical concepts in order for the students to complete the syllabus which would enable the students to pass the final examinations by WAEC to the detriment of Biology practical activities. Biology equipment and materials such as light microscope, hand lens/magnifying glass, some permanent slides were inadequate and equipment and materials such as dissecting kits, photometer, light intensity probe, barometer, maximum-minimum thermometer, Fehling's/Benedict's solution and millon's reagent were unavailable and this made organisation of practical lessons by the teachers difficult. Additionally, qualified Biology laboratory assistants were not available in the various schools to play complementary roles to the Biology teachers in organising practical lessons for the students. Also, funds were not readily released by the school authorities for the purchase of materials and equipment for practical activities and this hampered effective organisation of hands-on activities for the students to acquire science process skills. Biology practical guide book which would serve as a yardstick for organisation of practical activities was unavailable in the schools and this compelled Biology teachers to organise practical lessons on topics of their discretion in prediction of practical activities by WAEC in the final practical examinations. Large class size of Biology students coupled with inadequate equipment forced the teachers to conduct practical activities mostly in groups where some of the students did not get the needed opportunity to manipulate the equipment and also go through the experimental procedures for effective attainment of science process skills. Finally, professional development sessions which provide teachers with the opportunity to update and upgrade their knowledge and skills for effective organisation of practical lessons was irregular reflective journals on Biology practical activities which would provide a repertoire of experiences in relation to acquisition of science process skills was not kept by both students and teachers.

In relation to Research Question 4, content analysis of Biology practical workbooks of students revealed some integrated science process skills such as defining operationally and controlling variables were not acquired by students because the student were not exposed to experimental processes that would enable them define operationally and also control variables. Moreover, the regularity with which other science process skills were developed was below expectation in connection with the requirements of the Biology syllabus.

In connection with Null Hypothesis 1, the varied performance of the students in the different schools on the science process skills of drawing, classifying, interpreting and hypothesising could be linked to disparity in the availability of science equipment and materials for practical work in the various schools, different rates of exposure of students to practical activities in the various schools, varied pedagogical approaches that were adopted by Biology teachers to inculcate science process skills in students, intelligence levels of students and students' attitudes towards practical work in the various schools.

In relation to Null Hypothesis 2, Male and female students performing at the same level on the drawing and hypothesising science process skills could be attributed to the fact that the male and female students were exposed to the science process skills of drawing and hypothesising at almost the same level in the various schools and hence their parallel level in the attainment of drawing and hypothesising skills.

The difference in the performance of students from the well-endowed schools and less-endowed schools could be due to availability and effective utilisation of more laboratory apparatus for practical activities in the well-endowed schools than the less-endowed schools, differential rates of exposure of students to practical activities in the two categories of schools, different pedagogical approaches that were adopted by the Biology teachers in the two categories of schools to develop science process skills in students, intelligence levels of students, students' attitude towards practical work and the quality of Biology teachers available in the various schools.

Recommendations

The following recommendations are made based on the findings of the research. It is recommended to the Biology teachers at SHSs that practical activities should be organised frequently for Biology students in order to acquire and master science process skills that are stipulated in the Biology syllabus and to learn Biology meaningfully.

It is recommended to the authorities of SHSs that practical periods should be allocated on the school time table as stipulated in the Biology syllabus and Biology teachers should be supervised by school authorities to stick to these periods by organising practical activities for students so that they could develop and master the science process skills and also study the Biology concepts well.

In connection with the overloaded Biology syllabus hindering the effectiveness of Biology teachers to teach the theoretical and practical skills within the stipulated time frame, it is suggested to the CRDD that the Biology syllabus should be re-evaluated in terms of the content and practical activities to be undertaken by students within the given time interval. And after the re-examination, the syllabus should be pilot-tested within the specified period of time to see its feasibility before implementing it on a nationwide basis.

With respect to unavailability of qualified Biology laboratory assistants, it is suggested to the Ministry of Education (MOE) to liaise with the universities for personnel to be trained with Biology laboratory skills that would enable them function as qualified laboratory assistants to Biology teachers at SHSs. In this way, the qualified laboratory assistants would not only lessen the workload of the Biology teachers but also facilitate the organisation of practical work under most topics in the syllabus which would help the students to develop science process skills.

In line with large class size of Biology students, it is recommended that Biology teachers should organise practical activities in batches with support from qualified laboratory assistants.

In terms of unavailability, inadequate and mal-functioning laboratory equipment and materials, it is suggested that the Ministry of Education, school authorities, Non-Governmental Organisations and philanthropists should collaborate to provide the necessary equipment and materials that are required for Biology practical activities to the various SHSs.

Also, school authorities should endeavour to release funds for the purchase of equipment and materials for Biology practical activities and there should be frequent school-based in-service training programme as well as organisation based in-service programmes for Biology teachers to be equipped with the relevant skills to effectively organise practical activities for the students to attain science process skills.

Furthermore, there is the need for Biology Practical Guide Book to be developed through collaborative efforts of Ghana Education Service (GES), WAEC and Biology teachers for standardisation of Biology practical activities in SHSs so that the performance of Biology teachers in terms of organising practical activities can be measured.

Finally, Biology teachers and students should write reflective journals on practical activities as an effective strategy to enhance acquisition of science process skills by students

Suggestions for Further Research

1. A feasibility study of the Biology syllabus in terms of the topics to be covered within the stipulated time frame is required at SHS level in Ghana.
2. An investigation into how science process skills are developed in science students at SHSs should be pursued by researchers.

3. A study should be conducted into availability of equipment and materials for practical work in relation to the topics in the Biology syllabus.
4. There is the need for a study to be conducted into effect of exposure to laboratory apparatus on acquisition of science process skills and academic achievement of students in Biology.

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APPENDICES

APPENDIX A

TASK A: DRAWING

Instructions

You have 10 minutes to read carefully through the task and another 25 minutes to respond to the task on the drawing sheet provided. During the period of reading through the task, you may ask any question for clarification. Please, indicate your **ID Number** on the drawing sheet. You are expected to continue with task B at the end of the 25 minutes. This drawing sheet will be collected at the end of the entire period.

Scenario

A biology teacher in a Senior High School Form 3 had finished presenting a concept on *"Parts of a flower and their functions"* to his students. As he wanted to develop science process skill of drawing in them as well, he asked the students to draw a typical flower. Assuming you were in the teacher's class and had decided to draw a Hibiscus (*Hibiscus rosasinensis*) flower, answer the problem below.

Problem

Specimen A is a complete flower of Hibiscus (*Hibiscus rosasinensis*) on a table. Observe Specimen A carefully and make a labelled diagram of at least 10cm long and 8cm wide of it on the drawing sheet provided.

APPENDIX B

SCORING RUBRICS FOR TASK A

Score	Performance Criteria
5	**Excellent Drawing Skill** • Drawing matches with given dimensions • Appropriate title provided to the drawing • Appropriately ruled guidelines used ✓ Ruled guidelines must be horizontally parallel to one another ✓ Ruled guidelines must not cross each other ✓ Ruled guidelines must not bear arrow heads ✓ Ruled guidelines must touch the exact part(s) of the flower • At least, four parts of the flower correctly labelled ✓ Labels are not in capital letters ✓ Labels are correctly spelt • Drawing resembles specimen provided • Clarity observed in the drawing ✓ No double line used except on cut surfaces ✓ No shading observed in the drawing.
4	**Very Good Drawing Skill** • Drawing matches with given dimensions • Appropriate title provided to the drawing • Appropriately ruled guidelines used

	✓ Ruled guidelines must be horizontally parallel to one another ✓ Ruled guidelines must not cross each other ✓ Ruled guidelines must not bear arrow heads ✓ Ruled guidelines must touch the exact part(s) of the flower • At least, four parts of the flower correctly labelled ✓ Labels are not in capital letters ✓ Labels are correctly spelt • Drawing resembles specimen provided
3	**Good Drawing Skill** • Drawing matches with given dimensions • Appropriate title provided to the drawing • Appropriately ruled guidelines used ✓ Ruled guidelines must be horizontally parallel to one another ✓ Ruled guidelines must not cross each other ✓ Ruled guidelines must not bear arrow heads ✓ Ruled guidelines must touch the exact part(s) of the flower • At least, four parts of the flower correctly labelled ✓ Labels are not in capital letters ✓ Labels are correctly spelt

2	**Fair Drawing Skill** • Drawing matches with given dimensions • Appropriate title provided to the drawing • Appropriately ruled guidelines used ✓ Ruled guidelines must be horizontally parallel to one another ✓ Ruled guidelines must not cross each other ✓ Ruled guidelines must not bear arrow heads ✓ Ruled guidelines must touch the exact part(s) of the flower
1	**Poor Drawing Skill** • Drawing matches with given dimensions • Appropriate title provided to the drawing
0	**No Drawing Skill** • No response/Drawing does not resemble the specimen

APPENDIX C

TASK B: CLASSIFYING

Instructions

You have 10 minutes to read carefully through the task and another 20 minutes to respond to the task on the worksheet. During the period of reading through the task, you may ask any question for clarification. You are expected to continue with task C at the end of the 20 minutes. This worksheet will be collected at the end of the entire period.

Scenario

Biologists need to put living organisms in the environment into the various taxa based on the characteristics that they possess which are peculiar to that group. On your table are four plant specimens namely: *Cyperus rotundus*, *Sida acuta*, *Commelina sp* and *Talinum triangulare* which are labelled B, C, D and E respectively.

Problem

Look at Specimens B, C, D and E carefully and classify them into the taxonomic classes of *Monocotyledoneae* and *Dicotyledoneae* based on observable characteristic features of the plants. Give at least **three (3)** corresponding reasons for classifying them into their respective classes in the table below

Class	*Monocotyledoneae*	*Dicotyledoneae*
Specimen(s)		
Reasons		

APPENDIX D

SCORING RUBRICS FOR TASK B

Score	Performance Criteria
5	**Excellent Classification Skill** • *Cyperus rotundus* (Specimen B) and *Commelina sp* (Specimen D) are monocotyledons. • *Sida acuta* (Specimen C) and *Talinum triangulare* (Specimen E) are dicotyledons. • *Cyperus rotundus* and *Commelina sp* have fibrous root system whereas *Sida acuta* and *Talinum triangulare* have tap root system. • *Cyperus rotundus* and *Commelina sp* have parallel venation in their leaves whereas *Sida acuta* and *Talinum triangulare* have net/reticulate venation in their leaves. • *Cyperus rotundus* and *Commelina sp* have leaf sheath at the base of the leaf whereas *Sida acuta* and *Talinum triangulare* have petiole at the base of the leaf.
4	**Very Good Classification Skill** • *Cyperus rotundus* (Specimen B) and *Commelina sp* (Specimen D) are monocotyledons. • *Sida acuta* (Specimen C) and *Talinum triangulare* (Specimen E) are dicotyledons. • *Cyperus rotundus* and *Commelina sp* have fibrous root system whereas *Sida acuta* and *Talinum triangulare* have tap root system. • *Cyperus rotundus* and *Commelina sp* have parallel venation in

	their leaves whereas *Sida acuta* and *Talinum triangulare* have net/reticulate venation in their leaves.
3	**Good Classification Skill** • *Cyperus rotundus* (Specimen B) and *Commelina sp* (Specimen D) are monocotyledons. • *Sida acuta* (Specimen C) and *Talinum triangulare* (Specimen E) are dicotyledons. • *Cyperus rotundus* and *Commelina sp* have fibrous root system whereas *Sida acuta* and *Talinum triangulare* have tap root system.
2	**Fair Classification Skill** • *Cyperus rotundus* (Specimen B) and *Commelina sp* (Specimen D) are monocotyledons. • *Sida acuta* (Specimen C) and *Talinum triangulare* (Specimen E) are dicotyledons.
1	**Poor Classification Skill** • *Cyperus rotundus* (Specimen B) and *Commelina sp* (Specimen D) are monocotyledons/*Sida acuta* (Specimen C) and *Talinum triangulare* (Specimen E) are dicotyledons.
0	**No Classification Skill** • No response/Wrong classification

APPENDIX E

TASK C: INTERPRETING

Instructions

You have 10 minutes to read carefully through the task and another 20 minutes to respond to the task on the worksheet. During the period of reading through the task, you may ask any question for clarification. You are expected to continue with task D at the end of the 20 minutes. This worksheet will be collected at the end of the entire period.

Scenario

A biology teacher planted four viable maize seeds in four empty tins of milk which contained moist loamy soil that were rich in organic matter and other conditions necessary for germination of seed. When the seeds germinated into maize seedlings, he measured the lengths of the four maize seedlings and selected two maize seedlings that were almost of equal lengths which he labelled A and B. He put plant A onto the field where conditions were favourable for starch to be produced in the plant and plant B into a dark room where one of the conditions necessary for starch to be produced in the plant was absent. He continuously supplied the same amount of water to the two plants and used a thread to measure the lengths of the plants at 5 days interval. He then transferred the measurements taken by the thread to a metre rule to determine the heights of the plants in centimetres. A graph of the growth rate of the two plants was plotted as shown in Figure 1.

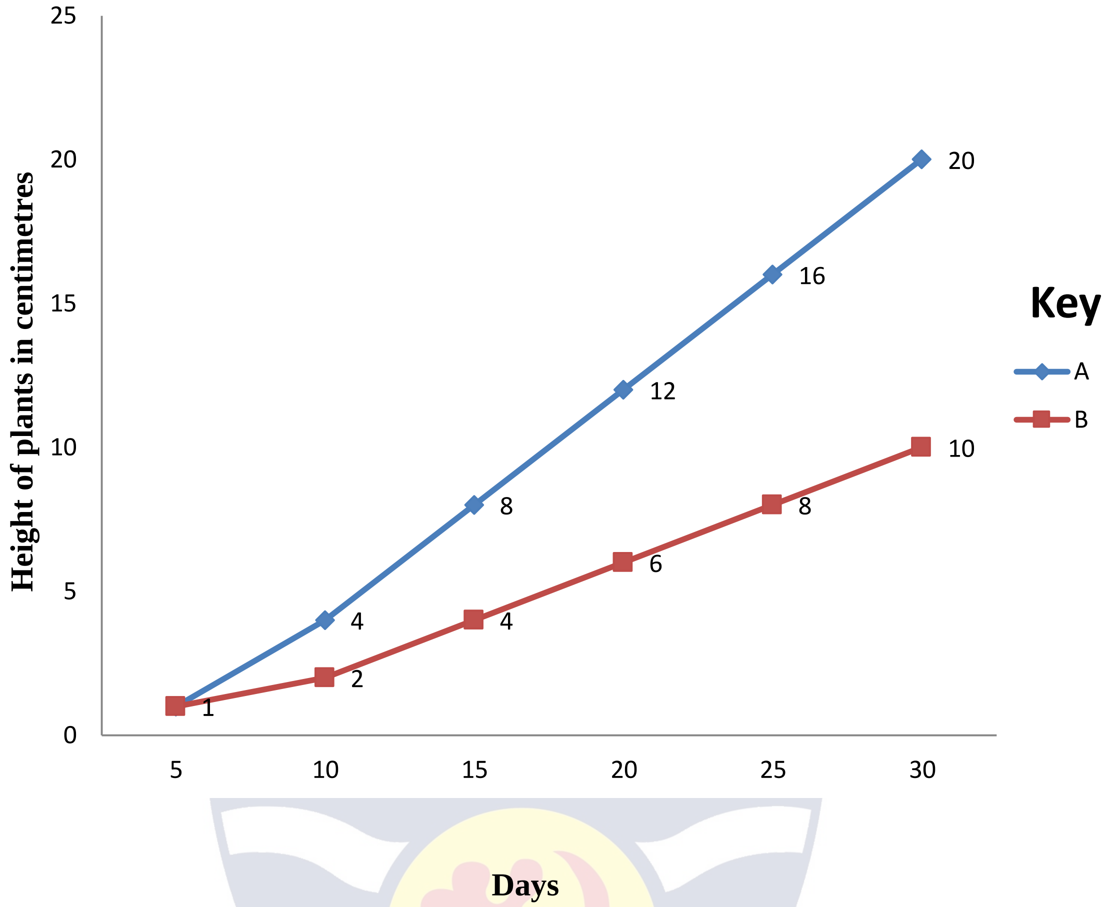

Figure 2: Growth rate of two maize plants.

Problem

Interpret the growth rate of the two maize plants and give reasons to support your argument.

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APPENDIX F

SCORING RUBRICS FOR TASK C

Score	Performance Criteria
5	**Excellent Interpretation Skill** • Plant A had increased in height more than plant B within the 25 days interval. • This had arisen because plant A was exposed to all the conditions necessary for starch to be produced/photosynthesis to occur. • Plant B was put into a dark room and, therefore, sunlight was absent/limiting factor for photosynthesis to occur. • Photosynthesis results in the growth rate of plants and had occurred at a higher rate in plant A than plant B, hence the increase in height of Plant A than Plant B. • For instance, the height of plant A on the 30th day was 20cm whereas that of plant B was 10cm.
4	**Very Good Interpretation Skill** • Plant A had increased in height more than plant B within the 25 days interval. • This had arisen because plant A was exposed to all the conditions necessary for starch to be produced/photosynthesis to occur. • Plant B was put into a dark room and, therefore, sunlight was absent/limiting factor for photosynthesis to occur.

	• Photosynthesis results in the growth rate of plants and had occurred at a higher rate in plant A than plant B, hence the increase in height of plant A than plant B.
3	**Good Interpretation Skill** • Plant A had increased in height more than plant B within the 25 days interval. • This had arisen because plant A was exposed to all the conditions necessary for starch to be produced/photosynthesis to occur. • Plant B was put into a dark room and, therefore, sunlight was absent/limiting factor for photosynthesis to occur.
2	**Fair Interpretation Skill** • Plant A had increased in height more than plant B within the 25 days interval. • This had arisen because plant A was exposed to all the conditions necessary for starch to be produced/photosynthesis to occur.
1	**Poor Interpretation Skill** • Plant A had increased in height more than plant B within the 25 days interval.
0	**No Interpretation Skill** • No response/Wrong interpretation

APPENDIX G

TASK D: HYPOTHESISING

Instructions

You have 10 minutes to read carefully through the task and another 20 minutes to respond to the task on the worksheet. During the period of reading through the task, you may ask any question for clarification. This worksheet will be collected at the end of the period.

Scenario

An ecologist placed two balsam plants which she labelled F and G with almost the same number of leaves and height into two different environments. Plant F was placed in an environment with conditions of high light intensity coupled with adequate soil moisture and air currents whilst plant G was placed in an environment with high humidity coupled with adequate soil moisture and air currents as found in the environment of plant F for the same period of time.

Problem

From the above scenario, how will the two plants lose water into the atmosphere? Give reasons to support your answer.

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APPENDIX H

SCORING RUBRICS FOR TASK D

Score	Performance Criteria
5	**Excellent Hypothesising Skill** • Plant F will lose water in the form of water vapour at a faster rate into the atmosphere than plant G. • This is because plant F was placed in an environment with high light intensity among other conditions. • The high light intensity facilitates the opening of the stomata for water to escape as water vapour into the atmosphere. • Plant G was placed in a humid environment among other factors. • In a humid environment, the stomata tend to close and thus reduce the exit of water in the form of water vapour from the plant into the atmosphere.
4	**Very Good Hypothesising Skill** • Plant F will lose water in the form of water vapour at a faster rate into the atmosphere than plant G. • This is because plant F was placed in an environment with high light intensity among other conditions. • The high light intensity facilitates the opening of the stomata for water to escape as water vapour into the atmosphere. • Plant G was placed in a humid environment among other factors.

3	**Good Hypothesising Skill** • Plant F will lose water in the form of water vapour at a faster rate into the atmosphere than plant G. • This is because plant F was placed in an environment with high light intensity among other conditions. • The high light intensity facilitates the opening of the stomata for water to escape as water vapour into the atmosphere.
2	**Fair Hypothesising** • Plant F will lose water in the form of water vapour at a faster rate into the atmosphere than plant G. • This is because plant F was placed in an environment with high light intensity among other conditions.
1	**Poor Hypothesising Skill** • Plant F will lose water in the form of water vapour at a faster rate into the atmosphere than plant G.
0	**No Hypothesising Skill** • No hypothesising/No response/Wrong hypothesis stated

APPENDIX I

INTERVIEW GUIDE FOR TEACHERS

INTRODUCTION

This interview guide seeks information on the frequency of organisation of Biology practical lessons as well as the factors that affect effective organisation of Biology practical lessons for the students to acquire science process skills in Senior High Schools. This exercise is for research purpose and, therefore, the information provided will be treated with confidentiality. You are, therefore, required to be honest with your responses in order to improve upon the organisation of Biology practical lessons which will facilitate the acquisition of science process skills by students. Thank you.

SECTION A: BACKGROUND INFORMATION

School Code:……………………………………………………………….

Sex:

Male [ ]

Female [ ]

Academic Qualification……………………………………………………

Professional Qualification…………………………………………………..

Teaching Experience……………………………………………………….

SECTION B: FREQUENCY OF BIOLOGY PRACTICAL LESSONS

1. How frequent do you organise Biology practical activities for your students?

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2. Approximately, how many practical activities do your students carry out in a term?

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SECTION C: FACTORS THAT AFFECT EFFECTIVE ORGANISATION OF BIOLOGY PRACTICAL ACTIVITIES FOR ACQUISITION OF SCIENCE PROCESS SKILLS

1 (a) Do you organise Biology practical activities based on most topics in the syllabus? Give reasons for your answer.

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(b) What are the topics on which students have carried out practical activities?

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(c) What specific activities have they carried out under those topics?

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2 (a) Do you have a laboratory for Biology practical activities?

A. Yes [ ]

B. No [ ]

(b_1) If yes, is the laboratory equipped with the necessary materials and tools for Biology practical activities?

A. Yes [ ]

B. No [ ]

(b_2) If the laboratory is not equipped with the necessary materials and tools, what are some of the necessary materials and tools that are lacking in the laboratory for effective organisation of Biology practical activities?

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(c) If you are not having a laboratory for practical activities, where do you organise Biology practical activities for your students?

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3. Do you have a qualified Biology laboratory assistant to help you in organising Biology practical activities? Give reasons for your answer.

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4(a) Do your students carry out Biology practical activities individually or in groups? Give reasons for your answer.

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(b) If Biology practical activities are carried out in groups, how many students form a group?

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(c) If students are too many in a group, how does it affect the practical work?

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(d) If Biology practical activities are carried out in groups, how do you form the groups during practical activities?

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5 (a) Do you have separate periods for teaching the theory and practical lessons in Biology on your school time table?

A. Yes [ ]

B. No [ ]

(b_1) If yes, how many times do you have practical activities in a week?

…………………………………………………………………………………

…………………………………………………………………………………

(b_2) If no, what time do you organise Biology practical activities for your students?

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(c) If instructional periods are used for practical activities, do your students get enough time to carry out the practical activities? Give reasons for your answer.

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6 (a) Are funds made available by the school authorities for the purchase of materials and equipment for Biology practical activities? Give reasons for your answer.

....

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(b) What do you do if funds are not made available by the school authorities for the purchase of materials and equipment for Biology practical activities?

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....

7. Do you have a Biology Practical Guide book to serve as a resource/reference material for organising practical activities? Give reasons for your answer.

....

....

8 (a) What are the challenges that you face in organising Biology practical activities for your students? Give reasons for your answer.

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(b) How do you overcome the challenges?

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(c) Do you document the challenges and their possible solutions for future reference? Give reasons for your answer.

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9. Have you ever attended any in-service training to update and upgrade your knowledge and skills required for effective organisation of practical activities? Give reasons for your answer.

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10. When was the last in-service training you attended?

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APPENDIX J

INTERVIEW GUIDE FOR STUDENTS

INTRODUCTION

This interview guide seeks information on the frequency of organisation of Biology practical lessons as well as the factors that affect effective organisation of Biology practical lessons for the students to acquire science process skills in Senior High Schools. This exercise is for research purpose and, therefore, the information provided will be treated with confidentiality. You are, therefore, required to be honest with your responses in order to improve upon the organisation of Biology practical lessons which will facilitate the acquisition of science process skills by students. Thank you.

SECTION A: BACKGROUND INFORMATION

School Code……………………………………………………………………

Type of School:

Mixed sex [ ]

Single sex [ ]

Age:..

Class:..

SECTION B: FREQUENCY OF BIOLOGY PRACTICAL LESSONS

1. How frequent do you carry out Biology practical activities?

....

....

2. Approximately, how many practical activities do you carry out in a term?

....

....

SECTION C: FACTORS THAT AFFECT EFFECTIVE ORGANISATION OF BIOLOGY PRACTICAL ACTIVITIES FOR ACQUISITION OF SCIENCE PROCESS SKILLS

1(a) What are the topics on which you have carried out practical activities?

....

....

....

(b) What specific activities did you carry out under those topics?

....

....

....

2 (a) Do you have a laboratory for Biology practical activities?

C. Yes [ ]

D. No [ ]

(b_1) If yes, is the laboratory equipped with the necessary materials and tools for Biology practical activities?

A. Yes [ ]

B. No [ ]

(b_2) If the laboratory is not equipped with the necessary materials and tools, what are the necessary materials and tools that are lacking in the laboratory for effective Biology practical activities?

....

....

....

(c) If you are not having a laboratory for practical activities, where do you carry out Biology practical activities?

....

....

3 (a) Do you have a qualified Biology laboratory assistant to help you in carrying out Biology practical activities? Give reasons for your answer.

....

....

....

(b) If you do not have a qualified Biology laboratory assistant to help you during practical activities, from whom do you get assistance during Biology practical activities?

....

....

4 (a) Do you carry out Biology practical activities individually or in groups? Give reasons for your answer.

....

....

....

(b) If Biology practical activities are carried out in groups, how many students form a group?

....

....

(c) When you are too many in a group for a practical activity, how does it affect you?

……………………………………………………………………………………

……………………………………………………………………………………..

(d) If Biology practical activities are carried out in groups, how do you form the groups?

……………………………………………………………………………………

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5(a) Do you have separate periods for the theory and practical lessons in Biology on your school time table?

A. Yes [ ]

B. No [ ]

(b_1) If yes, how many times do you have practical activities in a week?

....

....

(b2) If no, what time do you engage in Biology practical activities?

....

....

(c) If instructional periods are used for practical activities, do you get enough time to carry out the practical activities? Give reasons for your answer.

....

....

....

6 (a) What are the challenges that you face in carrying out Biology practical activities?

....

....

....

(b) How do you overcome the challenges?

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………………………………………………………………………………………

(c) Do you document the challenges and their possible solutions for future reference? Give reasons for your answer.

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APPENDIX K

GUIDE/FRAMEWORK FOR ANALYSING BIOLOGY PRACTICAL WORKBOOK OF STUDENTS.

Topic	Practical Activities Carried out by Students	Science Process Skills Exposed to by Teachers

APPENDIX L

GUIDE/FRAMEWORK FOR ANALYSING BIOLOGY SYLLABUS AND TEXTBOOK

Total number of units	Year One	Year Two	Year Three

APPENDIX M

INTERRATER RELIABILITY TABLES

Number of scores	TASK A: DRAWING		TASK B: CLASSIFYING	
	Rater One	Rater Two	Rater One	Rater Two
1	2	2	3	3
2	1	1	1	1
3	0	0	2	2
4	3	2	2	2
5	1	1	2	2
6	1	1	2	2
7	2	2	2	2
8	1	1	2	1
9	3	3	3	3
10	1	1	0	0
11	2	2	2	2
12	2	2	1	2
13	3	2	2	2
14	0	0	2	2
15	2	2	0	0
16	3	3	2	3
17	2	2	4	4
18	1	1	3	3
19	2	2	1	1

20	1	1	2	2
21	3	2	3	2
22	1	1	1	1
23	3	3	2	1
24	1	1	2	2
25	2	2	1	1
26	2	2	1	1
27	2	2	3	3
28	3	3	2	2
29	3	3	0	0
30	1	2	3	3
31	2	2	1	1
32	3	3	0	0
33	1	1	1	2
34	2	2	1	1
35	2	2	2	2
36	1	1	3	3
37	1	1	2	2
38	3	2	1	1
39	3	4	2	2
40	2	1	3	3

Source: Field Work, 2018

According to Miles and Huberman (1994), interrater/intercoder reliability

$$= \frac{Number\ of\ agreements}{Total\ number\ of\ agreements + disagreements}\ X\ 100\%$$

Total number of agreements + disagreements

$$= \frac{33}{33+7}\ X\ 100\%$$

$$= \frac{33}{40}\ X\ 100\%$$

= 82.50% for Task A.

Interrater/intercoder reliability for Task B

$$= \frac{Number\ of\ agreements}{Total\ number\ of\ agreements + disagreements}\ x\ 100\%$$

$$= \frac{34}{34+6}\ x\ 100\%$$

$$= \frac{34}{40}\ x\ 100\%$$

= 85% for Task B

Number of scores	TASK C: INTERPRETING		TASK D: HYPOTHESISING	
	Rater One	Rater Two	Rater One	Rater Two
1	4	4	3	3
2	2	2	1	1
3	0	0	1	1
4	3	3	2	2
5	4	4	1	2
6	3	3	1	1
7	2	1	0	0
8	4	4	1	1
9	1	2	2	3
10	0	0	1	1
11	3	3	3	3
12	2	2	0	0
13	1	2	1	1
14	4	3	0	0
15	2	2	1	1
16	3	3	2	2
17	1	1	2	2
18	2	2	1	2
19	3	3	2	2
20	4	4	1	2
21	4	4	3	2

22	0	0	3	3
23	2	1	2	2
24	3	3	2	2
25	3	3	1	1
26	3	3	3	3
27	0	0	0	0
28	5	5	1	1
29	2	2	1	1
30	3	3	0	0
31	3	3	3	3
32	3	3	0	0
33	4	4	1	1
34	3	2	2	2
35	2	2	4	4
36	3	3	2	2
37	4	3	1	1
38	2	2	0	0
39	2	2	2	2
40	1	1	2	1

Source: Field Work, 2018.

According Miles Huberman (1994), interrater/intercoder reliability

$$= \frac{Number\ of\ agreements}{Total\ number\ of\ agreements + disagreements}\ x\ 100\%$$

$$= \frac{33}{33+7}\ x\ 100\%$$

$$= \frac{33}{40}\ x\ 100\%$$

= 82.50% for Task C

Interrater/intercoder reliability for Task D

$$= \frac{Number\ of\ agreements}{Total\ number\ of\ agreements + disagreements}\ x\ 100\%$$

$$= \frac{32}{32+8}\ x\ 100\%$$

$$= \frac{32}{40}\ x\ 100\%$$

= 80% for Task D

APPENDIX N

MULTIPLE COMPARISONS TABLE

Tukey HSB: Multiple Comparisons

Dependent Variable	(I) Type of schools	(J) Type of schools	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Drawing	School A	School B	-.35	.196	.476	-.91	.21
		School C	.30	.196	.644	-.26	.86
		School D	.40	.196	.321	-.16	.96
		School E	.50	.196	.113	-.06	1.06
		School F	-.15	.196	.973	-.71	.41
	School B	School A	.35	.196	.476	-.21	.91
		School C	.65*	.196	.013	.09	1.21
		School D	.75*	.196	.002	.19	1.31
		School E	.85*	.196	.000	.29	1.41
		School F	.20	.196	.910	-.36	.76
	School C	School A	-.30	.196	.644	-.86	.26
		School B	-.65*	.196	.013	-1.21	-.09
		School D	.10	.196	.996	-.46	.66
		School E	.20	.196	.910	-.36	.76
		School F	-.45	.196	.199	-1.01	.11
	School D	School A	-.40	.196	.321	-.96	.16
		School B	-.75*	.196	.002	-1.31	-.19
		School C	-.10	.196	.996	-.66	.46
		School E	.10	.196	.996	-.46	.66
		School F	-.55	.196	.059	-1.11	.01
	School E	School A	-.50	.196	.113	-1.06	.06
		School B	-.85*	.196	.000	-1.41	-.29
		School C	-.20	.196	.910	-.76	.36
		School D	-.10	.196	.996	-.66	.46
		School F	-.65*	.196	.013	-1.21	-.09
	School F	School A	.15	.196	.973	-.41	.71
		School B	-.20	.196	.910	-.76	.36
		School C	.45	.196	.199	-.11	1.01
		School D	.55	.196	.059	-.01	1.11

		School E	.65*	.196	.013	.09	1.21
Classifying	School A	School B	.50	.263	.403	-.26	1.26
		School C	.57	.263	.247	-.18	1.33
		School D	1.03*	.263	.002	.27	1.78
		School E	1.72*	.263	.000	.97	2.48
		School F	1.38*	.263	.000	.62	2.13
	School B	School A	-.50	.263	.403	-1.26	.26
		School C	.07	.263	1.000	-.68	.83
		School D	.52	.263	.347	-.23	1.28
		School E	1.22*	.263	.000	.47	1.98
		School F	.88*	.263	.013	.12	1.63
	School C	School A	-.57	.263	.247	-1.33	.18
		School B	-.07	.263	1.000	-.83	.68
		School D	.45	.263	.525	-.31	1.21
		School E	1.15*	.263	.000	.39	1.91
		School F	.80*	.263	.031	.04	1.56
	School D	School A	-1.03*	.263	.002	-1.78	-.27
		School B	-.52	.263	.347	-1.28	.23
		School C	-.45	.263	.525	-1.21	.31
		School E	.70	.263	.087	-.06	1.46
		School F	.35	.263	.767	-.41	1.11
	School E	School A	-1.72*	.263	.000	-2.48	-.97
		School B	-1.22*	.263	.000	-1.98	-.47
		School C	-1.15*	.263	.000	-1.91	-.39
		School D	-.70	.263	.087	-1.46	.06
		School F	-.35	.263	.767	-1.11	.41
	School F	School A	-1.38*	.263	.000	-2.13	-.62
		School B	-.88*	.263	.013	-1.63	-.12
		School C	-.80*	.263	.031	-1.56	-.04
		School D	-.35	.263	.767	-1.11	.41
		School E	.35	.263	.767	-.41	1.11
Interpreting	School A	School B	.42	.247	.518	-.28	1.13
		School C	.63	.247	.118	-.08	1.33
		School D	1.05*	.247	.000	.34	1.76
		School E	1.25*	.247	.000	.54	1.96
		School F	.85*	.247	.009	.14	1.56
	School B	School A	-.42	.247	.518	-1.13	.28
		School C	.20	.247	.965	-.51	.91
		School D	.63	.247	.118	-.08	1.33

		School E	.83*	.247	.012	.12	1.53
		School F	.43	.247	.518	-.28	1.13
		School A	-.63	.247	.118	-1.33	.08
		School B	-.20	.247	.965	-.91	.51
	School C	School D	.42	.247	.518	-.28	1.13
		School E	.63	.247	.118	-.08	1.33
		School F	.23	.247	.943	-.48	.93
		School A	-1.05*	.247	.000	-1.76	-.34
		School B	-.63	.247	.118	-1.33	.08
	School D	School C	-.42	.247	.518	-1.13	.28
		School E	.20	.247	.965	-.51	.91
		School F	-.20	.247	.965	-.91	.51
		School A	-1.25*	.247	.000	-1.96	-.54
		School B	-.83*	.247	.012	-1.53	-.12
	School E	School C	-.63	.247	.118	-1.33	.08
		School D	-.20	.247	.965	-.91	.51
		School F	-.40	.247	.585	-1.11	.31
		School A	-.85*	.247	.009	-1.56	-.14
		School B	-.43	.247	.518	-1.13	.28
	School F	School C	-.23	.247	.943	-.93	.48
		School D	.20	.247	.965	-.51	.91
		School E	.40	.247	.585	-.31	1.11
		School B	.30	.222	.755	-.34	.94
		School C	.32	.222	.687	-.31	.96
	School A	School D	.67*	.222	.031	.04	1.31
		School E	.77*	.222	.007	.14	1.41
		School F	.80*	.222	.005	.16	1.44
		School A	-.30	.222	.755	-.94	.34
		School C	.03	.222	1.000	-.61	.66
Hypothesizing	School B	School D	.38	.222	.540	-.26	1.01
		School E	.48	.222	.270	-.16	1.11
		School F	.50	.222	.218	-.14	1.14
		School A	-.32	.222	.687	-.96	.31
		School B	-.03	.222	1.000	-.66	.61
	School C	School D	.35	.222	.614	-.29	.99
		School E	.45	.222	.329	-.19	1.09
		School F	.48	.222	.270	-.16	1.11

	School A	-.67*	.222	.031	-1.31	-.04
	School B	-.38	.222	.540	-1.01	.26
School D	School C	-.35	.222	.614	-.99	.29
	School E	.10	.222	.998	-.54	.74
	School F	.13	.222	.993	-.51	.76
	School A	-.77*	.222	.007	-1.41	-.14
	School B	-.48	.222	.270	-1.11	.16
School E	School C	-.45	.222	.329	-1.09	.19
	School D	-.10	.222	.998	-.74	.54
	School F	.03	.222	1.000	-.61	.66
	School A	-.80*	.222	.005	-1.44	-.16
	School B	-.50	.222	.218	-1.14	.14
School F	School C	-.48	.222	.270	-1.11	.16
	School D	-.13	.222	.993	-.76	.51
	School E	-.03	.222	1.000	-.66	.61

Based on observed means.

The error term is Mean Square (Error) = .984.

*. The mean difference is significant at the .05 level.

APPENDIX O

TUKEY HSD: MULTIPLE COMPARISONS: CATEGORISATION OF SCHOOLS

Dependent Variable	(I) Categorization of schools	(J) Categorization of schools	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Drawing	Well-endowed schools	Endowed schools	.52*	.142	.001	.19	.86
		Less endowed schools	.35*	.142	.038	.02	.68
	Endowed schools	Well-endowed schools	-.52*	.142	.001	-.86	-.19
		Less endowed schools	-.17	.142	.434	-.51	.16
	Less endowed schools	Well-endowed schools	-.35*	.142	.038	-.68	-.02
		Endowed schools	.17	.142	.434	-.16	.51
Classifying	Well-endowed schools	Endowed schools	.55*	.188	.010	.11	.99
		Less endowed schools	1.30*	.188	.000	.86	1.74
	Endowed schools	Well-endowed schools	-.55*	.188	.010	-.99	-.11
		Less endowed schools	.75*	.188	.000	.31	1.19
	Less endowed schools	Well-endowed schools	-1.30*	.188	.000	-1.74	-.86
		Endowed schools	-.75*	.188	.000	-1.19	-.31
Interpreting	Well-endowed	Endowed schools	.63*	.176	.001	.21	1.04

	schools	Less endowed schools	.84*	.176	.000	.42	1.25
	Endowed schools	Well-endowed schools	-.63*	.176	.001	-1.04	-.21
		Less endowed schools	.21	.176	.452	-.20	.63
	Less endowed schools	Well endowed schools	-.84*	.176	.000	-1.25	-.42
		Endowed schools	-.21	.176	.452	-.63	.20
Hypothesising	Well-endowed schools	Endowed schools	.35	.157	.069	-.02	.72
		Less endowed schools	.64*	.157	.000	.27	1.01
	Endowed schools	Well-endowed schools	-.35	.157	.069	-.72	.02
		Less endowed schools	.29	.157	.163	-.08	.66
	Less endowed schools	Well-endowed schools	-.64*	.157	.000	-1.01	-.27
		Endowed schools	-.29	.157	.163	-.66	.08

Based on observed means.
The error term is Mean Square (Error) = .990.
*. The mean difference is significant at the .05 level.

APPENDIX P

INTRODUCTORY LETTER

UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF SCIENCE EDUCATION

Tel: 03320 96801/96951
Email: dse@ucc.edu.gh
Website: www.ucc.edu.gh

University Post Office
Cape Coast
Ghana

Your Ref:
Our Ref: DSE/ S.3/V.1/150

22nd November, 2017.

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF INTRODUCTION

We write on behalf of **Mr. Eric Manfred Dah,** an M.Phil (Science Education) student with registration number **ED/SCP/15/0008** who has been assigned to collect some data at your School.

Mr. Dah is conducting a research on the topic: "**Assessing Science Process Skills of Biology Students in Flowering Plants at Senior High Schools.**"

We therefore write to introduce and humbly request that you grant him the needed assistance.

Counting on your usual cooperation.

Thank you.

Yours faithfully,

Eugene A. Johnson
HEAD OF DEPARTMENT