UNIVERSITY OF EDUCATION, WINNEBA

DETERMINING THE PLANNING, INTEPRETING AND REASONING SKILLS OF STUDENTS IN BIOLOGY LABORATORY WORK

FREDERICK OWUSU

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DECLARATION

CANDIDATE'S DECLARATION

I, Frederick Owusu, declare that this dissertation with exception of quotations and references contained in published works which have all been identified and acknowledged, is entirely my own work, and it has not been submitted, either in parts or whole for another degree elsewhere.

Signature: …………………………………………

Date: ……………………………………………..

SUPERVISOR'S DECLARATION

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

Dr. Yeboah Kwaku Opoku (Supervisor)

Signature: …………………………………………

Date: ……………………………………………

DEDICATION

I dedicate this dissertation to my loving wife Mrs. Patricia Owusu, my children Cater Owusu Ofosu, Penuel Owusu Ofosu and Ansley Owusu Ofosu Adomako as well as my dear friend Yahaya Appiah.

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ABSTRACT

Over the years, the West African Examination Council Chief Examiner's reports in Biology have identified students' persistent weaknesses in following the correct sequence in describing experiments and offering explanations from certain observations. Students are also unable to explain and describe scientific methods and set-ups accurately, and draw correct conclusions from experimental data and results. The purpose of the study was to determine the competency of SHS biology students in planning, Interpreting and reasoning skills. The study adopted the "Basic Skills Assessment approach. The sample used for the study consisted of 180 SHS 3 elective biology students drawn from a mixed, boys and a girls' school each from grade 'A', grade 'B' and grade 'C' schools in some selected senior high schools in the Ashanti Region of Ghana. The instruments used for data collection were Performance Assessment Tasks under the heading Planning, Interpreting and Reasoning Tasks. Some of the key findings of the study included students' difficulty in giving detailed planning (45.56%), providing appropriate diagrams (43.89%) and safety precautions (48.33%) to experiments they engage in. Inability of students to draw correct conclusions from experimental data and results (38.89%) stands from the fact that they have problems establishing relationship between two variables. One of the recommendations from the study urges teachers to insist on detailed planning and inclusion of safety precautions and appropriate diagrams in students' write-up of experiments.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter is devoted to the background of the problem and other relevant introductory sections that include the research questions. The significance of the study, delimitations and limitations are also provided in this chapter.

1.1 Background to the Study

Assessment in education generally refers to a process for obtaining information that is used for making decisions about students, curricula, programs and educational policy. Idika and Eke, (2017) defined assessment as the global process of synthesizing information about individuals so as to describe, understand and perhaps help them better. He argues that assessment is a process and involves the collection of meaningful information to understand and help people cope with a problem.

According to Westminster.edu, Assessment is the process of gathering and discussing information from multiple and diverse sources in order to develop a deep understanding of what students know, understand, and can do with their knowledge as a result of their educational experiences. The process culminates when assessment results are used to improve subsequent learning. Globally, assessment is the basis for educational planning. In science education, it is the mechanism whose data provide students with feedback on how well they are meeting the expectations of their teachers and parents (Naah, Mayeem, Adjei, and Ossei-Anto, 2018). Assessment also provides teachers with feedback on how well their students are learning.

Performance assessment has long been part of science education (Naah, Mayeem, Adjei, and Ossei-Anto, 2018). According to Altbach, Reisberg, and Rumbley (2019), those to be assessed in performance assessment are to demonstrate to data gathered by personal observations. Laboratory work permits students to plan and to participate in investigations or to take part in activities that help them improve their manipulative skills. Darling-Hammond, Hyler, and Gardner, (2017) have reported that as a result of learning practical skills and scientific learning methods, students experience an increase in motivation and teachers gain the opportunity to evaluate the knowledge of their students.

Laboratory work in science education has been discussed for several decades. Teachers, researchers and policy makers are convinced about its value for understanding science (Wei, Chen, and Chen, 2019). The role of laboratory work and field studies has been elaborated by Fadzil and Saat, (2017). The purpose of laboratory work in science education includes; helping students learn science through the acquisition of conceptual and theoretical knowledge. Again, it helps them learn about science by developing an understanding of the nature and methods of science. Also, laboratory work enables students to do science using the protocols of scientific inquiry. The increased support for purposeful learning complements scientific theories and how to apply them. Furthermore, laboratory work should stimulate the development of analytical and critical skills and create interest in science.

Currently, science educators and teachers agree that laboratory work is indispensible to the understanding of science (Chiu, Lin, and Tsai, 2016; Akuma and Callaghan, 2019). The main purpose of laboratory work in science education is to provide students with conceptual and theoretical knowledge to help them learn scientific concepts, and through scientific methods, to understand the nature of science. Laboratory work also gives the students the opportunity to experience science by using scientific research procedures. In order to achieve a meaningful learning, scientific theories and their application methods should be experienced by students. Moreover, laboratory work should encourage the development of analytical and critical thinking skills and encourage interest in science (Akuma and Callaghan, 2019).

There is a concern about the effectiveness of laboratory work in helping students understand various aspects of scientific inquiry (Fitzgerald, Danaia, and McKinnon, 2019). Often, teachers desire to develop students' higher order thinking skills. eg. critical thinking. However, their assessment practices do not reflect these global achievement goals (Akuma and Callaghan, 2019). It is well- known that, the assessment model used influences how and what students learn (Boud, 2013). It is not known how teachers assess laboratory work skills or whether all laboratory work is included in their assessment. Moreover, it is not known how the assessment criteria are applied. What the teacher wants to achieve with laboratory work and what students actually learn in different laboratory contexts require more attention. Understanding these goals and results will determine the type of assessment to use when science learning processes are emphasized. When students are tested in practical skills eg. Planning, carrying out experiments and investigation outcome is distinctly different from what can be tested by conventional pen and paper tests (Zulaiha, Mulyono, and Ambarsari, 2020)

The main goal of laboratory work is to connect theory to practice i.e., familiarise the students with scientific objects and phenomena, and to stimulate interest and enjoyment (Akuma and Callaghan, 2019). Another goal of laboratory work is to teach laboratory skills and techniques. According to Akuma & Callaghan (2019), laboratory work also allows students to confront and challenge their misconceptions and provide opportunities for informal discussions about the theories, models and concepts.

The curriculum states that laboratory work should include inquiry skills, identifying problems, generating research questions, planning and conducting investigation, formulating, communicating, and defending explanations (Lederman, et al., 2014). A study by Akuma and Callaghan (2019), however, shows that most laboratory work do not cover this goal. Thus, laboratory work in schools should require more inquiry methods such as planning and design (Adlim, Nuzulia, and Nurmaliah, 2018).

In spite of efforts to better define the purposes and role of laboratory work in science education, research has shown that teachers see laboratory activities as contrived (Chiu, Lin, and Tsai, 2016). In general, teachers cannot see laboratory activities as conceptually integrated with theoretical science lessons. In addition, teachers fail to understand that laboratory activities may provide opportunities for students to produce new knowledge through scientific investigations. According to a research conducted by Lederman (2013), teachers perceive laboratory work solely as an activity for the purpose of verification. Researcher have also uncovered that teachers' do not think of the laboratory as an environment where scientific knowledge claims are discussed.

Different reasons have been given for the problems relating to laboratory work. According to Good and Lavigne (2017), problems in their capabilities directly by creating some product or engaging in some activity. Naah, Mayeem, Adjei, and Ossei-Anto (2018), states that, performance assessment is of many forms and shapes depending on such factors as the subject matter, the class or grade level of the students, students' previous experiences in science and the time available for the period of the assessment.

The keystone of performance assessment is the use of graded authentic task. An authentic task is one in which students are required to address problems grounded in real-life contexts. In the context of science laboratory, students are graded on the performance of manipulating variables, using scientific apparatus, identifying hypotheses, making measurements and calculations, organizing and managing data, and the communication of results (Adnan and Bulut, 2014). Graded laboratory performances go beyond grading a final field report. This strategy considers the processes that become the laboratory report as well. In the evaluation of a performance task, the process of performing the task is emphasized more than the final product itself.

In assessing any science process skills, one could develop assessment instrument that is valid, reliable, and usable. Such instrument should also be independent, complete and unique (ICU). According to Naah, Mayeem, Adjei, and Ossei-Anto, (2018), to validate the construct and content of an instrument, the instrument needs to be subjected to the judgment of experts. They were also of the view that a valid assessment instrument does not automatically make other assessment instruments valid, even if they are correlated to each other.

Practical work in the laboratory gives students concrete learning experiences in which they explore new ideas and relate concepts and theories. Some researchers on the other hand, claim that the laboratory, instead of being a place for science and experiments, has become a place where tasks set by the teacher are carried out. No attention is given to the methods or purposes during laboratory work, only the set tasks are carried out (National Research Council, 2012). George-Williams, Ziebell, Kitson, Coppo, Thompson, and Overton, (2018) have connected the problems with laboratory work to a poor evaluation of the purposes of the tasks undertaken in the laboratory.

Wei & Li (2017), examined science teachers thinking on the nature and purpose of practical work in the context of the National Curriculum for Science in England. Data was collected through individual interviews with science teachers about their classroom practice. The findings suggest that little attention is being given to procedural understanding in terms of ideas relating to the quality of data. It is argued that this is a key limiting factor in the development of students' ability to engage in genuine investigative work.

Akuma and Callaghan, (2019) investigated the ideas of biology teachers on the role of laboratory work. According to the results of this study, teachers agree that laboratory work is an important part of biology and science lessons. However, teachers focus on the most common purposes of laboratory work. Such as building the connection between theory and practice and increasing motivation. Furthermore, teachers do not consider the purposes of laboratory work as being concerned with scientific process skills. Moreover, the interpretation of the leaning outcomes of experimental activities differs between students and teachers.

The importance of laboratory work in science education is well known. However, there is a lack of clarity regarding the purposes of laboratory work and the perceptions and experiences of the students do not conform to known purposes (DeKorver and Towns, 2015). It is important that biology students and teachers' ideas about the purposes of laboratory work is understood in order for the expected outcomes to be acquired from laboratory work and for the proper planning of lessons.

Jailani, Sugiman, and Apino, (2017) have reported that the goal of performance assessment is to provide scores for students' efforts in science processes used during an inquiry. Newman (as cited in Naah, Mayeem, Adjei, and Ossei-Anto, (2018) found out that "students did not exhibit appropriate proficiency in laboratory skills if they were exposed to only traditional laboratory work. According to Tamir (as cited in Naah, Mayeem, Adjei, and Ossei-Anto, (2018) "when students are exposed to more laboratory activities and experiences, they score much higher on practical skills on performance-based assessments"

How students engage in laboratory activities also influences how and what they learn (Kober, 2015), Laboratory work is to engage students in finding out and "learning how through first hand experiences. On how the type of school influences the planning, interpreting and reasoning skills of SHS biology students, research findings suggest that girls do better in certain subject areas such as Mathematics and Science when boys are not in the class (Robinson and Gilibrand, 2004). In girls-only Mathematics and Science classrooms, research indicates that girls are engaged in learning more of the time; show more cooperative learning behavior and identity better with their female classmates than when they are in co-educational classes.

1.2 Statement of the Problem

One of the general aims of the Teaching Syllabus for Biology (Senior High School) emphasizes the "development of practical skills required to work with scientific equipment, biological materials and living things" (Ministry of Education, 2010). In line with this, the need to teach Biology is to guide and inculcate in the learner, skills in observing and measuring, formulating hypothesis, predicating and designing, investigating, recording data and interpreting results, drawing conclusions and communicating them (Ministry of Education, 2010). Yet, WAEC Chief Examiners for Biology have over the years reported of students' weaknesses in scientific skills such as planning, performing, reasoning and predicting. A number of specific students' weaknesses reported by Chief Examiners raise serious questions whether students are not taken through laboratory work or there is lack of diligence attached to it. Some of the persistent weaknesses identified by Chief Examiners for Biology over the years (WAEC, 2019) were as follows:

a. Failure of candidates to follow the correct sequence in describing experiments and offering explanations from certain observations
b. Some candidates were not able to explain and describe scientific methods and scientific set-ups accurately.
c. Inability of students to draw correct conclusions from experimental data and results.
d. Inability of students to explain data for graphs.
e. Inaccurate drawing.

A study by Akuma and Callaghan, (2019) shows that most laboratory work does not cover inquiry skills: identifying problems, planning and conducting investigations, communicating and defending explanations. Naah et al. (2018) found out that students did not exhibit appropriate proficiency in laboratory skills if they were exposed to only traditional laboratory work.

It is not clear whether students' demonstration of inadequate competency in scientific skills lies with the type of school of students or the frequency with which laboratory work is organized. It would therefore be necessary to assess the laboratory skills of SHS biology students in order to help determine their competency in science laboratory skills such as planning, interpreting and reasoning.

1.3 Purpose of the Study

The purpose of the study was to determine the competency of SHS biology students in planning, interpreting and reasoning skills, and to determine if the type of school and gender has influence on the proficiency in demonstrating planning, interpreting and reasoning skills.

1.4 Research Objectives

The study was guided by the following research objectives

1. Determine the level of proficiency shown by SHS biology students in the skills of planning, interpreting and reasoning when involved in a laboratory work.
2. Determine the relationship between the type of schools and the planning, interpreting and reasoning skills of SHS biology students.
3. Determine which gender shows more proficiency in the skills of planning, interpreting and reasoning.

1.5 Research Questions

The research questions that were addressed by the study are as follows:

1. What is the level of proficiency shown by SHS biology students in the skills of planning, interpreting and reasoning when involved in a laboratory work?
2. What is the relationship between the type of schools and the planning, interpreting and reasoning skills of SHS biology students?
3. Does gender affect skills of planning, interpreting and reasoning?

1.6 Significance of the Study

The findings of this study will inform biology teachers to adapt their teaching methods to meet the level of proficiency required by the students to be able to plan, to make valid inferences and also to perform laboratory activities with precision.

According to Ministry of Education, (2010), one of the general aims to be achieved in elective biology course is that the student should be able to develop practical skills required to work with scientific equipment, biological materials and living things. With this aim of the MOE, biology teachers should look for avenues to provide learning situations that will offer the students to develop the skills and habits of mind that yield and refine scientific knowledge, integrating the learning and application of content knowledge and process skills.

Therefore, the findings of this study are expected to help or motivate teachers to use all appropriate methods to provide learning situations that will help the students. It will also motivate students to engage in worthwhile task and problem-solving activities that demand the students' use of acquired requisite knowledge effectively and creatively

It is also hoped that the findings of this study will focus attention on critical issues for curriculum developers, Ghana Education Service and the West Africa Examination Council to include more inquiry skills in science laboratory work.

1.7 Delimitations

This study was confined to only three of the science process skills. These were planning, interpreting and reasoning. The task that was designed for assessing the proficiency of the students in those skills was limited to only topics in biological pest control, food test and soil in biology. The study also focused on SHS3 biology students because it was assumed that by year 3 in SHS, a biology student might have had at least two years' experience of developing his/her science process skills in planning, interpreting and reasoning.

1.8 Limitation

The study focusing on selecting one school each across the various grades of classification of SHS in Ghana Education Service in the Ashanti Region of Ghana may place a limitation on the study. This is because findings may not apply to all schools in the country

1.9 Organization of the Study

The remaining chapters of the thesis are organized as follows: Chapter Two discusses literature related to the study. Chapter Three describes the Methodology used in the study, that is, the research design; research instrument, sample, procedure for data collection and the data analysis are discussed.

In Chapter Four, the findings are presented and discussed in relation to the research questions. Finally, Chapter Five gives the summary, conclusions, recommendations and areas for further research.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Overview

In this chapter, literature relating to assessment of laboratory skills are reviewed and discussed. Literature review discusses Definition of Laboratory Work, Need for Laboratory Work in Biology, Laboratory skill. The review also discusses Assessment, Performance Assessment in Science, etc.

2.1 Laboratory work

Laboratory work engages students in 'finding out' and 'learning how' through first-hand experiences (Enweronu-Laryea, et. al., 2013). According to Setiawan, Innatesari, Sabtiawan, & Sudarmin, (2017), laboratory work permits students to plan and to participate in investigations or to take part in activities that help them improve their manipulative skills.

Takunyaci & Izzet Kurbanoglu, (2021) pointed out that practical experiences that utilise hands-on inquiry can be considered as one of the most effective methods of learning about science and developing the higher order thinking skills. This practical learning which takes place in an inquiry-based laboratory will help students to come out with ideas on their own and to make them capable of explaining phenomena in nature. Hands-on experiences according to Wentzel, (2020) emphasises the science process skills of observing, measuring, recording, classifying, interpreting data, inferring predicting, investigating and making models. Hands-on experiences can also provide practice in reasoning. Any student in the field of study and at any level, needs to show some proficiency in the acquisition of the scientific skills of planning performing and reasoning (Naah, Mayeem, Adjei, & Ossei-Anto, 2018).

2.2 Definition of Laboratory Work

Tamir et al as cited in Matthews, (2014) defined practical work as the study of natural phenomena by observations and experiments in the laboratory, as well as outdoor settings. A laboratory practical test can be described as a project which requires some manipulation of apparatus or some action on materials and which involves direct experiences of the with the materials or events at hand. Further, Stains, et al., (2018) affirm that the laboratory activities incorporate laboratory demonstrations, hands-on activities, and experimental investigations. Laboratory work is an active learning process, which requires students to be involved in observing or manipulating real objects and materials. It plays a distinctive and imperative role for the development of students' understanding of scientific concepts, improvement of their cognitive skills as well as for the development of positive attitudes (Yaman, 2018).

Several studies have been carried out about the role of laboratory work in science (Stains, et al., 2018). Laboratory practical work uses as primary means of instruction in science (Ural, 2016); offers opportunities for students to manipulate equipment and materials (Yaman, 2018); helps students to construct confidence in their problem-solving abilities (Gobaw and Atagana, 2016); maximizes their conceptual development (Ural, 2016); and develops their academic overall performance (Aladejama and Aderibigbe, as cited in Gobaw , 2016). Moreover, laboratory practical activity in science values learning new abilities and the usage new equipment, gives opportunity for students' social interaction, illustrates materials given in lectures and develops excessive interest; and stimulate students to extra efforts of achievement (Hunt et al., 2012). However, Di Trapani and Clarke (2012) said that the laboratory activities largely focus on illustrating concept and the delivery of information due to several factors. Among the factors are equipment and other resource constraints, large class size, lack of sustained and repeated exposure to given practical skills and experimental techniques, poor organizational and time management, and variations in instructors' abilities in coaching the laboratory teaching and learning.

2.3 Need for Laboratory Work in Biology

Smýkal, et al., (2015) stated that Biology as a scientific field of study should be learnt partly through experimental method. Majority of the subject in biology cannot be considered as entire without including some practical work in it. It should be demonstrable. Therefore, practical classes form an essential part of the learning experience for biology students, cultivating both their subject-specific and generic skills that will be of value throughout their university lives and future careers. Biology laboratory is the primary area to develop these skills and competences of students.

2.4 Laboratory skill

Laboratory skills are the most important part when conducting psychomotor assessments. According to the Australian Science Teachers Association (ASTA), laboratory skills consisting of:

a. working with equipment and chemicals, including: handling procedures, use and maintenance, and conscious attitudes for safety,
b. Working with live specimens,
c. Work environment, developing skills. Various laboratory skills students must possess are: planning, selecting, reasoning, operating; Matching equipment; Reading the measuring instrument carefully, interpreting;

d. Handling, preparing and being aware of chemical hazards; detecting, calibrating and correcting errors in adjusting equipment; drawing equipment accurately.

In biology, learning practicum is one type of learning approach that is often used. Practicum activities become inseparable from Biology learning. Practicum is an integral part of science learning, which is the underlying reason why biology, physics, and chemistry are referred to as experimental science. The teaching and learning process by practicum gives students the opportunity to experience themselves, follow a process, observe an object, analyze, prove, and draw their own conclusions about a particular object, situation, or process. Therefore, one of the capabilities that must be mastered by prospective biology instructors is the skill to design lab activities.

To equip students with practical skills critical in their future careers, laboratories ought to be efficiently utilized by both instructors and students. Again, instructors themselves should possess these skills. Hence, attention in the process of developing and evaluating a laboratory work task is vital, such as the teachers' objectives and the task designed are influenced by teachers' views about science and learning, practical and institutional factors, such as the resources available, the requirement of the curriculum, its mode of assessment, and so on (Wei and Li, 2017).

2.5 Assessment

Assessment is a way to know the success of a person achieving a goal through overall performance. Assessment consists of two components, namely: the collection of information and making a conclusive assessment primarily based totally on the information that has been collected . To know the achievements of a student, the student is given some tasks in the circumstances that have been determined in such a way as to know the ability of the student through various tasks in different situations and conditions. Assessment is needed to measure what a person can do, the extent to which a person's overall performance improves after a lesson. One function of assessment is to determine whether a person has mastered a positive skill, or knowledge. In this case the skill or knowledge is required to carry out a job. This type of assessment, referred to as a mastery assessment and this is an important part of competency-based total training . The purpose of the assessment is to gather sufficient evidence that individuals can perform or behave according to the requirements described in a particular role. Another form of assessment is the dimension of the ability level. Assessment of abilities allows to determine whether a person has mastered something he or she has learned. Assessment is intended to collect sufficient evidence to show that a person can work out or behave according to certain standards in a particular role.

The acknowledged weaknesses of conventional paper and pencil assessments have led to the recent development of alternative testing strategies. One of the most widely used of these is Performance Assessment. The keystone of performance assessment is the use of graded, authentic task (Gobaw and Atagana, 2016). An authentic task is one in which students are required to address problems grounded in real-life contexts. In the context of science laboratory, students are graded on the performance of manipulating variables, using scientific apparatus, identifying hypotheses, making measurements and calculations, organizing and managing data, and the communication of results.

In the evaluation of a performance task, the process of performing the task is emphasized more than the final product itself.

2.6 Performance Assessment in Science

A major tenet of current reform efforts in science education worldwide is the opportunity for all students to participate in the science inquiry process (Rowland, 2014). One effective vehicle for affording this participation is inquiry-based instruction (Kirschner, Soremekun, and Eller, 2020). Such instruction is intended to help students develop the skills and habits of mind that yield and refine scientific knowledge integrating the learning and application of content knowledge and process skills.

Assessment of Science programmes incorporating problem solving and science processes skills in the classroom or laboratory uses a suitable method of assessment known a Performance Assessment. By design, performance assessments measure student learning of complex mix of knowledge and abilities more appropriately than paper and pencil tests (Muijs and Reynolds, 2017). Simply defined, performance assessments or tasks are those in which examinees demonstrate their knowledge and skills by engaging in a process or constructing a product (Shultz, Whitney, and Zickar, 2020). In science classroom, performance assessments evaluate students 'on the quality of their ability to perform specific tasks and the products they create in the process (Kirschner, Soremekun, and Eller, 2020). Whether designing, conducting an experiment or analysing data to draw evidence-based conclusions, performance tasks measures students' ability in science.

Abosalem, (2016) observed that the use of performance assessment has become increasingly widespread in science as well as in other content areas. Assessing of students' performance in science processes has been the objective of a number of National and International assessments. These assessments include First International Science Study (FISS), the National Assessment of Educational Progress (NAEP), the Second International Science Study (SISS), and the Assessment of Performance Unit (APU) in the United Kingdom (Abell, 2013).

The term assessment presents different perceptions and conceptions. To authors, scholar and curricularists, there is a plethora of terms and definitions (Khan, 2017); to the teachers and the learners, it is a hot issue and to the general public, it is desirable as well as detestable. The many vocabularies or terms used include: alternative assessment, authentic assessment, performance assessment, traditional or conventional type, naturalistic assessment, Process assessment, product assessment, etc. (Sato and Ando, 2017).

Assessment has been found to serve useful purposes to a number of people including learner, teachers, administrators and employers (Khan, 2017). For learners, it provides efficient learning by focusing the students' attention on what is important. It promotes retention and transfer of leaning, promotes self-evaluation and self-monitoring by the use of well-defined expectations and criteria, motivates leaning by communicating progress concerning what a student knows or is able to do, and it shows evidence of work that can be used to get a job, scholarships, and entrance to the next stage of schooling. For teachers, it provides formative and summative data about student learning and attainment, specifically competency gain, provides diagnostic data to improve learning, assists instructional planning by providing informed feedback, helps to determine effectiveness of approaches and methods, entails programme accountability, and it is a tool to communicate to others.

The influence of educational assessment on education systems is evident in its effects on curriculum design, education policies, institutions of learning, teachers and their teaching and assessment styles, and learners and their learning and studying styles. It is normal practice that when a new Curriculum is introduced an examination prototype is provided to guide both teachers and students on the assessment expectations and the structure of examination papers for the given curriculum.

Educational assessment is thus an integral component of the education process, in particular teaching and learning (Abosalem, 2016). As an integral part of instruction at all levels of the educational system, assessment answers questions such as:

1. Are we doing what we think we are doing?
2. How can we do it better?
3. When do we do it?
4. Are teachers truly measuring students' capabilities in all areas of cognitive psychomotor and affective?
5. Are teachers not measuring capabilities in the cognitive areas when they mean to measure skills?
6. Are teachers employing the right instrument in assessing?

According to Gipps, (2011) assessment is the most powerful policy tool in education and will probably continue to be the single most significant influence on the quality and shape of students' educational experience and hence their learning. Educational assessment can be perceived as an endeavour by teachers to ascertain the status of students' knowledge (cognitive understandings and abilities), skills and attitudes as variables of educational interest (Good and Lavigne, Looking in classrooms, 2017). Educational assessment not only encompasses the techniques teachers and examining bodies apply when grading students' knowledge and skill or comparing them to one another (Kolb, 2014), it is also a means to help students learn and teachers improve their instruction. Educational assessment should thus be viewed as assessment for learning and skills development and not simply as assessment of learning. In assessment for learning, the assessment activities are designed to contribute to the acquisition and consolidation of student knowledge and skills. The customary ranking of students in order to certify learning or evaluating programs should be a secondary use of assessment: (Darling-Hammond, 2015)

Assessment activities produce information that serves several functions of significance to both the learners and the teacher. Teachers may use such information for summative and or formative purposes. In summative assessment, such as in the case of end of term or year and national examinations, the assessment results provide a summary of the students' Overall performance. This summary forms the basis for judging how well students learning attained curriculum goals, and deciding on students' progression to the next class or further studies. The summary is also useful for comparing students with one another (norm-referenced assessment) and for preparing students reports for parents, administrators and inspectors or other interested agencies (Bolier, et. al. 2013). Summative assessment data does not always filter back into the classroom to impact on instruction or directly improve learning Summative assessments do, however, influence instruction indirectly; Such as when teachers 'teach to the test' and select those learning activities that they feel are emphasised in examinations (Binkley, et al., 2012). In the process, students may consolidate and master the content of examination questions rather than the skill of teaching assessment tasks or acquiring a wider range of competencies.

In using assessment information for formative purposes, teachers make judgments about the strengths and weaknesses of individual students in achieving curriculum goals and the effectiveness of instruction to help students achieve instructional objectives. It also helps teachers to decide how to improve instruction and promote productive interactions with their students (Ganagana and Anero, 2014).

Formative use of assessment information thus provides a link between assessment and classroom instruction by enabling teachers to give clear feedback to their students on their learning. Through the feedback, students become aware of target learning outcomes, the kind of performance they need in order to succeed and where they need to apply effort (Falchikov, 2013). Students can use this feedback to actively assess leaning at a personal level and set goals and academic expectations for themselves. It is indeed the responsibility of students to act on feedback from assessment tasks to improve their understanding and performance (Bekoe, Eshun, and Bordoh, 2013).

Though assessment is important in the education of students, Verona and Vitale, (2018) observe that it is often poorly understood, its purpose confused and its design inadequate, and therefore inefficiently used. Information obtained from traditional assessment models does not adequately reflect the quality of students thinking and their level of understanding (Abosalem, 2016). The poor attention given to measuring higher-order thinking skills and intellectual and manipulative processes in standard assessments has led to the strong criticism leveled against standard assessment (Sippo, et. al., 2018). Many students succeed in external examinations through memorisation and proceed to tertiary institutions, where they may begin to experience some learning difficulties.

Teachers are also under pressure to go over as many topics as possible each year and prepare students for achievement in examinations. In the process they lose out on opportunities of exploring the subject fully with their students (Frey, Schmitt, and Allen, 2012). Assessment-directed teaching thus deprives students of real-life experiences of raising questions about observations, constructing responses, identifying problems and finding solutions to those problems.

Traditional multiple-choice achievement tests in science have been criticized in several ways. Despite their efficiency (economical to develop, administer, and score) they do not measure some aspects of knowledge that are valued in science education: for example, the ability to formulate a problem or carry out an investigation. Hence multiple-choice tests are limited in capturing students' conceptual understanding and problem-solving skills; they are limited in their very nature by the requirement to select, not produce, a response; they do not look like the science conducted in the laboratory or the field, and consequently may provide only limited information about what students know and can do in science. Finally, they lead teachers to teach a multitude of often unrelated facts rather than conceptual and procedural understanding.

With the increase in research findings on assessment practices, it has become evident that there is the need for assessment models that will capture a wider range of assessed attributes than has been the case in the past (Greer and McCalla, 2013). The purpose of assessment is to measure how much students know about a topic or subject and what they are able to do with the knowledge in context. The instrument used in such measurements should therefore provide accurate information about the student's level of knowledge (Opitz, Heene, and Fischer, 2017). It is anticipated that alterative assessments will improve the alignment between curriculum goals, teaching and learning, and assessment. Alterative assessments comprise the use of alternative assessment tools as well as the use of assessment as a learning process the tasks used for assessment of learning can also be used as exercises through which students can further explore their understanding and application of knowledge in a topic of study. Since they focus on both assessment of achievement and understanding, they help students learn the contents and skills targeted by the assessment tasks (Binkley, et al., 2012).

Performance assessments have caught public attention in the past years as a complement to multiple-choice tests. Performance assessments are assumed to tap higher-order thinking processes and be more directly related to what students do in their classroom and what scientists actually do-observe, hypothesize, record, infer and generalize.

Performance assessment can be viewed as a concrete task, with its corresponding response format and scoring system performed by a student on particular occasion and scored by a rater (eg. a teacher) who judges the student's performance based on the procedure used by the student and the accuracy of the response (Moss & Brookhart, 2019). The measurement method might be hands-on, notebook, computer simulation, or paper and pencil. Carless, (2012) see performance assessment is a combination of:

1. A task that poses a meaningful problem and whose solution requires the use of concrete materials that react to the actions taken by the student.
2. A format for the student's response
3. A coring system that involves judging not only the right answer but also the reasonableness of the procedure used to carry out the task.

Without all three, a performance assessment is undefined.

According to Zeichner, Payne, and Brayko (2015), for a performance assessment to be useful for teaching, it needs to be linked directly to instructional units, and have a well-designed scoring system that clearly reflects what students understand and can do. Moss & Brookhart, (2019) also found out that performance assessment can be managed efficiently as hands-on science instruction and that scoring can be easy and quick to learn and use. The management of performance assessment depends on the instructional approach used in the classroom. Students understanding of the performance-based (laboratory) activities and what these would mean to them depend on the direct pertinent experiences they engage in while they go about "hands-on activities in the laboratory. Naah, et. al. (2018) states that the way students are engaged in the laboratory activities influence how and what they learn and urge them to lean more since it makes the subject matter fascinating to them. Tight (2012), confirmed the fact that performance tasks undertaken by students in the laboratory and based on day-to-day life experiences, make them more motivated to see the practical nature science to life situations.

Performance Assessment refer to assessment techniques that integrate science investigations, such as hands-on practical tasks to measure and evaluate a student's content and procedural knowledge, and his/her ability to use the knowledge in reasoning and solving problems. Students are able to demonstrate their knowledge, skill and work habits through:

1. Manipulating and operating scientific instruments and equipment to generate relevant data
2. Recording, analysing and interpreting data
3. Drawing relevant conclusions from data
4. Communicating the product of their investigation orally and in written reports.

In performing the assessment task, the students may apply a procedure learned n class, a combination and integration of procedures, as well as thoughtful adaptation of their knowledge to the given task (Falchikov, 2013).

Performance assessments are designed to judge student abilities to use specific knowledge and research skills. Most performance assessments require the student to manipulate equipment to solve a problem or make an analysis. Rich performance assessments reveal a variety of problem-solving approaches, thus providing insight into a student’s level of conceptual and procedural Knowledge

Performance assessment strategies are composed of three distinct parts:

- A performance task;
- A format in which the student responds:
- And a predetermined scoring system.

Tasks are assignments designed to assess a student's ability to manipulate equipment for a given purpose. Students can either complete the task in front of a panel of judges or use a written response sheet. The student is then scored by comparing the performance against a set of written criteria.

The purpose of performance assessment is to evaluate the actual process of doing science or mathematics (Gobaw, 2016). Performance assessments examine students' actual application of knowledge to solve problems. In some cases, the solution of the problem may imply the application of a specific procedure learnt in a class; in others, a combination of procedures, still in others it may require a thoughtful adaptation of students' knowledge. The assessment of student's knowledge focuses on the performance and the result. However, performance assessments are typically inappropriate for measuring student knowledge of facts. According to Gobaw, (2016) performance assessments have the following purposes:

1. Diagnostic purposes: what do students know about how to solve certain types of problems? Do they know how to control variables? How to use instruments? How to evaluate findings? Information provided at the beginning of the course may help decide when to start or what issues of the course need special attention.
2. Instructional purposes: a good performance assessment often is indistinguishable from a learning activity, except for standardization and scoring. In this light, a performance task that stimulates the authentic tasks of a scientist or mathematician may be used as either an instructional activity or an assessment activity. If the assessment task is used in such a way that the

student would normally not know it is an assessment activity, it is called an embedded task.

3. Monitoring purposes, the goal of performance assessment is to judge the level of competency students have achieved in doing science and mathematics. Accordingly, performance assessment strategies are best used to monitor student process skills and problem-solving approaches. The most effective performance assessments are authentic tasks that are open-ended with multiple-correct solution paths.

Performance assessment can be administered individually, in pairs, or collaborative groups. If it is administered in pairs or groups, students should write in their own answer response sheet. It is important for one to keep in mind that when students, solve the problem in pairs or groups, the goal and the composition of the group will affect the student's individual performance. In this context, it should be clear exactly what the purpose of the assessment is (eg. how well student s ability to interact and collaborate with others). It is also important for one to have predetermined criteria to evaluate the students' performance. Students should not be scored/ graded against their peers but based on the criteria predefined.

Performance assessment, also known as alternative or authentic assessment is a form of testing that requires students to perform a task rather than select an answer from a ready-made 1ist (Evans, 2013). For example, a student may be asked to generate scientific hypothesis, solve mathematics problems or conduct a research on an assigned topic.

2.7 Authentic Assessment

This is a form of assessment in which students are asked to perform real-world tasks that demonstrate meaningful application of essential knowledge and skills. According to Kolb, (2014), authentic assessment means engaging in worthwhile tasks and problem-solving activities that demand students' use of acquired requisite knowledge effectively and creatively Such tasks are either replicas of or analogous to the kinds of problems faced by adult citizens and consumers or professionals in the field. Muijs and Reynolds, (2017) sees authentic assessment as one that calls upon the examinee to demonstrate specific skills and competencies: that is, to apply skills and knowledge they have mastered. Authentic assessment engages students in applying knowledge and skills in the same way they are used in the "real world" outside of school. It is a performance-based assessment that requires a student to go beyond basic recall and demonstrate significant, worthwhile knowledge and understanding through a product, performance, or exhibition. The assessment comprises an authentic task, such as performing scientific research. Students appear to learn best when they see the importance of learning and the learning environment is familiar to them. Authentic scenarios can provide this environment and relevance to students.

Comparisons with traditional standardized tests will help to clarity what authenticity means when considering assessment design and used:

1. Authentic assessments present the students with the full array of tasks that mirror the priorities and challenges found in the best instructional activities: conducting research etc. Conventional test is usually limited to paper-and-pencil, one-answer questions

2. Authentic assessments attend to whether the student can craft polished, thorough and justifiable answers, performances or products. Conventional tests typically only ask the student to select or write correct responses-irrespective of reasons (There is rarely an adequate opportunity to plan, revise and substantiate responses on typical tests, even when there are open-ended questions). As a result,
3. Authentic assessment achieves validity and reliability by emphasizing and standardizing the appropriate criteria for scoring such (varied) products: traditional testing standardizes objective items and hence, the (one) right answer for each.
4. Test validity depends in part upon whether the test simulates real-world tests of ability. Validity on most multiple-choice tests is determined merely by matching items to the curriculum content (or through sophisticated correlations with other test results)
5. Authentic tasks involve ill-structured challenges and roles that help students rehearse for the complex ambiguities of the game of adult and professional life. Traditional tests are more like drills, assessing static and too-often arbitrarily discrete or simplistic elements of those activities (Kolb, 2014).

Performance assessments are more complex than objective-type tests in that they measure multiple reasoning and knowledge (declarative and schematic dimensions of knowledge). Constructing good performance assessment tasks requires considerable time. Several trial runs with students to get their input are necessary before the tasks can be used for the actual assessment (Zeichner, et. al., 2015). Zeichner, et. al., (2015) further advice that good performance assessment tasks are essential if they are to positively influence teaching Therefore, educators are cautioned not to assume that changing the assessment formats will necessarily change teaching styles; and as such the use of performance assessments with teachers who teach to the test will improve their teaching. Teaching to poorly constructed performance tests may lead to distorted hands-on science teaching.

If performance assessments are to influence teaching, then the tasks and corresponding rubrics need to be carefully constructed and scorers adequately trained. Studies on performance assessment have shown that specific scoring criteria and examples showing expected competencies are essential for consistent evaluation through performance assessments. Indicating to students the expected performances regarding the tasks prior to their attempting the task motivates them to improve their performance (Binkley, et al., 2012).

In attempt to expose Junior Science student's performance assessments, an exploratory study by Mertens, (2014) involving a group of four teachers and their seven classes of students was conducted. In the study, the performance tasks used, directed students to demonstrate their knowledge and procedural skills through planning, investigating and recording, analyzing and interpreting data, and applying the data in a given situation. Findings from the study indicated that the performance tasks engaged students in thinking processes they were not normally exposed to, which they appreciated (even if they found it rather difficult at first). Also, the assessment tasks encouraged students to be more attentive during class when they were working on practical activities.

Performance assessment has the following advantages:

1. Performance tasks clarity the meaning of complex learning targets.
2. Performance tasks assess the ability "to do.
3. Performance assessment is consistent with modern learning theory.

Modern learning theory emphasizes that students should use their previous knowledge to build new knowledge structures, be actively involved in exploration and inquiry through task-like activities and construct meaning for themselves from educational experience. Performance assessment engages students' and actively involves them with lite situational tasks.

4. Performance tasks require integration of knowledge, skills and abilities. Complex performance tasks especially those that span longer periods of time require students to use many different skills and abilities.
5. Performance tasks broaden the approach to student assessment.
6. Performance tasks let teachers assess the processes students use as well as the products they produce. Many performance tasks offer the teachers the opportunity to watch the way a student goes about solving a problem or completing a task. Appropriate scoring rubrics help one to collect information about the quality of the processes and strategies students use as well as assess the quality of the finished product.
7. Performance assessments may be linked more closely with teaching activities. This happens when the teaching requires students to be actively involved in inquiry and performance activities.
8. Performance assessments provide a way of observing the application of procedures.

9. Performance assessments simulate the real-world tasks that scientists, mathematicians, engineers and researchers encounter.

2.8 Challenges for Performance Assessment

The inclusion of performance assessment as part of school science assessment models is a recent development in the history of educational assessment, even though performance assessments have been in use for some time in other fields. Teachers and examination authorities have not readily embraced their use. Insufficient knowledge on their use by teachers to fairy assesses students' performance, unsuccessful experiences and or an inconclusive execution of performance assessment is thought to be responsible for their poor acceptance by teachers (Hernandez-Martinez and Vos, 2018). Other reasons for the apparent lack of widespread use of performance assessment, particularly tor large-scale national examination bodies, include issues of reliability, generalisability performance in one task to other tasks, and costs in respect of time for production and administration tests, and resources (Falchikov, 2013). There is undoubtly, no single assessment model that can apprise science learning experiences n totality. There is always some limitation that will affect the suitability of an assessment model for a particular purpose. It is possibly due to these problems that performance assessments have been considered viable assessment approaches much later in the last century (Muijs and Reynolds, 2017).

Performance assessments are particularly vulnerable to reliability problems that relate to content sampling, standardization and scoring. Performance assessment techniques measure understanding of content by students in greater detail, but the scope of curriculum goals explored is limited to a few assessment tasks, The breadth of coverage observed in standard or objective-type tests (structured short-answer and multiple-choice tests) is traded for depth in performance assessments. The lack of adequate coverage in curriculum topics assessed can give distorted information about student achievement. For example, very high or low scores can be allocated while the tasks used emphasized certain topics or concepts over others. The use of fewer tasks in performance assessments is dictated by the degree of complexity of the tasks used which require more time. In order to obtain a more comprehensive picture of students' knowledge and skills, a substantial number of performance tasks are necessary. This would mean constructing a number of different performance tasks per subject over a longer period of time (Falchikov, 2013).

Generalisability of results is another problem. The performance of students on a small sample of tasks cannot be generalised to other tasks or to the general performance of the students. A good performance in one task does not necessarily mean that the same student will demonstrate similar abilities in a different task (Good and Lavigne, 2017).

Performance is task dependent. Again, multiple tasks would be required to enable generalisations from performance assessments results. Generalisability is a problem for summative assessment, which tasks the overall achievement of the student into consideration. The apparent task dependability of performance assessment is a reality that needs to be worked with because some subject content is concrete and can be easily understood while other areas are abstract and therefore more difficult to understand. The intellectual demands of performance tasks are content dependent.

2.9 Science Process Skills

Science process skills are activities that scientists execute when they study or investigate a problem an issue or a question. These skills are used to generate content and to form concepts (Matthews, Science teaching: The contribution of history and philosophy of science, 2014). Aydogdu, (2015), regard process skills as the way of thinking measuring, solving problems and using thoughts. This implies that thinking and reasoning are skills involved in investigative teaching and learning strategies. Hence teachers and learners can apply science process skills while developing teaching and learning inquiry competences.

Science process skills are commonly used to describe a set of broadly transferrable abilities that are reflective of what scientist do. Some science educators have argued that teaching student's science facts is not as important as developing their science process skills so that they can learn this knowledge on their own (Pike, Rodríguez-Pose, and Tomaney, 2016). Studies in the United States have shown that elementary school students who are taught process skills, not only learn to use those processes, but also retain them for future use.

Some studies have shown that instead of using the didactic approach, teaching science through the use of activity-based approaches significantly improved students' achievement in science process skills (Siahaan, et. al., 2017). Toplis, (2015) suggested a few crucial factors that influence the acquisition of process skills in the laboratory work. Firstly, students need the relevant content knowledge that is assumed by the task to be mentally engaged. For example, a more knowledgeable student would be able to explain an observation, which in turn validates his knowledge and gives him a certain amount of intellectual satisfaction. The doing of science has to be coupled with learning about science, if students are to appreciate the value of scientific inquiry (Renninger and Hidi, 2015). A second factor suggested by Toplis, (2015) is students' ownership of laboratory tasks. Ownership would be more apparent in open laboratory tasks, where the student has to design his own experiment than in closed laboratory tasks, where the correct experimental procedure is written out in a cookbook style and the student is likely to carry out the tasks unthinkingly. Another effective strategy to enhance would be to let students keep a "scientific journal" (Molefe, Stears, and Hobden, 2016). It was observed that diary writers tend to build more confidence in their own interpretations, engage in intellectual debates with themselves over the plausibility of their explanations and ask questions that are more quantifiable. The students need the process skills both when doing scientific investigations and during their learning process (Prayogi and Yuanita, 2018). For these reasons, students should be informed about the importance of science process skills. Science process skills are defined as the adaptation of the skills used by scientists' for composing knowledge, thinking and making conclusions. Students need hands-on practice to effectively learn and master science process skills. Classroom activities using science content provide opportunities to develop these skills and encourage students to learn to think like scientists. Science activities using process skills allow students to manipulate objects and events to investigate scientific phenomena, analyses data and present their findings.

Science Process Skills can be classified as either Basic Science Process Skills or Integrated Science Process Skills (Rohaeti and Prodjosantoso, 2018). Integrated science process skills are regarded as more advanced than basic process skills

(Hardianti and Kuswanto, 2017). Brain and Town (2016), argue that scientists are only able to use integrated skills effectively once they have mastered the basic skills.

2.10 Basic Science Process Skills

Basic science process skills apply specifically to foundational cognitive functioning in especially the elementary grades. In addition, these skills also form the backbone of the more advanced problem-solving skills and capacities. They represent the foundation of scientific reasoning learners are required to master before acquiring and mastering the advanced integrated science process skills (Hardianti and Kuswanto, 2017). Kurniawan and Indrawati, (2019) maintain that basic science process skills are interdependent, implying that investigators may display and apply more than one of these skills in any single activity.

i. Observing: using your senses to gather information about an object or event. It is a description of what was actually perceived. This information is considered qualitative data. Almost every activity of science begins with observation. From nature to the test tube and to experiments in the laboratory, observation must be used.

   The crux of a science experiment is to be able to see something in your environment and then, after watching how it works or acts, pose a question as to why it behaves in that manner. A student who watches an ant crawling on the ground and thinks," there is an ant, on the ground, going in circles, is passively observing his surrounding and is not actively engaged. The student who sees the same ant and thinks why is that ant going in circles? That is not normal, Shouldn't that ant be trying to go somewhere, is a student who has been taught to actively observe, which is crucial in science.

Observation skill is valuable for and crucial to both the process of teaching and studying the ways of science. Wahyuni, Indrawati, Sudarti, and Suana, (2017) investigating Nigerian teachers' mastery and use of observation processes in biology teaching discovered that teachers scored reasonably well on mastery and effective use of the Skill.

ii. Measuring: using standard measures or estimations to describe specific dimensions of an object or event. This information is considered quantitative data.

Students who are well versed in observing the environment can easily come up with a question to try to answer. However, in order to be able to do so, they must know how to use measurement accurately.

Measurement in science is precise, where certain pieces of the experiment must remain constant while others must change. A student who knows how to use measurement correctly will understand which items or objects must change and which must remain static in order to arrive at a conclusion,

iii. Interring: formulating assumptions or possible explanations based upon observations.

iv. Classifying: grouping or ordering objects or events into categories based upon characteristics or defined criteria. Classification as a science process skill is important because it contributes to the extent to which students understand, conceptualise and attach meaning to scientific ideas. To attain competency in the use of classification means that students are able to conceive an order and add meaning to their experience of the world around them (Darmaji, Kurniawan, and Suryani, 2019). Darmaji et. al., in addressing the issue of mastery of classifying in Nigerian schools, found a positive significant relationship between student mastery of the skill and mastery of the skill by the teacher.

v. Predicting guessing the most likely outcome of a future event based upon a pattern of evidence.

vi. Communicating using words, symbols, or graphics to describe an object, action or event. Communication is a critical aspect of scientific investigation. Without it, scientific investigation would be pointless. No one, other than the original investigator would be able to know the results or findings of the investigation. Thus, the skill of communication must be included in the early stages of teaching and studying of science Thoughts, ideas, research findings and all sorts of vital information need for be communicated for awareness, learning, instruction and other purposes. A student might be able to observe and measure something but if he cannot communicate his results, the outcome is muddled, confusing mess. Students must learn how to be clear and concise in presenting their results. They must also know what pieces of the experiment are noteworthy and which portions are just simply data and do not need to be included in the explanation.

Numerous research projects have focused on the teaching and acquisition of basic process skills. Jacobi, Freund, and Araujo, (2015) surveyed the basic process skills of 700 middle school students with no special process skill training. They found that only 10% of the students scored above 90% Correct, even at the eighth-grade level. Several researchers have found that teaching increases levels of skill performance. Kurniawan and Indrawati, (2019) investigated predicting among third and fifth graders, and Hild and Brückmann, (2019) observing among seventh graders. From these studies it can be concluded that basic skills can be taught and that when learned, readily transferred to new Situations (Hild and Brückmann, 2019). Teaching strategies which proved effective were

1. Applying a set of specific clues for making predictions in process skills.
2. Using activities and pencil and paper simulations to teach graphing, and
3. Using a combination of explaining, practice with objects, discussions and feedback with observation.

Studies focusing on the Science Curriculum Improvement Study (SCIS) and Science - A Process Approach (SAPA indicate that elementary school students, if taught process skills abilities, not only learn to use those processes, but also retain them for future use. Researchers, after comparing SAPA students to those experiencing a more traditional science programme, concluded that the Success of SAPA lies in the area of improving process-oriented skills (Widen, 1975, as cited in Onesti, et. al., 2017). Thus, it seems reasonable to conclude that students learn the basic skills better if they are considered an important object of instruction and if proven teaching methods are used.

2.11 Integrated Science Process Skills

These are immediate skills that are used in problem-solving. Integrated skills include skills such as identifying variables, constructing tables of data and graphs, describing relationships between variables, acquiring and processing data, analyzing investigations, constructing hypotheses, operationally defining variables, designing investigations and experimenting (Kurniawan and Indrawati, 2019). As the term integrated implies, learners are called upon to combine basic process skills for greater expertise and flexibility to design the tools they apply when they study or investigate phenomena. This process can lead to the realization and achievement of integrated science process skills as observable and demonstrable outcomes in:

i. Formulating hypotheses: stating the proposed solutions or expected outcomes for experiments, these proposed solutions to a problem must be testable: Finding a solution to the problem involves decision- making (Milne, 2017). Before an inquiry is conducted, the investigator should suggest tentative answers to the problem. These tentative solutions are hypotheses (Rehman, Zhang, and Sher, 2020).

ii. Identifying of variables: stating the changeable factors that can affect an experiment. It is important to change only the variable being tested and keeps the rest constant. The one being manipulated is the independent variable, the one being measured to determine its response is the dependent variable, and all variables that do not change and may be potential independent variables are constants.

iii. Describing relationships between variables explain relationships between variables in an experiment such as between the independent and dependent variables plus the standard of comparison.

iv. Designing investigations: designing an experiment by identifying materials and describing appropriate steps in a procedure to test a hypothesis.

v. Experimenting: carrying out an experiment by carefully following directions of the procedure so the results can be verified by repeating the procedure several times. Opara, (2015) conducted an investigation of teachers' mastery and effective use of the skill of experimentation in Nigerian classrooms. It was found that students experience with apparatus and experiments had a highly significant relationship with their understanding of science and of experimentation as a process of science.

vi. Acquiring data: collecting qualitative and quantitative data as observations and measurements.

vii. Organizing data in tables and graphs: making data tables and graphs for data collected.

viii. Analyzing Investigations and their data: interpreting data statistically, identifying human mistakes and experimental errors, evaluating the hypothesis, formulating conclusions, and recommending further testing where necessary. Scientific inquiry is empirical in nature. Through observation and experiments, data are gathered. Once collected, the data need interpretation so that meaning and sense can be related to the data. Interpreting and inferring are critically determinant activities of science. Information gathered from scientific investigation usually is not readily useful and meaningful to other scientists and the wider Community. Data have to be analyzed and interpreted, and inferences have to be made to produce and extend knowledge which is to have usefulness and meaningful applications for life.

Opara, (2015) found out from a study on teachers' mastery and effective use of the skill of interpreting data in the teaching and guided study of integrated science in Nigerian schools that in spite of teachers being aware of the importance of the skill and having a high degree of mastery of the skill themselves, their students indicated that they rarely used the skill.

ix. Understanding cause and effect relationships: what caused what to happen and why?

x. Formulating models recognising patterns in data and making comparisons to familiar objects or ideas.

Several studies have investigated the learning of integrated science process skills. Gay, (2018) found that third graders can identity variables if the context is simple enough. Nugent, et. al., (2015) systematically integrated experimenting lessons into a middle school science curriculum. One group of students were taught a two-week introductory unit on experimenting which focused on manipulative activities. A second group was taught the experimenting unit, but also experienced one additional process skill activity per week for a period of fourteen weeks. Those having the extended treatment outscored those experiencing the two-week unit. These results indicated that the more complex process skills cannot be learned via a two-week unit in which science content is typically taught. Rather, experimenting abilities need to be practiced over a period of time.

Further study of experimenting abilities shows that they are closely related to the formal thinking abilities described by Piaget. In fact, one of the ways that Piaget decided whether someone was formal or concrete was to ask that person to design an experiment to solve a problem.

Science Process Skills have a great influence on science education because they help students to develop higher mental skills, such as critical thinking, making decision and problem solving. Science Process Skills are used in real life as well as in science. Students are required to explain how real events occur. Science Process Skills involves creativity and critical thinking along with scientific thinking. Dewi, Poedjiastoeti, and Prahani, (2017) aimed to determine the relationship between science process skills and scientific creativity, and they found a meaningful correlation between the two, therefore it is possible to say that science process skills can be thought as a measurement of creativity in making scientific discoveries and contributing to countries development.

Szott, (2014) state that students at all levels show poorly developed skills of problem analysis, planning, and carrying out of controlled experiments in a study of first year tertiary students. Cox, Imrie, and Miller, (2014) claims that many students cannot identity the basic question involved in experiments. He suggests that they see experiments merely as using equipment rather than as a process of generating information.

Science learning and the development of science process skills are integrated activities. Harlen and Qualter, (2018) argue that the development of science process skills is a valid aim for science laboratory work. Appleton, (2013) proposes that there is much theoretical support for the value of laboratory work in helping students to understand science classes. Ibrahim and Lede, (2018) in a report on science instruction in Massachusetts, claim that elementary schools' teachers lack basic science skills. They suggested that teacher education students should be involved in considerable practical science to develop the appropriate skills.

Planning as a Science Process Skills refers to the process of deciding what to do and how to do it (Darling-Hammond, Hyler, and Gardner. 2017). Planning is an art as well as a science. It requires judgment, sensibility and creativity. They opined that practical work is not just putting the apparatus together when seen, but it needs planning, designing a problem, creating a new approach and procedure and also putting familiar things together in the new arrangement.

Good planning requires a methodical process that clearly defines the steps that lead to optimal solutions. This process should reflect the following principles:

1. Logical-each step leads to the next.
2. Transparent-everybody involved understands how the process operates.
3. Comprehensive all significant options and impacts are considered.
4. Efficient-the process should not waste time or money.
5. Informative-results are understood by stakeholders (people affected by a decision)

Good planning is comprehensive, insightful and strategic. Effective planning requires correctly defining problem and asking critical questions.

Planners must manage information flow, including gathering, organizing and distribution (Darling-Hammond, Hyler, and Gardner, 2017). Planners should anticipate questions and provide accurate and understandable information, using visual information (maps. graphs. tables, etc,) and appropriate examples.

Interpreting as a science process skill refers to the process of organising data and drawing conclusions from it. Students can analyse and share their results by interpreting data, inferring and communicating. Recording data in a chart and making a graph helps students to look for patterns in the data and draw conclusions about what the data mean. For example, students can investigate chemical weathering by placing pieces of limestone in water and vinegar and charting the change in mass of each piece over time. Students use the chart to interpret the data and conclude that vinegar weathers more of the limestone than water. Then students can use this conclusion to infer that acid rain causes chemical weathering of limestone. Students can communicate their findings by making a line graph and writing summary or laboratory report.

One of the most important and pervasive goals of schooling is to teach students to think. All school subjects should share in accomplishing this overall goal. Science contributes its unique skills, with its emphasis on hypothesizing, manipulating the physical world and reasoning from data.

Reasoning a science process skill are major contributors to academic and everyday life success. Science education reform document have long emphasized helping students to develop scientific reasoning skills, a major goal for science education (Singer and Smith, 2013). Educators believe that reasoning skills play an important role to students' ability 'to develop scientific understanding and conduct scientific investigation. Eshun and Amoah, (2018) asserted that the low performance of students in the reasoning task could be attributed to over reliance on model isolationist pedagogy with an excessive amount of reliance on textbooks and rote problem solving, even though this type of isolated learning have been found to be detrimental to the success of science students.

According to Baker, (2017)) scientific reasoning skills mark the development of adolescent cognition and are often demanded for effective decision-making and problem-solving. Reasoning skills are also intrinsic to the process of knowledge acquisition and conceptual change (Mertens, 2014).

Scientific reasoning is complex in nature (Robertson, 2016). Baker, (2017) see reasoning as a specific type or branch of thinking that involves drawing inferences from initial premises and is closely related to Judgment, decision-making and problem-solving. Martens (2014), argued that scientific reasoning requires more than the strategies of controlling variables and inductive causal inferences, which have been dominant in reasoning studies. According to Martens, scientific reasoning is a conscious, purposeful knowledge seeking-process that is social in nature. It is a process that people go through in order to revise their ideas and build new understandings. The heart of this reasoning process is a coordination of theory and evidence, which does not only mean revising the theory in the light of the evidence, but differentiating between and contemplating both. Successful theory-evidence coordination requires questioning existing theories, seeking contradictory evidence and eliminating alternative explanations.

Toplis, (2015) regarded formal or advanced reasoning as largely hypothetico-deductive in structure and consisting of a number of interrelated aspect or schemata that functions independently depending on the situation or task.

Despite the apparent failure of much of contemporary science teaching to impart science process skills to students, there is evidence that the appropriate kind of instruction can be successful. Widodo and Budijastuti, (2020) worked with year 8 general science students and year 11 and 12 Physics students in what they describe as open-inquiry laboratory sessions they found that students develop higher-order process skills through non- traditional laboratory experiences that provided the students with freedom to perform experiments of personal relevance in authentic contexts. Students learned to

i. Identify and define pertinent variables.
ii. Interpret, transform, and analyse data.
iii. Plan and design an experiment, and
iv. Formulate hypotheses.

National Research Council, (2012) also working with teacher education students stated that, scientific problem-solving skills can be developed through laboratory investigations.

2.11 Influence of Type of School on Laboratory Skills of Students

While one of the most obvious features of a school is whether it is for one or both sexes, it does not follow that this will have a major impact on its successes, however defined. The ability of the pupils, the socio-economic status of the parents, the leadership and teaching, reputation and income, and size, among other things, could all be expected to have a bearing, and they may not only act separately but also in various and varying combinations.

Nevertheless, the issue of whether to mix or separate the sexes tor schooling touches the emotions, and it has become one of the most researched topics in education.

According to Sadler, Sonnert, Hazari, and Tai, (2012) the type of school from which the students came is one of the factors that influence science achievement. Studies have reported that boys do better in single-sex schools (Wang and Degol, 2013). Against the claim a number of other studies have found that boys appear to achieve more academically when co-educated (Miller and Halpern, 2014).

There is thus little decisive evidence for either girls or boys achieving more in single-sex or co-educational schools, but it is still believed that there are effects. Blakemore, Berenbaum, and Liben, (2013) in Australia studied the changes in a boys' school and girls' school that were brought together to form two co-educational schools. He found that there were no academic disadvantages for either sex in the change, nevertheless, the teachers believed that girls did less well in the male' subjects.

Comparisons of girls' and boys' achievement by school type come out more often in favour of single-sex schools. But the differences tend to be small and inconsistent and open to other explanations, for example, the ability and social background of the pupils. Commentators around the world have concluded that while differences may be found between single-sex and co-educational schools, those differences are unlikely to be due mainly or even substantially to the fact of being single-sex or co-educational and a separating the sexes is not a recipe for raising educational performance.

As with achievement, it is widely believed that single-sex education is beneficial for subject choice. In the United States, the website of the National Association for the Single Sex Public Education makes the bold claim that Single-sex schools break down gender stereotypes. In the UK, the Girls' Schools Association frequently makes similar assertions. Noguera, (2012) argued that girls are much more likely to specialise in science, mathematics and languages when they are educated separately, because boys undermine their confidence in mixed classes. Despontin (as cited in Noguera, 2012) also said that girls were less likely to put themselves forward and ask questions when boys are present.

A major claim for single-sex schools, particularly girls' schools, is that they are effective in combating gender stereotyping. Several studies have obtained evidence that girls and boys attitudes to subjects are apparently influenced by the gender composition of the school. Blakemore, Berenbaum, and Liben, (2013) for example, found in a questionnaire survey of 2300 13–14-year-olds in 13 single-sex and mixed comprehensive schools that there were statistically significant differences between the school types in attitudes towards the sciences. Boys in single-sex schools were more likely to say they liked biology and girls in single-sex schools were more likely to say they liked physics and chemistry but the differences between the girls and boys far outweighed the differences between single-sex and co-educational schools. Again, it was the boys who were more likely to be influenced by co-education than the girls.

In girl-only learning environments, girls are exposed to more successful female role models. The top students in all academic subjects and the leaders in sport and extra-curricular activities are girls. Building onto this, some research indicates that, adolescent girls feel better about themselves in many ways when they are educated in girls' schools as opposed to co-educational schools (Okeke, 2020). In general, they feel better about their bodies and their body image as well as about their academic abilities. By promoting self-esteem, single-sex schools may better equip girls to light for their, human rights in gender-biased male-dominated societies (Okeke, 2020).

However, critics of single-sex education argue that girl-only schools are unnatural social settings which isolate girls from boys. In well-managed co-educational environments boys and girls learn to respect and value each other's ideas. They lean to listen and communicate with each other. Isolating girls and boys in single-sex schools is considered a barrier to them developing the effective interpersonal skills they will need to function as grown-ups in their society (Wasike, 2020). Again, single-sex schools can lead boys and girls, who are not witnessing the ideas, talents and skills of the other sex, to rigidly stereotype the other sex. This can reinforce the existing gender bias in society.

Since the inception of public education, there has been much debate about the type and role of schools to be used to educate children. Before the beginning of public education for the masses in the United States, many students were being educated in single-sex environments. The debate over single-sex or co-educational schools began with the introduction of government directed education in the mid-1800s. Jackman-Ryan, (2021) states that, single-sex education has a long history and tradition in the United States (and elsewhere). Jackman-Ryan, (2021) goes on to discuss how single-sex institutions dominated education, especially for the upper class until recent decades.

While single-sex education has been the preferred method of instruction of private and religious institutions, it is co-education that has been dominant in the public domain since the beginning of education for the masses. Co-education was especially prevalent in rural areas due to the case of educating a large number of students in a single setting. This was viewed as a much more practical solution to compulsory education rather than developing separate single-sex academics. Single-sex education rose out of societies that felt only males were worthy of an education. Many cultures clung to this sentiment for several generations. Even today there are those that would say women are not worthy of being educated. Randolph (2019), underscores the commonly held beliefs of the 1800s when he states that Single-sex education in the United States originated in a society that valued education only tor males. The all-girls' schools that were eventually created were a reaction to the exclusion of females from the halls of learning and in many cases, also an affirmation of the view that men and women needed different types of education.

Others feel an argument for single-sex education can be made on the basis that male dominance in the classroom does not lead to equal educational opportunities. There have been numerous studies that demonstrate the success of females in a single-sex class. Many of these studies attribute this success to the absence of a male population. Wang and Degol (2013), state that "…. based on the argument that boys so dominate mixed classes that "true" equality of opportunity demands that the sexes be educated separately.

The merits, and drawbacks, of single-sex education have been hot topics in education ever since the beginning of compulsory public education in the United States. There are many studies that demonstrate the positive effects of single-sex education. On the other hand, there are a number of studies that try to show that single-sex education is not as beneficial as some might think.

Das (2018), states that over the past three decades the relative merits of Single-sex and co-education for the educational and socio-emotional development of school-aged students, particularly at the secondary level, have been debated extensively. He, reported that some research evidence has been supportive of co-education, while other studies have cited the benefits of single-sex education. Much of the research in the field has been conducted to demonstrate the benefit for women, especially in colleges, but very little has been done to study the impact on younger grades or for men. Bennett (2015), supports the need for further research by saying that any number of studies show that single-sex education is beneficial for college-age women, but the work done so far to study the issue for students in Kindergarten through 12th grade is, at best, spotty and inconclusive. Reasons for the disparity in that, volume of research is not clear. Perhaps it is due to the sentiment that it is more important currently to level the playing field for women, than it is to study the effectiveness of single-sex education for men.

Some studies suggest that single gender schools benefit both males and females, because they provide a stronger academic climate and reduce distractions (Dung, 2015). Other research points out that single gender schools are particularly beneficial for boys because they promote male bonding and optimize male character development (Chandler, 2017) and that males from low income and minority backgrounds especially profit from a single gender school.

Researchers suggest that the type of school will have an impact on the courses that boys choose as well. Some researchers also feel that in the single- sex environment boys will be more likely to pursue their actual interests, rather than being pressured by stereotypes to pursue traditional boys' courses. In a study on the performance of girls and boys in 30 single-sex and co- educational schools in England, Navarre, (2014) revealed that while both girls and boys did better in single-sex schools than they did in co-educational schools, the single-sex advantage was greater for the boys than it was for the girls.

The achievement levels of students attending single-sex schools compared to that of students attending coeducational schools is often a hotly debated aspect in the debate of single-sex versus co-educational schools. There are studies that demonstrate that single-sex schools are better at achieving higher academic levels; there also studies that demonstrate that co-educational schools are better at achieving higher academic levels. Das, (2018), report that the mean achievement scores in science for boys in the single-sex school were significantly better than those in coeducational schools. This result demonstrates that, on an average, the science achievement of male as well as female students in single-sex schools were moderately better than that of students in coeducational schools. Bofah and Hannula, (2016) reviewing studies on single-sex education, reported that grade point averages were higher for both girls and boys in single-sex Mathematics and Science classes than in mixed-sex classes. Navarre, (2014), refers to several studies that demonstrate the superior achievement levels of single-sex schools over co-educational schools. A study offered by Navarre, (2014) found out that even after controlling for students' academic ability and other background factors, both girls and boys did significantly better in single-sex schools than in co-educational schools. Another research study reviewed on Navarre, (2014) compared performances of students at single-sex and co-educational schools. Their analysis, based on six years of study of over 270000 students, in 53 academic subjects, demonstrated that both boys and girls who were educated in single-sex classrooms scored an average of 15 to 20 percentile ranks higher than boys and girls in co-educational settings

Navarre, (2014) cited a study from Jamaica and discusses how girls in single-sex schools are the highest achievers, followed by boys at single-sex schools, then boys at coeducational schools rounding out the bottom of the list. Advocates of single-sex schooling have claimed that current co-educational schooling disadvantages boys, and teaching boys and girls separately will boost boys' achievement and reduce the gender gaps. Bailey, (2016) argues that boys and girls have a number of hardwired differences that are best accommodated by single-sex schooling. He claims that in the co-educational classroom so many of the choices we make are to the advantage of girls, but disadvantage boys, and that schooling boys and girls separately is the best way to accommodate boys needs without disadvantaging girls.

According to Wasanga (as cited in George, 2020)) students in single- sex girls' schools had more confidence in learning science than those in mixed schools. The girls perceived their teachers' attitude towards them more positively. Again, in the report by Wasanga, the males had more confidence in learning science and perceived science to be more useful.

Helgeson, (2020) examined the effects of attending a single-sex school on progress in GCSE in a sample of British high school students. Helgeson's study reported that, after controlling for prior attainment, both girls and boys benefitted from single-sex schooling, and was some suggestion that girls benefitted slightly more than boys. Cheryan, et. al., (2017) examined educational achievement gains during attendance at single-sex and co-educational Australian Catholic High Schools, as measured by test score gains on reading, mathematics, science and writing components of the high school. The study found that pupils in single-sex schools had higher levels of achievement than pupils in coeducational schools, and that the advantages for single-sex schooling tended to be greater for girls than for boys.

Other studies have found that the effects of single-sex schooling are the same for males and females. For example, Sadler, et. al., (2012) found that gender differences in science achievement in Australian high school students were similar at single-sex and co-educational schools.

Some researchers would argue that there are factors, other than that of the sex of the students, which have an impact on the successes of single-sex schools. One frequent hypothesis is that single-sex schools perform better because most are private and can select their students from the cream of the crop. Wang and Degol, (2017) opine that "the outstanding performance of the single-sex schools in examination league tables has much more to do with academic selection, socioeconomic background and the standing of the school itself than with the segregation of the sexes. Bennett, (2015) reinforces the idea that it is not sex separation that is responsible for these successes. Chandler, (2017) argues that with regard to achievement levels there is no clear-cut winner. For every study that shows single-sex education to be more effective, there is one that shows co-education to be more effective.

2.12 Influence of Gender on Planning, Interpreting and Reasoning Skills

Gender differences in educational achievement have been widely reported in a number of countries, including the USA, UK, Australia and New Zealand. These reports have identified a male disadvantage across a range of curriculum areas, and a substantial male disadvantage in the attainment of educational qualifications, both at high school and in tertiary education. For example, in 2007 New Zealand Secondary School Examinations, females gained a greater proportion of 'excellence' grades (the highest grade available) than males in every, major subject area. Including the traditionally male dominated fields of mathematics and science (New Zealand Qualifications Authority, 2007)

There are mixed reports on gender difference in science. Many researches have reported that there are no longer distinguishing differences in the cognitive, affective and psychomotor skill achievements of students in respect of gender (David and Stanley, 2002; Sungur and Tekkaya, 2003). Afuwape and Oludipe (2008) found out from a study that there was no statistically significant difference in academic performance in integrated science between male and female students. Findings revealed that the gender gap in integrated science achievement, among the sample data, could be disappearing. They however, found that male students had higher mean score than the female students.

Other researchers have reported differently on the issue of gender difference in a study carried out by Eriba and Sesugh (2006), they found that boys outperformed girls in science and mathematics. Other research reported that males are becoming the disadvantaged gender in schools and that fewer males are interested in science (Weaver-Hightower. 2003, Alkhateeb, 2001).

Among high school students, cognitive abilities that include previous science knowledge as well as reading ability as measured by traditional content-based tests have been shown to predict students' comprehension of science passages, science course grade, and state science test scores differently for males and females. Males scored higher on science knowledge and on reading comprehension whereas females scored significantly higher on science strategy Knowledge (O'Reilly and MeNamara, 2007). In terms of the format of questions and differences by gender on content-based tests, males were shown to score higher on both multiple choice and open-ended questions than females (Penner, 2003: O' Reilly and MeNamara, 2007)

A study conducted by Madigan (1997) to determine the relationship between student science course taking and the change in student science proficiency level between 8 and 12" grades revealed that 54% of students showed an increase in their science proficiency level, while 35% stayed at the same level and 11% declined. The chances of increasing in science proficiency level varied with the demographic and academic characteristics of students, in particular, male students were more likely than females to increase their science proficiency level between 8 and 12 grades. Gender continued to influence the likelihood of increasing in science proficiency level even after controlling for differences in previous science course taking. Males were more likely to increase in science proficiency than females (Madigan, 1997). High school physics coursework (content, pedagogy. and assessment) and confidence in physics courses were examined to determine their role in predicting introductory University Physics performance; Results revealed that high school physics and affective experiences differentially predicted female and male performance. High school physics courses that required a full understanding of topics seemed to benefit female students more than male students; Alternatively, University physics courses that required memorisation seemed to benefit male students' more than female students (Hazari, Tai, and Saddler, 2007).

Bacharach, Baumeister, and Furr (2003) examined he science performance among eight grade students. They found that the average eight grade science achievement scores were significantly different for males and female. Beaumont-Walters and Soyibo (2001) asserted that the scores of females on integrated science process skills were slightly higher than that of males.

A study by Lee and Burkam (1996), also examined gender difference in eight grade science achievement. Although females had better grades in science and a slight advantage in life science, females do not perform as well in physical science: this latter difference is most pronounced at the highest level of ability. Lee and Burkam (1996) suggested that this may be due to differences in laboratory experience. Laboratory experiences were more beneficial to the females than to the males on physical science achievement, but were not common in the eighth-grade classrooms survey. Further, females were less likely than males to participate in science activities outside the classroom, to visit science museums, and to have positive altitudes about science and about their science classes (Lee and Burkam, 1996).

Gender-based classroom practices have been shown to negatively impact the performance of females in science. By giving more attention to male students during science instruction, teachers may inadvertently be sending the message that female students are less capable in these areas (Sandler, Silverberg, and Hall, 1996). Negative attitudes about science related disciplines that are driven by gender-biased stereotypes may influence the number of women who pursue degree in Science, Engineering and Mathematics (STEM) fields. Stereotypical views held by female students as well as parents that science is a male-dominated field may prevent women from seeing benefits related to pursuing a career in science disciplines (National Research Council, 2006).

The manner in which subject matter is covered has been highlighted an important factor affecting the science achievement of females. One meta-analysis found several strategies that had a positive impact on science achievement among students, including females. These strategies include relating learning to students' previous experiences, collaborative learning varying the level and type of questions asked during lessons, using inquiry-based approaches that allow for hands-on manipulation of science material, employing a variety of assessment methods, and incorporating instructional technology into lessons (Schroeder, Scott, Huang, Tolson, and Lee, 2007). In addition, females tend to perform better on areas of standardised science assessment that address the human application of science such as lite sciences.

Also, females tend to enroll in advanced coursework und pursue degrees in science fields that have a direct application to improving the human condition (lngels and Dalton, 2008). These trends suggest that females may be turned off from studying STEM subject matter and pursuing careers in STEM fields due to stereotypes that such fields have little or no impact on the human condition (Green as cited in Amelink, 2009).

Among US fourth-graders, trends in international Mathematics and Science Study (TIMSS) conducted by the International Association for the Evaluation of Educational Achievement (lEA), revealed that the science achievement gap may be narrowing between males and females. In 2007 male and females showed no measurable difference in their average science performance. While differences were not significant, examining performance by content areas shows males outperformed in one content area, earth science.

There was no measurable difference detected in the average scores by gender in either the life science or physical science domains (Gonzales et al. 2004). Males outperformed females overall in science in 2003, which was also the case in 1995.

Comparison of TIMSS 2003, 1999 and 1995 US Eight Grade Score results by gender reveal continued higher performance in science by males in certain content areas. In 2007, males performed significantly higher than female classmates overall in science, scoring higher in three of the science content domains: Biology, Physics and Earth Science. There was no measurable difference detected in the average science scores of US eight-grade males and females in the chemistry domain. In 2003, males outperformed females in science, which was also the case in 1999 and 1995 (Gonzales et al. 2008). In 1995, statistically significant differences favoured males in overall science, earth science and physical science, but there were no differences in life science, environmental issues, and the nature of science.

Lee and Burkam (1996) found that males tended to do much better than females in physical science, while females held a modest advantage in the life sciences. In terms of academic achievement, females benefitted much more than boys did from laboratory experiences. Lee and Burkam (1996) concluded that science laboratory experiences and other forms of hands-on learning particularly in the physical sciences could help to promote gender equity and science achievement at the middle level.

Meech and Jones (1996) looked at motivation and strategy use and questioned whether females were rote learners. After studying 213, 5th and 6th-grade students self-reports of confidence, motivational goals and learning strategies, Meech and Jones (1996), found few gender differences. Compared with females, however, males showed greater confidence in their science abilities. Average-achieving females reported greater use of meaningful learning strategies, whereas low-ability females reported a stronger mastery orientation than low-ability females. Both genders showed greater confidence and mastery motivation in small-group instruction than in whole-class instruction.

Meech and Jones (1996), concluded that the evidence did not support females being more likely than males to learn science in a rote or verbatim manner. In a similar vein, Valanides (1996) worked with 195 7^{th} -8^{th} and 9^{th} grade students to determine their formal reasoning abilities. Valanides (1996), did not find differences in how males and females engage in reasoning processes. This was supported by Willingham and Johnson (1997) when they asserted that females and males receive similar grades in their courses at high schools.

Examining participation in science fairs, Greentield (1995) sought to determine whether the genders differed with respect to: decisions to enter science fairs, project topics (life science, physical science, earth science and mathematics) and project types (research or display). She examined 20 years of participation in the Hawaii State Science and Engineering Fair a concluded that:

1. Females are more likely now than 20 years ago to participate;
2. Female representation in the physical sciences has increased over the years;
3. Females continue to be less likely than males to engage m physical Science projects, earth science and mathematics; and

4. Females tend to avoid projects based on scientific inquiry and experimental research in favour of those based on library research.

In her study of science achievement, Greentfield (1996) concluded that males reported more stereotyped views of science than females. Seshie (2001) in a study reported that both males and females' chemistry students engaged in laboratory work exhibited the same level of proficiency in the skills of planning Johnson (2001), however, found out from a study that females performed better than males in the skills of planning, performing and reasoning. Ossei-Anto (1996) also found out from a study that females scored higher on performing and reasoning tasks. He however found out that there are statistical differences between males and females where males scored higher on the planning task.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This Chapter provides a detailed description of the research design, population, sample and sampling technique, instruments, procedure for data collection and data analysis.

3.1 Research Design

The study determined the level of competency of SHS biology student in planning, interpreting and reasoning skills; again, the relationship between the type of school and the effect of gender in planning, interpreting and reasoning skills were assessed. The study adopted the Basic Skills Assessment approach to accomplish this; Basic Skills Assessment is psychological assessment which is basically a judgmental process whereby a broad range of information, often including the results of psychological tests, is integrated into a meaningful understanding of a particular person. Psychological testing is thus a narrower concept referring to the psychometric aspects of a test, the actual administration and scoring of the test, and the interpretation made of the scores (Geisinger and McCormick, 2013).

Psychometric tests are standardized tests designed to evaluate psychological functions, intelligence, ability, personality, interests and values.

They are pen and paper or computer based and are taken under standardized conditions. The results are quantified by reference to a scale derived from research and the answers are objectively marked and analysed to produce a score or profile.

The basic skills assessment approach was used because it is a test of minimum competency. Students also engage in hands-on activities that are scored as right or wrong. The rationale behind the design of the research is to enable one to compare the levels of proficiency of the students on the skills of planning, interpreting and reasoning. Additionally, it will offer an opportunity to determine the relationship among the students' level of planning, interpreting and reasoning in practical work in biology. In Psychological testing, however, it is usually not possible to control all the extraneous variables.

The research design also adopted descriptive sample survey to determine the strategy employed by teachers in teaching the skill of planning, interpreting and reasoning skills. This type of research explains and interprets the problems, conditions and practices, actual or existing beliefs and points of views that are going on. This includes more people and explains the characteristics of the population by choosing an objective sample. This type of research design is useful because it collects data once, and therefore is economical and efficient. It also generates digital data. This research explains what is available due to the way biology works in senior high schools. According to Gunn, Taylor and Hutcheon, (2014), descriptive sampling involves the collection of data on hypotheses or questions related to the current state of a subject. In addition, Cyr, et al., (2017) recommends descriptive samples to summarize demographic samples, so that references can be made about characteristics, attributes or behaviour of the population.

3.2 Population

The population for this study was 180 SHS three (3) elective biology students offering General Science programme for the 2020/ 2021 academic year in selected SHS in Ghana. There were nine schools offering the general science programme. Three schools each from each category of SHS as per Ghana Education Service standard. The three schools in each category were classified as a Single-sex boy, Single-sex girls' and a mixed school. There were three single-sex boys' schools, three single-sex girls' schools and three mixed (co-educational) schools.

Two (2) elective Biology teachers each from the schools sampled making 18 teachers were also engaged to complete a questionnaire on the strategy employed by teachers in teaching the skill of planning, interpreting and reasoning skills.

3.3 Sample and Sampling Procedure

The sample consisted of 180 students from three both single sex and co-educational Senior High Schools (SHS) offering elective biology for the West African Secondary School Certificate Examinations (WASSCE) and 18 teachers from the nine schools.

Purposive sampling was used to select the schools which participated in the study. Three single-sex girls' school, three single-sex boys' school and three co-educational schools were selected.

A visit was made to the selected schools to collect the number of classes offering elective biology in each of the schools; one class was selected randomly from each of the selected schools. Table 1 shows the type of school and number of students in each selected class.

Table 1: Number of Students and teachers in each Selected school that in the Study

CATEGORY	TYPE OF SCHOOL	NUMBER OF STUDENT
A	SINGLE-SEX BOYS'	20
	SINGLE-SEX GIRLS'	20
	MIXED	20
B	SINGLE-SEX BOYS'	20
	SINGLE-SEX GIRLS'	20
	MIXED	20
C	SINGLE-SEX BOYS'	20
	SINGLE-SEX GIRLS'	20
	MIXED	20
Total		**180**

3.4 Instrument

The research instrument that was developed for the study was performance assessment tasks. This was a researcher-developed instrument. The tasks for the students comprised of the tasks under the following headings

i. Planning task

ii. Interpreting task

iii. Reasoning task

Under the planning task (Task A), students were presented with a problem and list of materials. Students were required to plan and design an experiment to solve the problem. Students were also required to list in order, the steps they will use to solve the problem.

On the interpreting task (task B), students were presented with a biological data and were asked to interpret data as far as they can. Students were also required to establish relationship between two variables on the data provided.

Under the reasoning task (task C), students were presented with a data on an experimental result and were asked to give reasons for the experimental results recorded and hence state what could be derived from the experiment.

The Performance Assessment Tasks (Task A-Planning skills, Task B-Interpreting skills, Task C - Reasoning skills) have been shown in Appendix A-C.

3.5 Validity of the Main Instrument

Validity determines whether the research instrument truly measures that which it is intended to measure. In order to make sure that the questionnaires were valid, they were given to the supervisor, who went through and gave the necessary suggestions and corrections to ascertain the content and face validity of the items.

3.6 Pre-Testing of Instrument

The instruments were shown to colleagues and supervisor for their expert advice in order to establish face and content validity.

In order to check for the appropriateness of the data collection instrument and data procedures, the instruments were pre-tested before the main study. The research instruments were pre-tested using a sample size of 30 elective biology students from a selected class in a school in Kwabre East Municipal in the Ashanti Region of Ghana. The schools that were selected for the pilot test have the characteristics that are similar to those of the main study. The selected school was visited to administer the instruments.

To establish the reliability of the instrument, Kuder-Richardson (K-R20) estimate was used to establish the reliability since the tasks were scored dichotomously. Alpha values of 0.72, 0.76 and 0.89 were obtained for the planning skills, interpreting skills and reasoning skills respectively. The inter-rater reliability coefficient was found using the Pearson's Product Moment Correlation Coefficient. The inter-rater reliabilities were found to be 0.95, 0.98 and 0.96 for planning task, interpreting task and reasoning task respectively. These results reinforce the research of Gipps (2011) which found that the inclusion of clear rubrics and training for markers, and exemplars of performance at each point or grade, levels of inter-rater reliabilities can be high.

The scoring format and the detailed marking scheme for the various task can be seen in Appendices D.

3.7 Data Collection Procedure

A letter of introduction from the Department of Science Education was sent to each of the schools identified for the study. After sending the letters of introduction to the Headmasters and Headmistresses, the schools were visited for the following reasons:

1. To establish support with the biology teachers and the students offering elective biology.
2. To obtain first-hand information of the various classes in form three (3).

There was a meeting with the students involved on the date and time greed for each school. I then explained to the students what will be done and the purpose of the research being conducted. On the day of study, the students were made to sit in such a way that any student in an adjacent left or right row beside another student respond to a different task. Data collection lasted for three Weeks. Three schools were visited in each week.

3.8 Data Analysis

The data was analysed using the research questions as guide. The data was organised and then coded with various numbers assigned to each distinctive variable. After coding, inputs were made of the coded data using Statistical Product for Service Solution (SPSS) version 20 for analysis. Descriptive statistics (percentages) were used to analyse items to answer Research question 1. Kruskal-Wallis test, which is an alternative to ANOVA, was used to analyse items to answer Research question 2. This is because when the test of normality of distribution of scores was done using Kolmogorov-Sminoy statistics, a significant value (sig value) of 0.024 and 0.035 were obtained for interpreting and planning skills respectively. This suggests a violation of the assumption of normality, however, in the reasoning skills; a non-significant result (sig. value of 0.888, which is more than 0.05) was obtained. This indicates normality, therefore ANOVA Was used to analyse items to answer this part of Research question 2. Mann-Whitney U Test, which is an alternative to independent t-test, was used to analyse items to answer research question 3 Mann-Whitney U test was used because the test of normality produced significant values of 0.001, 0.001 and 0.003 for planning interpreting and reasoning skills respectively. These suggest a violation of normality.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Overview

The purpose of the study was to determine the level of competency of SHS biology students in planning, interpreting and reasoning skills and see whether the type of school has influence on the proficiency level in demonstrating planning, interpreting and reasoning skills when SHS biology students are engaged in laboratory work.

The chapter presents answers to the research questions and results of Mann-Whitney U analysis on gender and proficiency level, Kruskal- Wallis and ANOVA analysis on the type of school and proficiency levels of students in the skills of planning, interpreting and reasoning respectively.

4.1 Students' Proficiency

Research Question 1 sought to find out students" level of proficiency in the skills of planning, interpreting and reasoning when involved in laboratory work. To accomplish this, SHS 3 biology students were given tasks under the following heading:

Task A-Planning task

Task B- Interpreting task

Task C-Reasoning task

The results of the performance of the students in the various tasks are shown in Table 2, Table 3 and Table 4.

4.2 Students' Performance on Planning Skills

There were seven levels of scores for the skill of planning. A student is proficient enough when he/ she scores four points and above. A student is seen to be not proficient when he/she scores below four points. From Table 2, 21 students (11.80%) scored four points, 29 students (16.29%) scored five points, 30 students (16.85%) scored six points and 20 students (11.24%) scored seven points. These scores represent 56.18% of the total number of students who showed proficiency in planning skills. It suggests therefore that majority of the students showed skills of planning when engaged in laboratory work. According to Litman 2010, it can be concluded that majority of the students are good planners because they were able to manage information flows, including gathering, organising and distribution. They were also able to anticipate questions and provided accurate and understandable information. However, 43.82% of the students were not proficient enough in the skill of planning.

Table 2: Students' Performance on Planning Skills

SCORE	FREQUENCY	PERCENT
0	11	6.18
1	23	12.92
2	26	14.61
3	18	10.11
4	21	11.80
5	29	16.29
6	30	16.85
7	20	11.24
TOTAL	**178**	**100**

4.3 Proficiency of Students in Interpreting Skills

The proficiency of students in interpreting skills has been shown in Table 3. There were five levels of scores for the interpreting skills. A student is proficient enough when he/she scores three points and above. Students who scored below three points are regarded as not proficient enough. Results from Table 3 indicate that 18 students (10%) scored three points, 62 students (34.44%) scored four points and 36 students (20.0%) scored five points. These represent 64.5% of the students who showed proficiency in the interpreting skills. This indicates that a greater number of the students showed skills of interpreting from biological data. However, 35.5% of the students were not proficient enough in the skills of interpreting data. It may be that these students are deficient in logical thinking and proportional reasoning because according to Clements & Sarama, (2020) students who are deficient in logical thinking and proportional reasoning have difficulty in interpreting graphs.

Table 3: Proficiency of Students in Interpreting Skills

SCORE	FREQUENCY	PERCENT
0	22	12.22
1	18	10.00
2	24	13.33
3	18	10.00
4	62	34.44
5	36	20.00
Total	**180**	**100**

4.4 Proficiency of Students in Reasoning Skills

Table 4 talks about the level of proficiency of students in reasoning skills. There were five levels of scores for the reasoning skills. A student is proficient enough if he/she scores three points and above. Students who score below three points are not considered to be proficient enough. From table 4, 32 students (17.78%) scored three points, 46 students (25.56%) scored four points and 40 students (22.22%) scored five points, these scores represented 65.56% of the students who showed proficiency in the skills of reasoning. This suggests majority of the students showed reasoning skills from biological data. However, 34.44% of the students were not proficient in the reasoning skills.

Table 4: Proficiency of Students in Reasoning Skills

SCORE	FREQUENCY	PERCENT
0	10	5.56
1	21	11.67
2	31	17.22
3	32	17.78
4	46	25.56
5	40	22.22
Total	**180**	**100**

4.5 Mean Scores and Standard Deviations

The mean scores and the standard deviations for the individual tasks are shown in Table 5. Task 'A' had a mean score and standard deviation of 22.25 and 6.23 respectively. Task B had the mean score of 30.0 and standard deviation of 17.02. Task C had a mean score of 30.0 and the standard deviation of 12.98. The total task had a means of 82.25 and standard deviations of 36.23. Generally, the standard deviations are relatively small. This is an indication that the groups are homogeneous. That is, the students are performing at the same level.

Table 5: Mean Scores and Standard Deviations for the Individual Task

VALUE LABEL	NUMBER OF ITEMS	MEAN	STANDARD DEVIATION
TASK 'A' (PLANNING)	7	22.25	6.23
TASK 'B' (INTERPRETING)	5	30	17.02
TASK 'C' (REASONING)	5	30	22.22
TOTAL TASK	**17**	**82.25**	**36.23**

N=180

4.6 Adequate and Inadequate Responses

Both correct and wrong responses were sorted out after scoring the three tasks. Each item had two-point rating range: full score of 1 point for correct or adequate response; and zero or no score for wrong or inadequate response. For a response to be considered adequate, the student should score one point or should give a correct answer. So, an inaccurate response is the reverse.

4.7 Adequate and Inadequate Responses for Task 'A' (Planning skills)

The students' responses to Task A have been shown in Table 6. Under planning, 149 (82.78%) respondents had general strategy correct. 140 (77.78%) had systematic planning correct, 132 (73.33%) had clarity correct, 82(45.56%) had detailed planning correct, 103 (57.22%) had workable planning correct, 79 (43.89%) had appropriate diagram correct and 87 (48.33%) had safety precaution correct.

The students' responses were generally good. It implies that majority of the students have skill of planning. However, greater percentage of students did not have the skill of detailed planning, making appropriate diagram and taking safety precaution. As shown in Table 6, 98(54.44%), 101 (56.11%) and 93 (51.67%) respondents had no skill of detailed planning. making appropriate diagram and taking safety precaution respectively. This is an indication that under planning skills, majority of the students were not proficient when it comes to detailed planning, safety precautions and providing appropriate charts or diagram when planning their laboratory work.

Table 6: Adequate and Inadequate Responses for Task 'A' (Planning skills)

VALUE LABEL	NO SCORE		FULL SCORE	
	FREQ.	%	FREQ.	%
GENERAL STRATEGY	31	17.22	149	82.78
SYSTEMATIC PLANNING	40	22.22	140	77.78
CLARITY	48	26.67	132	73.33
DETAIL PLANNING	98	54.44	82	45.56
WORKABLE PLAN	77	42.78	103	57.22
APPROPRAITE DIAGRAM	101	56.11	79	43.89
SAFETY PRECAUTION	93	51.67	87	48.33

N=180

4.8 Adequate and Inadequate Responses on Task B (interpreting skills)

Students were to interpret a biological data. Their responses have been displayed in Table 7.

Table 7: Adequate and Inadequate Responses on Task B

VALUE LABEL	NO SCORE		FULL SCORE	
	FREQ.	%	FREQ.	%
RELATIONSHIP BETWEEN POTENCY OF EXTRACT AND TIME OF STORAGE	120	66.67	60	33.33
EXTRACT FROM PLANT 'A'	40	22.22	140	77.78
EXTRACT FROM PLANT 'B'	47	26.11	133	73.89
RECOMMENDED PLANT EXTRACT	30	16.67	150	83.33
REASON FOR ANSWER	43	23.89	137	76.11

N=180

From Table 7, 60 (33.33%) respondents had relationship between both plant extracts and the time of storage correct, 140 (77.78%) respondents were able to explain extract from plant A correctly, 133 (73.89%) respondents were also able to explain extract from plant B correctly. 150 (83.33%) respondents were able to recommend extract from plant A to people who may want to use one of the plant extracts to store their grains and 137 (76.11%) respondents were able to give reasons why they had recommended extract from plant A to people who may want to use one of the extracts to store grains.

The students' responses to individual items under the interpreting skills were generally good. This is an indication that majority of the students have skill or interpreting. However, 120 (66.67%) respondents were not able explain the relationship between extracts from both plants and the time of storage. This therefore suggests that majority of students have problem explaining the relationship between two items when they are to interpret a biological data.

The students 'responses to Task C have been shown in Table 8.

Table 8: Adequate and Inadequate Responses on Task C (Reasoning Skills)

VALUE LABEL	NO SCORE		FULL SCORE	
	FREQ.	%	FREQ.	%
MAJOR DIFFERENCE BETWEEN SET-UPS	30	16.67	150	83.33
AIM OF EXPERIMENT	41	22.78	139	77.22
REASON FOR RESULTS IN 'A'	19	10.56	161	89.44
REASON FOR RESULT IN 'B'	49	27.22	131	72.78
CONCLUSION FOR EXPERIMENT	70	38.89	110	61.11

N=180

In Table 8, 150(83.33%) respondents were able to give the major difference between set-ups 'A' and 'B' a 15 correctly, 139(77.22%) respondents were able to state the aim of the experiment correctly, and 161 (89.44%) respondents were able to give reasons for the experimental results in set-up A. 131 (72.78%) were also able to give reasons for the experimental result in set-up 'B' and 110 (61.11%) respondents were able to give a correct conclusion to the experiment.

In general, the performance of the students on various items in the reasoning skill has been very good. This is an indication that majority of the students have the reasoning skills.

4.9 Performance of School type on the Planning, Interpreting and Reasoning Skills

Research question 2 sought to find out how the type of school influences the planning, interpreting and reasoning skills of SHS biology students. To accomplish this, Kruskal-Wallis Test analysis, an alternate to ANOVA, was used for the planning and interpreting skills because when the test of normality was done using Kolmogorov Smirnov statistics, a significant value of 0.024 and 0.035 was obtained for the planning and interpreting skills respectively. This suggests a violation of the assumption of normality of ANOVA. However, ANOVA was used for the analysis of the reasoning skills because when the test of normality was done using the Kolmogorov Smirnov statistics, a non-significant value of 0.888 was obtained. This indicates normality.

4.9.1 Kruskal-Wallis test of Planning Skills by School Type

The performance of the type of school on the planning skills has been shown on Table 9. From table 9, the significance level was found to be 0.11. This is greater than the alpha level of 0.05, so this result suggests that there is no statistically significant difference in the planning skills across the three school types. The finding is consistent with the finding of Nicholson (2005) that with regard to achievement levels, there is no clear-cut winner. For every study that shows grade ‘A’ and ‘B’ education to be more effective, there is one that shows grade ‘C’ to be more effective.

Table 9: Kruskal-Wallis test of Planning Skills by School Type

VALUE LABEL	REASONING SKILLS
Chi-square	4.29
Df	2
p-value	0.11

P>0.05

4.9.2 Mean Rank for the Planning Skills by School Type

The mean ranks for the school types in the planning skills have been shown in Table 10. From Table 10, an inspection of the mean ranks for the school types suggest that grade ‘A’ school had the highest score (64.64) on the reasoning skills, with grade ‘C’ reporting the lowest (48.08). This is an indication that on the average, grade ‘A’ is performing better at similar levels in the planning skills than grade ‘B’ and grade ‘C’. In the grade ‘B’ and grade ‘C’ schools, the mean ranks revealed that grade ‘B’ performed better at similar levels than the grade ‘C’ who had the lowest mean rank. This finding is congruent to a finding by NASSPE (2005) that grade ‘B’ schools are the highest achievers, followed by grade ‘C’ schools. The finding of this study also suggests that grade ‘B’ schools perform better at similar levels in practical work than grade ‘C’. This is because Akinbobola and Afolabi (2010) argued that practical planning, designing a problem, creating a new approach and procedure and also putting familiar things in the new arrangement provide enhanced result in practical works.

Table 10: Mean Rank for the Planning Skills by School Type

Grade of school	N	MEAN RANK
GRADE 'A'	60	64.64
GRADE 'B'	60	60.26
GRADE 'C'	60	48.08
TOTAL	**180**	

4.9.3 Kruskal-Wallis Analysis of Systematic Planning by School Type

Further analysis to determine whether school type has influence on the systematic planning and detailed planning were conducted.

Table 11 shows Kruskal-Wallis analysis of systematic planning by school type. In Table 11, the significance level was found to be 0.006 and this is less than the alpha level of 0.05, this result suggests that there is a statistically significant difference in students plan being systematic, logical or scientific across the three school types. An inspection of the mean ranks for the school types suggest that grade 'B' had the highest score (67.71)) in planning systematically, with grade 'C' having the lowest score (46.72). With this finding, one can say that grade 'B' are good planners when it comes to planning an experiment systematically because Ford, Rogerson, Cody, & Ogah, (2015), argues that good planning requires a methodical process that clearly defines the steps that lend to optimal solutions, and this process leads to logical planning where each step leads to the next.

Table 11: Kruskal-Wallis Analysis of Systematic Planning by School Type

Value I label	Systematic Planning
Chi-square	10.39
Df	2
P- value	0.006

P<0.05

4.9.4 Mean Ranks for Systematic Planning by School Type

The mean rank for systematic planning by school type is shown in Table 12. Students' ability to describe experiments or procedures fully was found to be different across the three school types.

Table 12: Mean Ranks for Systematic Planning by School Type

GRADE OF SCHOOL	N	MEAN RANK
GRADE 'A'	60	60.50
GRADE 'B'	60	67.71
GRADE 'C'	60	46.72
TOTAL	**180**	

4.9.5 Kruskal- Wallis Analysis of Detailed Planning by School Type

The performance of the school types on detailed planning has been shown on Table 13 from Table 13, the significance level was found to be 0.01 and this is less than the alpha level of 0.05. This result suggests that there is a statistically significant difference in students describing a procedure fully across the three school types. The finding of this study suggests that when it comes to detailed planning of practical work or experiments, grade 'A', grade 'B' and grade 'C' schools perform at different levels.

Table 13: Kruskal- Wallis Analysis of Detailed Planning by School Type

Value I label	Systematic planning
Chi-square	7.56
Df	2
P- value	0.01

P<0.05

4.9.6 The mean ranks for the school types on detailed planning are shown on

From Table 14, an inspection of the mean ranks for the school types suggest that grade ‘A’ had the highest score (64.34) in describing procedures fully, with grade ‘B’ having the lowest score (47.62). Grade ‘B’ having the lowest score in detailed planning indicates that although they can plan experiments systematically to solve a given problem, most of the plans they design are not detailed enough to solve such problems.

Table 14: The mean ranks for the school types on detailed planning are shown on

GRADE OF SCHOOL	N	MEAN RANK
GRADE ‘A’	60	64.34
GRADE ‘B’	60	47.62
GRADE ‘C’	60	55.78
TOTAL	**180**	

4.10 Performance of School type on Interpreting Skills

Table 15: The performance of the school type on interpreting skills has been shown on

Value I label	Interpreting skills
Chi-square	3.95
Df	2
P- value	0.14

P>0.14

The significance level was found to be 0.14 and this is greater than the alpha level of 0.05. This result suggests that there is no statistically significant difference in the interpreting skill across the three school types. By this result, it can be said that the proficiency on the part of the students to interpret scientific data is the same in the three school types. Roth and McGinn as cited in Matthews, (2014), found out that competence on the part of students to interpret data depends on their experience and the degree of their participation in activities that involve interpreting data.

Since the finding of this research shows that there is no difference in the performance of students in the interpreting skills across the three school types, it therefore mean that the experience of the students and the degree of their participation in activities that involve interpreting data is at the same level in the three school types.

The mean ranks for the school types are shown in Table 16

Table 16: Mean Ranks for the School Types on Interpreting Skill

Grade OF SCHOOL	N	MEAN RANK
GRADE ‘A’	60	53.74
GRADE ‘B’	60	68.70
GRADE ‘C’	60	56.22
Total	**180**	

An inspection of the mean ranks for the school types suggest that grade ‘B’ had the highest score (68.70) in interpreting the scientific data, with grade ‘A’ school having the lowest score (53.74). This result indicates that when it comes to interpretation of scientific data, grade ‘B’ are the highest achievers followed by grade ‘C’. These findings are in agreement with a finding by Liben (2015) that grade ‘B’ schools are the highest achievers, followed by grade ‘C’ schools, and then grade ‘A’ schools rounding out the bottom of the list. The finding of this study is also consistent with a finding by Fonagy, Gergely, & Jurist, (2018), that pupils in grade ‘B’ and grade ‘C’ schools had higher levels of achievement than pupils in grade ‘A’ schools, and that the advantages for grade ‘B’ tended to be greater for grade ‘C’.

4.11 Performance of School Type on Reasoning Skill

A one-way analyst of variance was conducted to explore the influence of the type of school on reasoning skills. Samples were divided into Grade of school; Grade 'A', 'B' and 'C'. There was a statistically significant difference at the $p<0.05$ level in reasoning skills for the three groups. ($F (2, 177) =5.99$. $p= .003$). The actual difference in mean Scores between the groups were medium. The effect size calculated using Eta square, was 0.097. Post-hoc comparisons using Tukey HSD test indicated that the mean score for the grade 'B' (M=3.38. SE= 1.50) was significantly different from grade 'A' (M=2.82, SD =1.51), grade 'C' (M=3.85, SD=1.08). However, grade 'C' did not differ significantly from grade 'A'.

This finding of the study suggests that in reasoning skills; grade 'A', 'B' and 'C' schools performed at different levels. It also indicates that the performance of grade 'B' in reasoning skills is higher than grade 'C' and 'A' schools. Grade 'C' school, however did not outperformed grade 'A' schools in the reasoning skills because there was no statistically significant difference between the two schools.

The means and standard deviations for the school types is shown on Table 1 7.

Table 17: Means and Standard deviations for the School Types

Grade of School	**N**	**Mean**	**Standard deviation**
Grade 'A'	60	2.82	1.51
Grade 'B'	60	3.38	1.50
Grade 'C'	60	3.85	1.08
TOTAL	**180**	**3.32**	**1.43**

Table 17, it was found that the mean scores of the grade 'A' and 'B' schools were significantly better than the grade 'A' schools. Mean scores of 3.85, 3.35 and 2.82 were obtained for grade 'B', 'C' and 'A' schools respectively. Liben (2015) report that the mean achievement scores in science for grade 'C' schools were significantly better than those in grade 'A' schools. This result demonstrates that, on the average, the science achievements of grade 'B' and 'C' Schools were moderately better than that of students in grade 'A' schools. The findings of this research on the reasoning skills seem to agree with the finding of Liben (2015). The finding of this research is also congruent to a finding by Paul, Modi, and Patel, (2016) that grade point average was higher for both grade 'B' and 'C' Mathematics and Science schools than in grade 'A' schools.

Table 18 shows the analysis of variance of school types.

Table 18: Analysis of Variance of the School Types

Value label	Sum of Squares	df	Mean square	F	p
Between Groups	22.49	2	11.24	9.53	.003
Within Groups	208.51	177	1.18		
Total	**230.99**	**179**			

A study by Sousa, (2016) to determine the formal reasoning abilities of 7th,8th and 9th grade students found out that there were no differences in how different grade of school engage in reasoning processes. This finding of Sousa, (2016) seem not to agree with the finding of this study that grade 'A' proficiency in reasoning skills is statistically significant from that of grade 'B' and 'C'.

Table 19: Post-hoc Comparisons of School Types using Tukey HSD Test

Type of school	Type of school	mean difference	P
Grade A	Grade B	.47	.34
	Grade C	1.028*	.002
Grade B	Grade A	-.47	.33
	Grade C	.56	.33
Grade C	Grade A	-1.03*	.29
	Grade B	-.56	.33

P=0.05

From Table 19, Grade C schools differ significantly from grade 'A' school. However, Grade C School did not differ significantly from grade 'B' school.

According to Good and Lavigne, (2017) the type of school from which the students came is one of the factors that influence science achievement.

Similarly, the finding of this research has shown that the type of school the students attended determined the performance of students on the reasoning skills.

4.12 Influence of Gender on Students Planning, Interpreting and Reasoning Skill

Research question 3, was used to ascertain which gender shows more proficiency in planning, interpreting and reasoning skills. To accomplish this, Mann- Whitney analysis was used for the students' responses to the planning task, interpreting task and reasoning task.

Performance of students on planning skills is shown on Table 20.

Table 20: Mann-Whitney U analysis of Planning Skills by Gender

Value label	Planning Skills
Mann-Whitney U	1396.00
Z	-0.982
P-V value	0.326

Significance: P> 0.05

Mann-Whitney U test was conducted to find out which gender shows more proficiency in planning skills. The result of the test was not significant, z=0.98, p=0.33. The males had an average rank of 55.03 while the females had an average rank of 61.15.

From Table 20, it was found that there was no statistically significant difference in planning skills between the gender as the probability value (p = 0.33) is not less than or equal to 0.05. This demonstrates that in terms of planning skills male and females are not out-performing each other. Their level of performance in the planning skills is almost at par. This is congruent to a finding by Ramos, Dolipas, and Villamor, (2013) that there was no statistical difference m academic performance in integrated science between male and female students. Seshie et. al. (2015) also found from a study that, both male and females chemistry students who engaged in laboratory work exhibited the same level of proficiency in the skills of planning. This finding of Seshie et. al. (2015) is consistent with the finding of this study. However, Naah et.al., (2018) found from a study that there is statistically significant differences gender where males Scored higher on refraction of light under planning task. The finding of Naah et.al., (2018) is not congruent to the findings of this study that there is no statistically significant difference in the planning skills of males and females.

The mean ranks for the gender on planning skills are shown on Table 21.

Table 21: Mean Ranks for Gender on Planning Skills

Sex	N	Mean rank	Sum of Ranks
Male	99	55.03	3742.00
Female	81	61.15	2813.00
Total	**180**		

An inspection of the mean ranks revealed that females had the highest score (61.15) in planning skills. This finding is consistent with a finding by Bonta and Andrews, (2016) that females performed better than the males in the skills of planning. However, a study by Sucar, (2015) revealed that males were more likely to increase in science proficiency, than females. This finding by Sucar, (2015) is not congruent to the findings of this research.

Further analyses to determine whether gender has influence on systematic planning and detailed planning were conducted.

Table shows Mann- Whitney U analysis of systematic planning by gender.

Table 22: Mann-Whitney U Analysis of Systematic Planning

Value label	Systematic Planning
Mann-Whitney U	1281.50
Z	-2.00
P-value	0.045

Significance: P<005

A Mann-Whitney U test was conducted to find out which gender plan systematically. The result of the test was significant, Z = - 2.00, p = 0.045. The females had an average rank of 63.75 while the males had an average tank of 53.13. By this finding it indicates that females are the highest achievers when it comes to systematic planning of laboratory work or scientific experiments.

The mean rank for gender on systematic planning is shown on Table 23

Table 23: Mean Ranks for G Gender on Systematic Planning

Sex	N	Mean rank	Sum of Ranks
Male	99	53.13	3559.50
Female	81	63.73	2995.50
Total	**180**		

Table 23, it was found that the males had mean rank of 53.13 whilst the females had a mean rank of 63.75. This finding is consistent with the assertion by Beaumont-Walters and AKTAMIŞ, et., al.,(2016), that the scores of females on integrated science process skills were slightly higher than that of males. It therefore means that when it comes to the planning of practical work systematically, females out-score their male counterparts.

Mann-Whitney U test of detailed planning by gender has been shown on Table 24.

Table 24: Mann-Whitney U test of Detailed Planning by Gender

Value label	Detailed Planning
Mann-Whitney U	1415.50
Z	-1.07
P-value	0.29

Significance: P> 0.05

A Mann-Whitney U test was conducted to find out which gender's plan seems detailed enough to solve a given problem. The result of the test was not significant, Z = -1.07, p = 0.29. The males had an average rank of 59.87 while females had an average rank of 54.12. This finding suggests that there is statistical difference between the males and females in detailed planning of practical work. This indicates that when it comes to detailed planning. Males are the highest achievers

The mean rank for gender on detailed planning is shown on Table 25.

Table 25: Mean Ranks for Gender on Detailed Planning

Sex	N	Mean rank	Sum of Ranks
Male	99	59.87	4011.50
Female	81	54.12	2543.50
Total	**180**		

An inspection of the mean ranks revealed that males had a highest score of 59.87 as compared to the females who had a mean score of 54.12. This indicates that in detailed planning of practical work, greater proportion of the male than females performed better. This finding is consistent to a finding by Ramos et., al.,(2013), that although there was no statistical significance difference in academic performance in integrated science between male and female students, male Students had higher mean score than the female students.

4.13 Influence of Gender on Interpreting Skills

A Mann-Whitney U test was conducted to find out which gender shows more proficiency in interpreting skills. The result of the test was not significant, Z = -1.31, p = 0.19. The females had an average rank of 62.24 while the males had an average rank of 54.41.

Table 26 shows the performance of students on Interpreting Skills.

Table 26: Manu-Whitney U analysis of Interpreting Skill by Gender

Value label	Interpreting Skills
Mann-Whitney U	1339.00
Z	-1.31
P-value	0.19

Significance: P>0.05

Girls out-performed boys or both performed it the same level on questions in biological science (Hobbs, et al. cited in Naah (2018). This finding of Hobbs et al. is consistent with a finding of this research that greater proportion of girls than boys performed at similar levels on interpreting skills. However, from Table 25, the difference in performance between them was found not to be statistically significant.

The mean ranks for the gender on interpreting Skills, is shown on Table 27.

Table 27: Mean Ranks for Gender on Interpreting Skills

Sex	N	Mean rank	Sum of Ranks
Male	99	54.41	3754.00
Female	81	62.24	2543.50
Total	**180**		

4.14 Influence of Gender on Reasoning Skills

A Mann-Whitney U test was conducted to find out which gender shows more proficiency in reasoning skills. The result of the test was not significant. Z = -1.54. p = -0.14. The males had an average rank of 63.31 while females had an average rank of 52.87.

The Mann-Whitney U test on reasoning skills by gender has been shown on Table 28.

Table 28: Mann-Whitney U test of Reasoning Skills by Gender

Value label	Reasoning Skills
Mann-Whitney U	13165.00
Z	-1.54
P-value	0.14

Significance: P>0.05

A study by Piraksa, et., al.,(2014), to determine the formal reasoning abilities of students revealed that there were no differences in how males and females engage in reasoning processes. This finding of Piraksa, et., al.,(2014), is consistent with the finding of this research that there was no statistically significant difference in reasoning skills between males and females but Bonta & Andrews, (2016) found out from a study that females performed better than the males in the skills of reasoning.

The mean ranks for the gender on reasoning skills is shown on Table 29

Table 29: Mean ranks for Gender on Reasoning Skills

Sex	N	Mean rank	Sum of Ranks
Male	99	63.31	4178.00
Female	81	52.87	2368.00
Total	**180**		

An inspection of the mean ranks revealed that males scored higher on reasoning task than the females. The males had a mean rank of 63.31 while the females had a mean rank of 52.87. Although results from Table 28 revealed that there was no evidence of a difference in how males and females engage in reasoning processes, an inspection of the mean ranks has shown that males scored higher on biological tasks that require logical thinking, proportional reasoning and drawing inferences from a given data.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

In this concluding chapter, the key findings of the study are presented and some generalisations offered. It is hoped that the findings will focus attention on ethical issues for Biology teachers, Ghana Association of Science Teachers (GASI), curriculum developers, Ministry of Education, Ghana Education Service and the West African Examination Council. This study sought to determine the level of competency of SHS biology students in planning, interpreting and reasoning skills and the effect of the type of school on the proficiency level in demonstrating planning, interpreting and reasoning skills when SHS biology students are engaged in laboratory work. This was done by adopting the Basic Skills Assessment approach. The Basic Skills Assessment approach was used because it is a test of minimum competency in basic skills where students engage in hands-on activities that are scored as right or wrong. The sample used was 180 SHS 3 elective biology students drawn from single-sex boys, single-sex girls and co-educational schools in each grade of school that offered elective science in the Ashanti Region of Ghana. The instruments used for data collection was Perform assessment Task (A), planning, Interpreting Task (B) and Reasoning Task (C)

The Performance Assessment Tasks were administered to the students in such a way that any student in an adjacent left or right row beside another student respond to a different task

5.1 Summary of Key Findings

1. It was found in the study that:
   a. Majority of the students had difficulties with detailed planning providing, appropriate diagrams and safety precautions experiment they engage in.
   b. Majority of the students had problems establishing and explaining relationship between two variables.
   c. The number of students who showed high level of proficiency was above average

2. With regard to how school type influences the planning, interpreting and reasoning skills of students, the following were identified:
   a. School type was found not to be significantly related to the performance of the students at planning skills. However, a greater proportion of students in grade ‘A’ schools exhibited same levels of planning than their grade ‘B’ school counterparts
   b. School type was found not to be significantly ($p>0.05$) related to the performance of the students at interpreting skills. However, greater proportion of students in grade ‘B’ school exhibited same levels of interpreting than their counterparts in grade ‘C’ school and grade ‘A’ school.
   c. School type was found to be significantly ($p<0.05$) related to the performance of students at reasoning skills. However, grade ‘C’ school did not differ significantly (p0.05) from grade ‘A’ school.
3. On how gender influences the planning, interpreting and reasoning skills, the following were found:

a. Gender was found not to be significantly related to the performance of the students at planning skills. However, a greater proportion of females exhibited same levels of performance in planning than their male counterparts

b. Gender was found not to be significantly related to the performance of students at interpreting skills. However, greater proportion of females exhibited same levels of interpreting than their male counterparts,

c. Gender was found not to be significantly related to the performance of the students at reasoning skills. However, greater proportion of males exhibited same levels of reasoning skills than their female counterparts.

5.2 Conclusion

The difficulty students have in following the correct sequence in describing experiments and offering explanations from certain observations and inability of students to provide good and accurate drawings or diagrams as reported by the Chief Examiner of Senior High School Biology have been confirmed and elucidated by the findings of this study.

SHS 3 biology students exhibited varying levels of proficiency in skills of planning, interpreting and reasoning. The level of proficiency in reasoning skills was just above average as compared to that of planning and interpreting skills,

The type of school from which the students is coming from may not be a factor that influences the performance of students in the skills of planning and interpreting. However, the type of school which a student comes from appeared to influence the performance of students in the reasoning skills similarly, as reported by Young and

Fraser (1994) that the type of school from which the students came is one of the factors that influence science achievement.

Gender did not influence the performance of students in the skills of planning, interpreting and reasoning.

5.3 Recommendations

The following recommendations are offered:

1. Teachers are encouraged to take students through a lot of activities that involve planning processes for them to be more competent in the planning skills and also to develop their creativity.

2. Biology teachers should insist on detailed planning (describing procedure fully) when students are designing experiments to solve a given problem.

3. Teachers should provide avenues for students to establish relationship between two items under consideration in order to help them better explain relationships existing among variables correctly.

4. Biology teachers should insist on the inclusion of safety precautions and appropriate diagrams in students write-out of experiments.

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APPENDIX A

PERFORMANCE ASSESSMENT SKILLS (TASKS)

TASK A – PLANNING

TASK:
Introduction:

This laboratory task presents a problem and list of materials. You will have 15 minutes to plan and design an experiment to solve the problem. You will be given 2 minutes to recall the entire task before you start.

Problem:

The presence of proteins in urine of humans is an indication that the kidneys might not be performing properly. A laboratory technician was presented with two samples of urine from two patients to determine if there are traces of protein in them. If you were the laboratory technician, how would you determine the presence of proteins in the two samples of urine?

a) Under the heading PROCEDURE, list in orders, the steps you will use to solve the problem. You may include diagram(s) to help illustrate your plans for the experiment. Include any safety procedures you would follow.
b) At the end of 15 minutes, your answer sheet will be collected.

NOTE: You are not to perform the experiment. Just plan and come out with a way to solve the problem

Materials:

Sodium hydroxide solution

Copper (II) tetraoxosulphate (VI) solution

Urine

PROCEDURE

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DIAGRAM(S)

APPENDIX B

TASK B – INTERPRETING

Problem:

The weevil beetle causes serious damage to maize, both on the field and in storage. In storage, the weevil beetle is very destructive and reduces stored maize grains to powder. The females bore into grains and lay their eggs in them. Within each grain, an egg is laid after which the adult female leaves the grain and seals the bore to allow the egg to undergo metamorphosis. The egg hatches into a grub, which feeds on great quantities of the grain until it enters into the pupa stage. At this time, the grub would have completely eaten both the endosperm and the cotyledon of the grain.

To obtain a biological control method to protect stored grains from weevil infestation, an entomologist investigated the potency of extracts from two plant species believed to have repellent properties on stored grains and obtained the data below

Time of storage (months)	Weevil infestation (%)	
	Extract from plant A	Extract from plant B
1	0	0
2	0	6
3	0	7
4	0	8
5	0	10
6	0	20
7	7	30
8	10	60
9	20	90
10	30	98
11	40	100
12	60	100

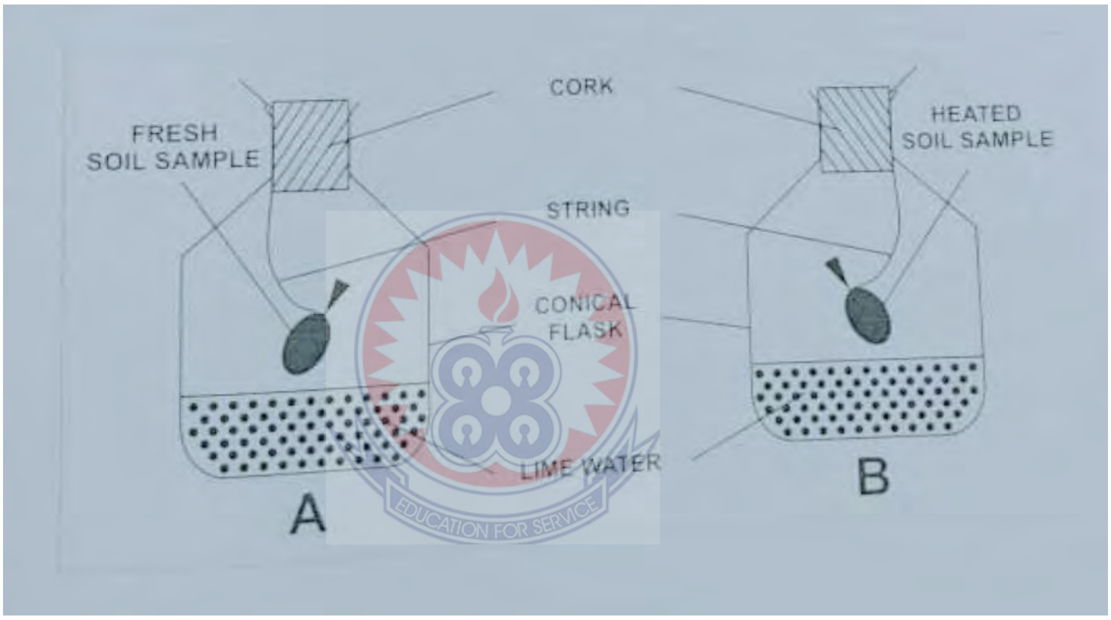
1. What is the **relationship** between the potency (ability to repel weevils) of extracts from both plants and time of storage?
2. Explain the potency of extract from plant A.
3. Explain the potency of extract from plant B.
4. Which of the plant extracts will you **recommend** to people who will want to use one of the extracts to store grains?
5. **Give reason** for your answer in **question 4** above.

APPENDIX C

TASK C – REASONING

Problem

A student conducted a laboratory experiment to study an important component of the soil. He put 10cm3 in each of the conical flask labeled A and B. in conical flask A. He put a hand full of fresh garden soil in a muslin bag and it as shown in diagram A. He put a handful of heated garden soil in a muslin bag and it as shown in diagram B.



The student then left the setups for about 2 hours. The results of the experiment were recorded in the table below.

Experiment	**Colour of lime water**	
	Flask A	**Flask B**
Beginning	Clear	clear
After 2 hours	Turns milky	clear

You are to:

a) **State the major difference** between the setups A and B.

b) **State the aim** of this experiment.

Give the reason(s) for the experimental results recorded in the data table above.

c) Under the heading **CONCLUSION,** state what could be derived from experiment.

APPENDIX D

DETAILED MARKING SCHEME

TASK:

1. Please circle the NR code when no attempt to response to the question is apparent.
2. You may circle each element present except where indicated otherwise, and sum up to determine a student's score for each item or skill.

TASK A – PLANNING

- **General planning** (NR 0 1)
  - Award 1 if student shows/demonstrates any sort of planning

- **Systematic plan** (NR 0 1)
  - Award 1 if student's plan is systematic, logical or scientific

- **Clarity** (NR 0 1)
  - Award 1 if student expresses an idea clearly

- **Detailed plan** (NR 0 1)
  - Award 1 if, and only if, student describe the procedure fully
- **Workable plan** (NR 0 1)
  - Award 1 if student's plan seems feasible/workable, even if he/she uses materials different from those in the material list.
- **Appropriate diagram/chart** (NR 0 1)
  - Award 1 for diagram/diagrams
- **Safety precaution** (NR 0 1)
  - Award 1 for any appropriate safety precaution student will state. (NR 0 1)

  TOTAL: NR 0 1 2 3 4 5 6 7 8

TASK B – Interpreting

- Award 1 mark if student states that the potency of extracts from both plants declined with age/time OR the active ingredients in the extracts probably broke down with time or vaporized. (NR 0 1)
- Award 1 mark if student states that the potency of extract from plant A was 100% for the first six months, declined slowly between the sixth and eighth months, with a rapid decline between the eighth and twelfth months. (NR 0 1)
- Award 1 mark if student states that the potency of the extract from plan B decreased slowly for the first five months, decreased rapidly between the fifth and ninth months and broke down completely after the eleventh month. (NR 0 1)
- Award 1 mark if a student recommends extract from plant A to people. (NR 0 1)
- Award 1 mark if student states that the extract from plant A was more potent for storing maize grains than the extract from plant B. (NR 0 1)

Maximum marks = 5 marks

TOTAL: NR 0 1 2 3 4 5

TASK C – Reasoning

- Award 1 mark if student states that setup A contains a bag of fresh soil while setup B contains a bag of heated soil. (NR 0 1)
- Award 1 mark if student gets the aim of experiment as 'to show the presence of living organisms in the soil. (NR 0 1)

Maximum marks = 2 marks

Reasons:

Award 1 mark each for the following reasons:

- Lime water in A will turn to milky because of production of carbon dioxide by living organisms in soil sample. (NR 0 1)
- Lime water in B will remain clear because no carbon dioxide was produced due to the soil sample which had been heated and hence living organisms in it have been killed. (NR 0 1)

Maximum marks = 2marks

CONCLUSION

- Award 1 mark if student states that soil contains micro-organisms which respire actively. (NR 0 1)

Maximum marks = 1 mark

TOTAL: NR 0 1 2 3 4 5