

**AKENTEN APPIAH MENKA UNIVERSITY OF SKILLS TRAINING AND
ENTREPRENEURIAL DEVELOPMENT (AAMUSTED)**

**ASSESSING SCIENCE PROCESS SKILLS OF BIOLOGY STUDENTS IN
SELECTED BIOLOGY TOPICS IN SENIOR HIGH SCHOOLS IN ASANTE-
MAMPONG MUNICIPALITY**

GLADYS FOSUAA

2025

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BY

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**A thesis submitted to the School of Graduate Studies, Akenten Appiah-Menka
University of Skills Training and Entrepreneurial Development, in partial
fulfilment of the requirements for the award of a Master of Philosophy degree in
Science Education**

SEPTEMBER, 2025

DECLARATION

Candidate's Declaration

I hereby declare that this thesis, with the exception of quotation and references contained in published works which have been duly acknowledged; is the result of own original work and that no part of it has been presented for another degree in this university or elsewhere.

Gladys Fosuaa

Signature..... Date.....

Supervisors Declaration

We hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development.

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Signature..... Date.....

Dr. Eric Appiah-Twumasi (Co-supervisor)

Signature..... Date.....

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DEDICATION

I dedicate this work to my parents, especially, my father, Nana Boadi who has helped me in all diverse ways. God richly Bless him.

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ABSTRACT

This study assessed the science process skills (SPS) proficiency among senior high school biology students in Ghana specifically Ashanti Mampong. The research employs a quantitative approach to assess the science process skills among senior high school biology students. Using a sample of 118 students, the study evaluated three primary Science Process Skills; Observation, Classification, and Measurement. The findings demonstrated considerable differences in students' performance across the three assessed science process skills. Observation skills was determined to be the most developed, followed by classification, while measuring skills had the lowest performance levels. ANOVA findings showed statistically significant variations in students' performance across different the three skills ($F = 133.31$, $p = 0.001$), showing that the observation and classification skills are more easily learned than the measurement skills. Furthermore, a gender-based study revealed that while male and female students fared equally in observation ($p = 0.04$) and classification ($p = 0.83$), there were significant variations in their measuring abilities. These disparities point to possible gaps in practical experience and teaching methodologies in scientific education. The study emphasizes the importance of focused treatments to increase students' science process skills, particularly measurement-related activities that are required for laboratory-based learning. The findings indicate that including more hands-on, inquiry-based learning experiences into the biology curriculum may improve science process skills development.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter talks about the background of the study which involves the ideas and concept developed by some scholars and experts relating to the problem under study. Also, the general statement of the problem, purpose of the study, objectives, research questions, significance of the study ,delimitations ,limitation and finally the organization of the study.

1.1 Background of the Study

Science process skills (SPS) are key qualities that enable students to conduct successful scientific enquiry .These skills includes observation,classification,inference, prediction, measurement, and testing, are critical for understanding and applying scientific concepts (Apeadido, Opoku-Mensah, & Mensah, 2024). Students must develop, practise, and own their learning abilities. It refers to the procedural skills, experimental and investigative science mindsets, or scientific inquiry abilities that science students are expected to have. Thus, the primary goal of science education is to provide students with scientific process skills (Ekici & Erdem, 2020). These abilities are a type of science in the sense that they include scientific effort and are required for learning to solve problems and apply them in everyday life (Nur, 2013). They are the actions that students engage in when performing scientific inquiry to obtain information. Science is viewed as both a process and an outcome, requiring observation, categorisation, and measurement to reach conclusions

such as scientific theories, hypotheses, and laws (Chalmers, 2013). In the context of senior high school biology instruction, developing and accessing these abilities is crucial for increasing scientific literacy and preparing students for higher education and careers in science-related industries (Bórquez-Sánchez, 2024).

This is in line with Zahra's (2017) assertion that teaching students Science Process Skills (SPS) can aid in the development of abilities and tasks like observation, questioning, problem-solving, hypotheses, experiment design, execution, data collection and analysis, drawing intriguing conclusions, and presenting work. The development of principles through induction, explanation and prediction, data observation and recording, variable identification and control, graph creation to identify relationships, design and execution of scientific investigations, and use of technology and mathematics during investigations are all examples of science process skills that are expected in learning. To put it another way, improving science process skills may aid students in acquiring the skills and mindsets of scientists (scientific attitudes) in order to meet technical learning objectives. Scientists use these skills when doing research (Mutlu & Temiz, 2013). These abilities, which include asking questions and finding answers, are essential in many areas of life. Implicitly, improving students' science process abilities provides them with essential tools to use in a variety of future situations. When performing science, people apply basic scientific process skills. Children who exercise the same skills are more engaged in their study. They utilise their senses to study things and occurrences, then seek for patterns in their discoveries. They categorise to generate new ideas by recognising similarities and differences. They communicate their knowledge and talents orally and in writing. They

quantify descriptions of things and events by measuring them. They presume explanations and are willing to change their judgements when new forms arise. Furthermore, they predict probable occurrences before they happen (Rezba, 2005). Science process skills are classified into two groups. Chiappetta and Koballa (2002) identify basic and integrated science process skills. Basic process skills include seeing, classifying, measuring, drawing conclusions, and making predictions. According to Karamustafaoğlu (2011), integrated science process skills include recognising and characterising factors, collecting and handling information, creating tables and charts, describing relationships between factors, planning materials, retrieving information and hypotheses, conducting examinations, and drawing conclusions. Science process skills are used to solve problems and conduct experiments. They are designed to improve cognitive and psychomotor abilities necessary for conducting scientific investigations and identifying concepts, principles, and theories in order to develop pre-existing conceptions (Akani, 2015).

Science education is built on reasoning, problem solving, and methods. As a result, one method for boosting pupils' scientific ability is to introduce them to science process skills (Hernawati, 2018). Biology is a scientific subject that studies both products and processes. Biology education aims to help students learn about themselves and the natural world around them. To obtain the desired concepts, the biology learning process should involve hands-on problem-solving tasks (Supriatno, 2018). Biology is based on experiments employing scientific techniques, sometimes known as scientific processes. The process includes observation, grouping (classification), interpretation, prediction, conclusion, and communication (Afaloby & Akinbolata, 2010).

Students are required to learn biological principles and understand their interrelationships. This instils ordered thinking in learners and stores the ideas required for embracing the technicalities of how living things interact with their surroundings and nature. It teaches pupils logical problem-solving abilities, which are crucial in many sciences. Science, particularly biology, is responsible for the knowledge and ability required to perform something appropriately in the environment because of its relevance in addressing phenomena involving living creatures and their relationship with the environment. This relationship is critical for a scientific call to change society (Moran, 2016).

Biology education is essential because it improves people's quality of life and solves numerous social problems such as health, food storage, agricultural production, and environmental conservation (Geist, 2013). Biology's prominence in Ghana's educational curriculum, from elementary to senior high, is reasonable given its essential role in modern society. Biology is intimately interwoven with scientific endeavours. Learning is inextricably linked to actions involving the discovery and scientific understanding of nature, therefore it requires knowledge in the form of facts, concepts, principles, and a scientific method (National Academy of Sciences, 2010). To conduct scientific tasks, you must possess the appropriate abilities. During the learning process, students must actively uncover the key concepts of biology subject through observation, experimentation, the creation of visuals, graphs, and tables, and the presentation of their results to others (Agustina & Dan Saputra, 2016).

Interestingly, another area that deserves attention is gender and its effects on science process skills since gender issues have been of interest and concern to researchers and education experts. Several mixed reports exist regarding this topic. Achievements in science are not distinctly influenced by gender (Afuwape & Oludipe, 2008; Babajide, 2010). According to reports, males dominate science and technology via science process abilities, pushing the few females who remain in these disciplines to the rear (Agyei, 2012; Yoloye, 2014). Other researchers have reported fresh data showing that boys are losing interest in school science, as shown by fewer boys pursuing science-related topics (Weaver-Hightower, 2003; Omoniyi, 2006). The debate over the impact of gender on scientific performance has yet to be fully resolved, since it remains a source of contention in the scientific community.

Assessing science process skills in senior high school biology students is critical for determining their scientific inquiry and problem-solving ability. Identifying students' ability in these areas enables educators to fix gaps and improve the overall quality of biology teaching (Dah, 2020). A practical evaluation of SPS is crucial for identifying students' strengths and areas for improvement in order to improve scientific literacy and prepare them for future scientific activity. Instead of measuring students' theoretical knowledge, SPS evaluations should examine their ability to use scientific techniques. Performance-based evaluations, such as laboratory experiments, scientific investigations, and problem-solving activities, provide realistic estimates of students' SPS (Adewumi & Adejoke, 2023).

Science and technology have advanced and changed dramatically in recent decades, making living simpler. Countries constantly change their educational curricula, especially science programs, to stay up with the times. Similarly, educational programs in Ghana have been examined to keep up with global trends, and numerous revisions have been implemented to meet new needs. Thus, Ghana's scientific curriculum was changed in 2022 to keep up with rapid advances in science and technology (Ministry of Education [MoE], 2022). Any country's ability to produce well-qualified scientists with a solid background in science necessitates the implementation of a science curriculum that fosters scientific inquiry and engages students in practical experience while meeting societal needs at all levels of education (Wrightson & Cooper, 2008).

In Ghana, the Curriculum Research and Development Division (CRDD, 2010) of the Ghana Education Service (GES, 2019) determines the substance of the teaching curriculum, while the West African Examinations Council (WAEC) reviews senior high schools. Both organisations value hands-on activities, scientific process skills, and the development of experimental methodologies in students. For example, the CRDD biology syllabus for SHS allocates two of six weekly hours to practical learning at all levels (MoE, 2010). The Ministry of Education's document prioritises the development of science process skills such as equipment handling, experiment planning and design, observation, manipulation, categorisation, sketching, measuring, interpretation, recording, reporting, and laboratory practice by 30%.

The WAEC SHS biology exam consists of three examinations: papers 1, 2, and 3. Papers 1 and 2 assess students' knowledge, understanding, and application of information, whereas Paper 3 examines practical and experimental abilities (MoE, 2010). Paper 3 has three questions. The first question tests students' ability to follow instructions and observe specimens. The second question examines scientific process abilities such as observation, communication, categorisation, reasoning, and conclusion. In this area of the question, students must use their senses to classify and investigate the components of a specific biological item. Students are expected to present their findings by describing the specific biological specimens (tests) utilised, observations made, and inferences or conclusions drawn from the biological specimen. The third question measures students' knowledge and familiarity with a biological specimen via drawing, a prescribed practical activity in the biology syllabus. Practical work is an important part of the biology curriculum at Ghana's Senior High School (SHS) level (Ampiah, 2006), since it helps students develop scientific process abilities.

Science process skills help students become more engaged in learning a concept (Ristanto, 2017). These are critical skills that students must possess when engaging in scientific activities. Observing, experimenting, and analysing are some of the scientific tasks that are intrinsically tied to the biology learning process. Scientific process abilities are expected to improve scientific literacy (Handayani et al., 2018). Assisting students in understanding biology subjects fast and properly. They are also useful not only in the classroom but also in real-world problem solving. Inadequate scientific process skills can lead to challenges in daily life, since they are used beyond school (Aydoğdu et al., 2012).

The goal of mastering basic process skills and adopting a good attitude towards science is to achieve high-quality student outcomes. According to Mushtaq and Khan (2012), student performance (academic achievement) is vital in generating exceptional leaders and workers for the country, holding them accountable for the country's economic and social growth.

Based on this, it can be seen how important science process skills are in daily life, especially when conducting learning activities. Therefore, it is necessary to research the assessment of science process skills in senior high school students in the Asante Mampong municipality.

1.2 Statement of the Problem

The acquisition of science process skills by SHS students is the main focus in both the (MoE, 2010) and WAEC syllabuses, and it is accomplished through practical work in Biology. Recognizing the significance of these science process abilities for biology students, is vital to investigate their use in learning, particularly in senior high schools in Ghana. A research found that scientific process skills have been implemented in a variety of science areas, including biology (Handayani et al., 2018). So far, assessments of scientific process competence have been intrinsic in character in connection to other facts of science topic area contents. However, the West African Examination Council (WAEC) Chief Examiner for Biology has noted students' inadequacies in scientific skills such as observing, identifying, measuring, sketching, and forecasting from 2012 to 2021. Omiko (2013) and Nweke (2015) agreed that low performance in practical work

correlates with bad performance in science process skills. However, a review of the Chief Examiners report for the practical paper biology Paper 3 from 2012 to 2021 of WAEC reveals that students' poor overall performance is due to poor performance in the practical paper questions. The questions evaluate scientific process skills, particularly higher-level ones like observation, classification, measurement, inference, and prediction. The WAEC Chief Examiner's assessment identified several weaknesses, including;

- a. Students' inability to appropriately categorise organisms into distinct groups (WAEC 2012).
- b. Students struggle to draw biological specimens in accordance with rubrics (e.g., incorrect size, lack of magnification, inadequate magnification) (WAEC, 2013, 2014, 2016).
- c. Inability to describe decomposer properties (WAEC 2021).

The Ministry of Education (MoE, 2010) prioritises the learning of science process skills in the biology teaching syllabus, with a 30% emphasis on practical and experimental capabilities. The curriculum defines three major psychological units of behaviour: knowledge and comprehension (30%), application of knowledge (40%), and practical and experimental skills (30%).

Experimental abilities entail the display of scientific inquiry processes and include abilities such as experiment planning and design, observation, manipulation, categorisation, sketching, measurement, interpretation, recording, reporting, and laboratory/field conduct (MoE, 2010).

Eleven science process competences that will be learnt in the third dimension are highlighted in the syllabus. Each of these has its own definition and includes handling equipment, designing and organising experiments, observing, manipulating, classifying, sketching, measuring, interpreting, documenting, reporting, and laboratory/field conduct. In order to educate student's problem-solving techniques and project completion, teachers are encouraged to include them in assignments, projects, case studies, and field research. Since Chief Examiners' reports from prior years have demonstrated that students' proficiency in these areas is insufficient, it is important to look into the extent to which this is done.

Despite these efforts, there is little effects on biology overall performance among SHS students in Asante Mampong Municipality and the entire nation. This means that there must be factors of the science process skills which have not been addressed as far as students' performance in biology is concerned. It is due to this low overall performance of students that, this study of assessing science process skills of biology students in selected SHS in Asante Mampong Municipality, Ghana.

1.3 Purpose of the Study

The purpose of the study is to assess science process skills of biology students in selected biology topics in senior high schools in Asante Mampong Municipality.

1.4 Objectives of the Study

Specifically, the study intended to find out:

1. Proficiency of Science Process Skills in biology students in senior high schools in Asante Mampong Municipality.
2. The difference in the learning outcomes of biology students in Science Process Skills in senior high schools in Asante Mampong Municipality.
3. Gender performance in Science Process Skills among biology students in senior high schools in Asante Mampong Municipality.

1.5 Research Questions

1. What is the proficiency of science process skills in biology students in senior high schools in the Asante Mampong Municipality?
2. What is the difference in the learning outcomes of biology students in Science Process Skills in senior high schools?
3. What is the performance of gender in Science Process Skills among biology students in the learning of biology in senior high schools?

1.6 Significance of the Study

To begin, this study would help biology students in Asante-Mampong municipality increase their skills as outlined in the biology syllabus while also improving students' learning attitudes towards science. As a result, students must comprehend the notion of biology in order to overcome difficulties in their daily lives. By recognising the link between students' science process skills and biology learning.

Secondly, the scientific process skills learning method strengthens the concept of "science for all" by ensuring that skills learnt are not readily lost and that students in Asante-Mampong municipality will apply such skills later in life. The findings will be crucial in developing policies and initiatives to reverse unfavourable trends in biology education, notably the issue of underachievement among biology students.

Finally, the study would help school administrators in Asante-Mampong municipality expand their supervisory responsibilities to ensure that biology students routinely participate in activities that enhance the development of science process skills. The beneficial effect of the science process skills learning strategy on students' accomplishment in this study will assist policymakers and curriculum developers establish applicable policies that advocate for teaching and tactics that encourage meaningful learning in biology.

1.7 Delimitation of the Study

The study is confined to some selected schools in the Asante Mampong municipality in the Ashanti Region of Ghana. SHS three biology students were used for the study. This study dealt with SHS biology students' basic science process skills such as observing, classifying, and measuring. This study used 15-item test made by the researcher to assess the level of mastery of the students in these Science Process Skills.

1.8 Limitation of the Study

Some of the limitations faced in this study were;

1. The study was confined to senior high school (SHS) biology students in the Asante Mampong Municipality, which may limit the generalizability of the findings to other regions or educational levels.
2. The study primarily assessed basic SPS such as observing, classifying, and measuring, which may have overlooked the influence of some basic and more complex integrated skills.
3. While the study explored gender effects, due to the unequal number of male students as female students in the sample size their effects on the SPS may not have been fully accounted for.
4. Variability in the availability of teaching resources such as laboratory equipments at some of the selected schools could have influenced students' performance.

1.9 Organization of the Study

The research was organised into five chapters, each with a brief overview. Chapter one introduces the study, outlines the problem, purpose, research questions, significance, delimitation, and limitations. Chapter two reviews literature, discusses the research questions, purpose, and literature review. Chapter three details the study methodology, including design, population, sample techniques, instruments, data collection, and analysis plan. Chapter four discusses the study's results, and the last chapter ends with a summary, conclusions, and recommendations for future research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

A review of the related literature to this study was given in this chapter. It included previous research as well as publications from reputable sources. A theoretical framework, conceptual framework, and empirical review are included in this chapter (Science Process Skills and Related Studies). It also covers the following topics: the nature of the SHS biology syllabus/curriculum, the model of practice-based science education, the role of practical work in biology teaching, student performance in biology, the classification of science process skills, the classification of basic science process skills, the importance of science process skills, the relationship between science process skills and academic achievement, and the objectives of science process skills.

2.1 Theoretical Review

This framework is consistent with the constructivist theory of learning, established by scientists such as Jean Piaget (1952) and Lev Vygotsky (1978), which stresses that learners actively create knowledge via experiences and interactions with their surroundings.

Constructivism promotes active learning, in which students observe, experiment, classify, and hypothesize (Piaget, 1952). These activities are crucial to SPS and work best when students actively participate in their learning. SPS are developed by actual experiences

such as laboratory experiments and fieldwork. Kolb's (2014) experiential learning theory complements constructivism by claiming that hands-on experiences improve skill development and understanding.

According to Vygotsky's (1978), sociocultural approach emphasizes the role of social interaction in learning. Collaborative activities, peer conversations, and teacher-guided inquiry all contribute to the successful development of SPS. This shows that with proper coaching, students might reach better levels of comprehension. Constructivism encourages student-centered learning in which students actively explore and develop knowledge (Bruner, 2009). This method is consistent with the emphasis on inquiry-based and practical activities in the SHS biology curriculum. According to constructivist philosophy, SPS are developed via iterative investigation and hands-on activities. This complements the SHS biology curriculum's emphasis on practical work as a method of developing both fundamental and integrated abilities (Kolb, 2014).

The theory also acknowledges that students bring varied past experiences and cultural influences to the classroom. Gender inequalities in SPS acquisition may come from variances in these experiences, emphasizing the importance of inclusive teaching techniques (Vygotsky, 1978). Students who engage in constructivist methods gain greater conceptual knowledge, critical thinking, and application skills, all of which are necessary for success in biology (Bruner, 2009). This is consistent with the study's emphasis on assessing SPS through actual activity.

2.2 Conceptual Framework of the Study

Observation, classification, measurement, and inference are all basic science process skills that provide the basis for scientific study. Studies emphasise its significance in assisting students to engage with and appreciate scientific phenomena at a fundamental level (Dahar, 2011). In contrast, integrated science process skills encompass more complex tasks such as experiment design, variable control, and data interpretation. These skills are required for higher-level thinking and problem solving in science (Felix, 2016). The shift from basic to integrated skills reflects a developmental step in which mastery of fundamental skills is required for integrated proficiency. This link is crucial to good biology instruction, as indicated in the SHS curriculum.

2.2.1 Curriculum and Pedagogy

The SHS Biology curriculum and syllabus play an important role in developing students' science process abilities. According to research, curriculum that explicitly incorporate SPS development result in superior learning outcomes (Laugksch, 2000). Effective pedagogical techniques, such as inquiry-based learning and hands-on experiments, have a significant influence on the development of both fundamental and integrated abilities (Bybee, 1997).

2.2.2 Gender Views and Attitudes

Gender variations in attitudes toward science and proficiency in SPS have been thoroughly established. According to research, social beliefs and gender stereotypes might impact students' interest and performance on science-related activities (Britner,

2008). Addressing these discrepancies through inclusive teaching practices is critical for ensuring equitable scientific education.

2.2.3 SPS and Learning Outcomes

Proficiency in SPS is closely related to enhance scientific comprehension and retention. Biology, being an experimental subject, needs students to use SPS for hypothesis testing and problem solving. According to research, students who are skilled in SPS are better able to understand difficult biological topics and attain academic achievement (Harlen, 1999).

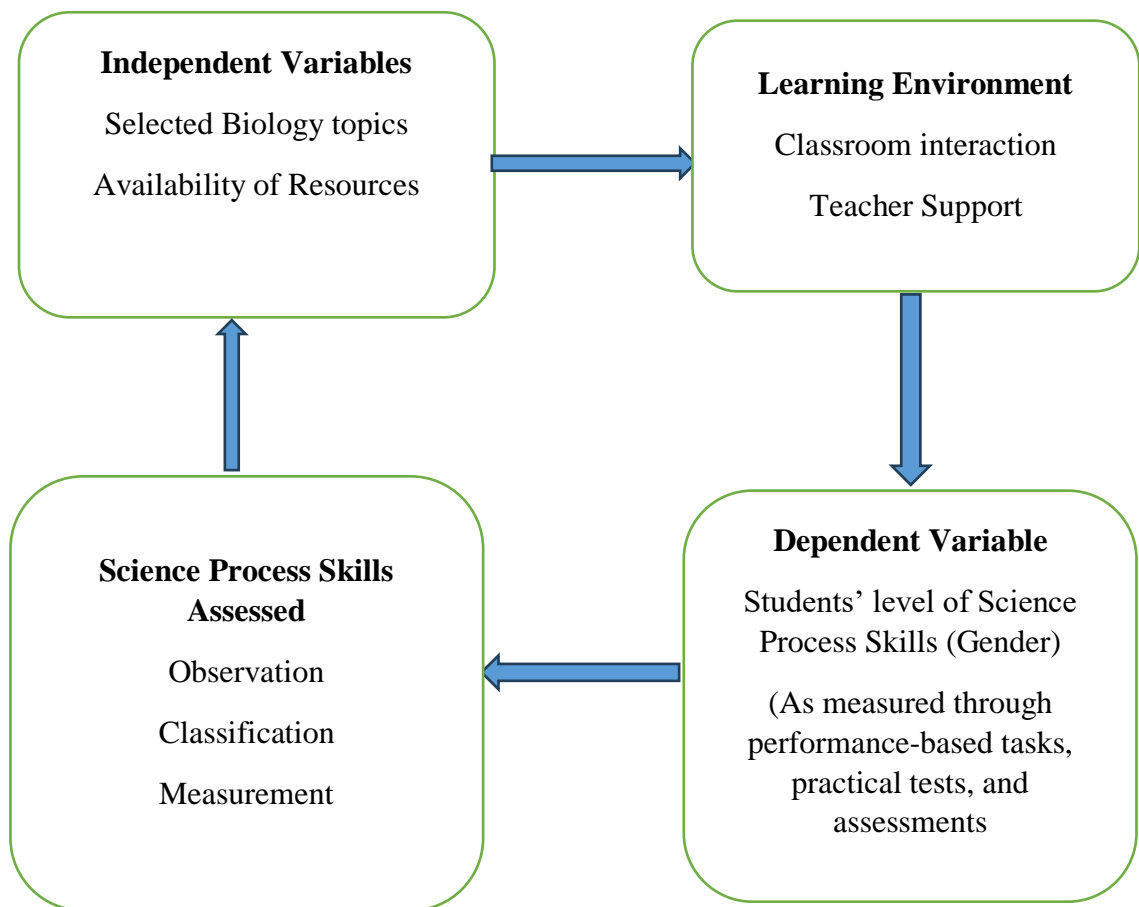


Figure 2.1: Framework for acquisition of science process skills
Source: Framework developed by the Researcher

The conceptual framework for assessing science process skills of biology students in selected topics in senior high schools illustrates a continuous cycle where various educational elements interact to influence students' skill development. It begins with independent variables such as selected biology topics, and the availability of resources (such as lab equipment or instructional materials). These factors directly influence the learning environment, which includes classroom interactions, teacher support, and opportunities for hands-on practical activities. A supportive and well-resourced learning environment facilitates the development and assessment of key science process skills such as observing, classifying, and measuring. These skills are then evaluated through practical tests, performance tasks, and other assessments to determine students' proficiency levels, which represent the dependent variable in the framework. The outcomes of this assessment can then inform adjustments in content emphasis, or resource distribution, thereby feeding back into the cycle and promoting continuous improvement in science education. This cyclical relationship emphasizes the dynamic and interdependent nature of teaching, learning, and assessment in developing science process skills among biology students.

2.3 Nature of Science Education

In today's world, education plays an extremely important role in developing human resources, and education is one of the most important policies for countries that are said to be highly wealthy. Education in national development is part of the development of human resources, which occupies a strategic position and core capital in realizing a progressive and independent nation (Ulya, 2018; Darmaji,

Kurniawan & Irdiyanti, 2019; Wirayuda, Wandai & Ginting, 2021). Education is a very important and essential activity in human life and cannot be separated from human life itself (Astalini, Kurniawan, & Putri, 2018). Quality education also produces quality human resources, and quality human resources are able to face life's challenges and actively adapt to changing times, especially the era of modernization. Education is achieved through learning activities in schools.

In accordance to Kalogianakis et al. (2021), science education is crucial for 21st-century learning and has to begin early (Tavares, 2021). Science education at all educational levels must perform appropriately in light of the growing worldwide scientific and technical advancements (Taştan, 2018). Teaching science to students who don't have a background in science is known as science education (Ohunene & Ebele, 2014). Teaching pupils critical thinking, fundamental scientific concepts, hands-on methods, creativity, and originality in scientific investigation are all part of science education.

Similarly, Olayinka (2019) defines science as the study of knowledge that may be converted into an evaluative fact-based system. Scientific education is required for individuals and nations to thrive and accomplish global economic objectives. According to Oplencia (2011), science education strives to teach students to think like scientists and build the attitudes that successful scientists can demonstrate.

Scientific education, economic, national, and human development have been associated in a large number of studies (Agarkar, 2017; Alam, 2009; Clement et al., 2017; Dovgyi et al., 2020; Drori, 2000; Helen, 2019; Jacob, 2013; Kyle, 2020; Sugimoto, 2019). It is well

known that the advancement of our society depends on giving young students the fundamental knowledge they need to comprehend ideas in their environment. Science education emphasises reasoning, problem solving, and process. As a result, familiarizing children with scientific process abilities might help them enhance their science skills. Scientific process skills are learning skills that students must implant, practice, and develop (Kyle, 2020). These are the skills required of science students, the experimental and investigative scientific habits of mind, or the skills of scientific inquiry. As a result, science education plays a significant role in providing learners with scientific process abilities (Ekici & Erdem, 2020). Scientific process skills are crucial indicators for meeting educational objectives (Gunawan et al., 2019). Furthermore, scientific process skills necessitate the integration of scientific abilities, knowledge, and a constructive attitude toward the advancement of a deeper comprehension of scientific principles.

2.4 Science Process Skills

The significance of science process skills in biology education has been underlined in a number of researches. According to Kuhn (2010), the development of critical thinking and problem-solving abilities depends on having science process skills. The importance of science process skills in improving scientific literacy is further highlighted by Bybee (2010). Science process skills are essential for training students for real-world applications, according to Hmelo-Silver (2004).

According to Hill (2011), science process skills are the core knowledge and presumptions that underpin the scientific method. In other words, information about nature is gathered

using scientific method abilities. Bajah (2000) asserts that these process skills are instruments used by scientists to carry out scientific research and that children who are properly introduced to science at a young age through the development of process skills would find the skills useful for the rest of their life. Additionally, he argues that whereas learnt process skills tend to stick with individuals for long periods of time, taught scientific content is quickly forgotten. Science process skills, according to Mandor (2002), let students better explore their environment, find answers, and resolve challenging problems.

Additionally, science process skills are a collection of general transferable talents that are crucial to the scientific community and represent the work of scientists, according to Padilla (2011). He distinguished between two types of scientific process abilities: integrated and fundamental. The development of integrative skills is based on fundamental skills, even if integrative science process skills are more intricate and focused on problem-solving in scientific fields. Yumusak (2016) contends that scientific process skills are incorporated into scientific thinking and decision-making. Teachers must therefore direct their pupils' scientific research using facts, ideas, and hypotheses. Preparing students to take part in research projects is one of the main objectives of scientific education. Students are taught scientific process skills to achieve this (Hernawati, 2018). Procedural skills, scientific inquiry abilities, or scientific habits of mind for testing and research are all considered science process skills (SPS). A number of studies (Arifullah et al., 2020; Duda & Susilo, 2019; Inayah et al., 2020; Irwanto et al.,

2017; Laksono et al., 2017; Langtang, 2018; Maison et al., 2020; Prabowo & Syarifudin, 2019; Savitri et al., 2019) have provided support for the idea of SPS.

Research has shown a relationship between attitudes towards science and scientific process abilities, with greater attitudes towards science being associated with higher scores on scientific process skills. Research indicates that favourable attitudes towards scientific education still have an effect. Therefore, scientific process skills must be given priority in the educational ecosystem. Scientific process skills include things like observing, measuring, classifying, communicating, forecasting, inferring, using numbers, questioning, controlling variables, generating hypotheses, operationally defining, building models, organising experiments, and interpreting results (Asy'ari et al., 2019). Similar to this, SPS has been thoroughly studied in two areas: integrated science process skills and fundamental science process skills (Duda & Susilo, 2019; Mohd Al-junaidi & Ong, 2013; Romadona et al., 2021). Classifying, predicting, inferring, measuring, observing, and communicating are the fundamental (simpler) procedural abilities that form the basis of science education. Integrated (more complex) skills including interpretation, experimentation, hypothesis generation, method design, and variable identification are indicative of improved scientific understanding. In elementary and high school, basic science procedures are essential for science education and encourage affective responses to the development of scientific ideas. Secondary and tertiary level model development is better suited for more complex and integrated science. Nonetheless, there is proof that science is not given enough attention in Nigeria's school system. Akinbobola and Afolabi (2010), for instance, examined scientific process skills

in practical physics tests given in Nigerian high schools in West Africa. The results showed a higher percentage of integrated (advanced) scientific process capabilities (37.20%) than basic (lower) scientific process competencies (62.80%). The results also showed that there were much more basic process skills than overall process skills on the final exams of West African Senior High Schools in Nigeria. Ezeudu, (2019) found that middle school students have weak scientific process skills in volumetric analysis. Research indicates that most students lack familiarity in science process abilities. As a result, nothing is known about how well Rivers State primary school pupils are able to use both fundamental and integrated science process abilities. Because of this, nothing is known about the basic and integrated science process abilities of the pupils in Rivers State elementary schools. Thus, the purpose of this study was to examine the general and fundamental science process abilities of secondary school pupils in Rivers State, Nigeria. The profile of science process competencies in the primary school system in Rivers State, Nigeria, was examined in this descriptive study.

2.5 Objectives of Science Process Skills

According to Tawil in Gusdiantini (2017), scientific advancement is speeding, and it is no longer feasible to educate students verbally, allowing them to develop scientific skills at a young age. It is crucial to implement. To the students: They must become accustomed to the capacity to broaden their knowledge, learn new material, and identify concepts. As a result, it might be claimed that the purpose of science process skills is to foster students' creativity in learning while also allowing them to actively develop and use their abilities. Students learn both how to achieve objectives and how to learn. This

is consistent with Laely's (2016) conclusion. The science process skills approach is a critical learning strategy. There are four reasons why you should use the scientific process skills method.

The first reason is that there is limited time to finish the curriculum, so educators opt for the most convenient technique of teaching facts and concepts: lectures (Berrett, 2012). As a result, students possess a wealth of knowledge but are not prepared to seek knowledge, discover concepts, or advance science.

Second, psychologists generally agree that students grasp difficult, abstract concepts better when they are supplemented by concrete examples that are relevant to the circumstance (Entwistle, 2013). Dealing with stuff helps you to put your knowledge of concepts into action. Discover the real deal. Students are intrinsically motivated to learn and driven by curiosity. The educator's goal is not to convey information, but to foster an atmosphere in which students may ask questions, observe, experiment, and discover facts and concepts for themselves. When educators play an overly dominant role, kids learn little, exhibit no interest, and lose drive and motivation (Doyle, 2023).

Moreover, scientific findings are not completely absolute; their outcomes are relative. If educators wish to instil scientific thinking in their pupils, they must be educated to continually ask questions, think critically, and seek potential solutions to issues. Students should be taught to think and act creatively. The most essential thing is not to offer pupils

as many "fish" as possible, but to give them "hooks" so they can fish for themselves (Haynes, 2020).

Lastly, the development should be integrated with the development of students' attitudes and values during the learning process. Emphasis on concept growth without adding attitudes and values leads to a "dry" intellectualism devoid of humanity. Our purpose is to bring together thoughts and people into a single, harmonious, and balanced human being. In other words, pupils have great intelligence and a strong personality, which helps them to thrive in life.

2.6 Process Competency Approach

The development of skills for acquiring and sharing knowledge is the main objective of this learning approach. Utilising one's mental or physical faculties allows one to acquire knowledge. The process skills approach is a teaching method that helps students comprehend the process of discovering or developing a notion as a scientific process skill, claims Henikusniati (2015). In order to give students a more meaningful learning experience and enhance their learning outcomes in line with the learning objectives outlined in the 2013 curriculum, educators strive to raise the calibre of students' knowledge. According to Idrus, (2022), the 2013 curriculum aims to develop Indonesians into obedient, productive, creative, imaginative, and capable individuals who can make contributions to their community, nation, and state.

Hosnan (2014) said that the science process skills approach is a teaching and learning strategy that stresses the skills of knowledge acquisition and communication. Science process skills may refer to the approach taken in the learning process that involves effectively and efficiently applying thinking power and invention to attain goals.

2.7 Classification of Science Process Skills

According to Rustaman (2005), science process skills are a set of talents that scientists use when doing scientific research. Direct experience can help students improve their science process abilities by offering a better knowledge of the processes and activities involved. Process skills include intellectual, manual, and social competencies. Science process skills are students' abilities to utilise the scientific method to grasp, develop, and discover science. Science process skills are essential for all students because they enable them to apply the scientific method to the development of science while also learning new or developing existing knowledge (Dahar, 2011).

The American Association for the Advancement of Science divides process competencies into basic and integrated categories (Kemendikbud, 2013). Table 2.1 shows how process skills are classified.

Table 2.1: Basic Process Skills and Basic Skills Integrated Process

Communicating	Controlling variables
Measuring	Defining operationally
Classifying	Formulating hypotheses
Predicting	Interpreting data
Inferring	Experimenting
	Formulating models

Basic science process skills and integrated science process abilities are the two categories into which Chiappetta and Koballa (2010) divide scientific process capabilities. Observing, classifying, recognising temporal or geographic correlations, using data, measuring, influencing, and forecasting are all fundamental scientific process abilities. Creating operational definitions, models, controlling variables, evaluating data, formulating hypotheses, and carrying out experiments are all examples of integrated science process abilities.

2.7.1 Basic Science Process Skills

Science process skills form the basis of the scientific method. There are six basic science process skills (Gürses et al., 2015).

1. **Observing:** This involves using all five senses to gather information about an object or event. This is a key Science Process Skill since the ability to make successful observations is essential to develop other Science Process Skills such as communication, categorisation, measurement, inference, and forecasting (Tilakaratne & Ekanayake, 2017).
2. **Communicating:** This includes the use of written and spoken words, graphs, tables, diagrams, and other forms of information display, including those that use

technology. Students must have solid communication skills in order to communicate their observations in class; thus, communication must be clear and effective, using descriptive phrases that both parties comprehend (Tilakaratne & Ekanayake, 2017).

3. **Classifying:** This skill comprises categorising or rating objects or events based on characteristics or criteria. This might be a binary system, in which a set of things is divided into two subsets, or a multilevel system, with many degrees or stages of categorisation (Tilakaratne & Ekanayake, 2017).
4. **Measurement:** This entails expressing the size of an object or event with either standard and non-standard measurements or approximations (Tilakaratne & Ekanayake, 2017).
5. **Inference:** Draw judgments about specific occurrences based on your observations and facts. These are explanations and interpretations derived from observations (Tilakaratne & Ekanayake, 2017).
6. **Prediction:** Use graphs to predict the outcomes of future occurrences. For the purposes of this investigation, we propose to employ three fundamental scientific process skills: observation, categorization and measurement (Tilakaratne & Ekanayake, 2017).

These basic skills are applied in everyday life when scientists plan and execute experiments, or when we all undertake fair testing experiments. All six essential talents are vital, whether alone or in combination (Tilakaratne & Ekanayake, 2017).

The six basic skills can be placed in a logical order of increasing sophistication, although even the youngest pupils will utilize all of them in order at various times. In the early grades, children spend more time developing skills like observation and communication. As kids become older, they spend more time developing their reasoning and prediction skills. Classification and measurement are employed more uniformly across grades. One reason for this is that categorization techniques are diverse and more sophisticated, and children must progressively get acquainted with the procedures and measurement systems over time (Aydogdu, 2015).

Integrating basic science process skills and progressively building abilities for constructing fair examinations is increasingly stressed as grades go, and students are required to do so beginning in junior high school (Shute et al., 2016). For example, the Virginia Standards of Learning (SOL) for fourth-grade students include generating hypotheses and identifying and controlling variables in basic experiments. At this level, students can begin to ask and answer their own scientific questions. The following section, Designing Experiments and Analysing Experimental Data, focusses on using integrated science process skills to organise experiments and draw conclusions. In the Virginia Learning Standards, the first Science SOL for each grade level, K-12, states which science process abilities should be taught and promoted at that level. For grades K6, each grade's SOL incorporates material from all disciplines of science grouped into a set of elements across that grade level, and the science process abilities in the SOL include "scientific inquiry, reasoning," which is regarded as a part of "reasoning. The SOLs for grades 7-12 (Biological Sciences, Physical Science, Earth Science, Biology,

Chemistry, and Physics) are no longer separated into vertical strands, although the first SOL at each grade level still describes science process skills. Understand what is being taught and practiced at that grade level. The goal for all grades K-12 is for students to teach and practise science process skills related to their grade level's SOL subject. Students deal with a variety of scientific curricular topics throughout the year, and they continue to use and improve grade-level science process skills (Scolforo, 2015).

2.8 Observation Skills of Science Process Skills

One of the most important skills in the scientific method is observation. In order to notice things and occurrences and gain knowledge about the world around us, we employ all five senses. Gaining proficiency in other scientific processes including communication, categorization, measurement, inference, and prediction also requires the capacity to make pertinent observations. Qualitative observations are the most basic observations acquired just with the senses. For instance, the leaves are smooth and waxy, or they are pale green in colour. Quantitative observations are those that contain numbers or amounts. For instance, if a leaf weighs five grams, or if the leaves are arranged in groups of five. Information from quantitative observations is more accurate than that from our senses alone (Tilakaratne & Ekanayake, 2017). It goes without saying that pupils require assistance in making pertinent observations, particularly younger ones. Good productive observations are precise and accurate written or drawn descriptions, and students must be encouraged to make these detailed descriptions (Seung, Choi & Pestel, 2016). Students can only enhance their comprehension of the subjects being studied if observations are done in such depth. We can help students create stronger, more

thorough descriptions whether they use their five senses or assist them in doing so. Ask students to comment on their first observations after listening to them in order to accomplish this. When pupils describe what they perceive, for instance, they could mention an object's colour but not its size or form. Students may list some of the qualities of fruits. Regardless matter which of their five senses they are utilising, students are expected to include specifics in their explanations. Students might be encouraged to give more thorough explanations in different ways. When anything changes, for instance, students should note it in their observations before to, during, and following the phenomena. Students should be encouraged to identify what they see, if at all feasible (Tilakaratne & Ekanayake, 2017).

2.8.1 Communication in the Observation Skill

Communication is directly linked to observation and is the second of the fundamental science process abilities. To share their insights with others, students need to be able to communicate. For others to grasp the information, communication must also be efficient and clear. Using so-called referents: references to things that the other person already knows, is one of the secrets of good communication. For instance, we frequently describe hues using references. When describing a certain shade of blue, green, or yellow, we may use terms like sky blue, grass green, or lemon yellow. Communicating with detailed language that all parties can comprehend is the goal. You leave room for misconceptions when you don't use a reference. Saying "hot" or "rough," for instance, could give your viewers a different impression of how hot or harsh something is. Students may use their shoe size as an example while attempting to describe the size of a

pine cone. His shoe is either smaller or larger than the pine cone (Tilakaratne & Ekanayake, 2017).

In actuality, the extra science process skill of measuring is really a particular instance of communication and observation. A property is measured by comparing it to a unit, which is a predetermined reference value. There are two components to the measurement. One is a unit name that indicates the amount of something, while the other is a number that indicates the amount of something. Measurements become quantitative observations when numbers are used. Pupils can express their observations verbally, in writing, or in illustrations. Visual presentations, maps, charts, diagrams, and graphs are some of the other communication techniques frequently employed in research (Tilakaratne & Ekanayake, 2017).

2.8.2 Classification Skills

Classification of science process skills, according to Suryaningsih (2017), is the capacity to comprehend the vast array of events and things in life and make it easier to classify them into various groups. By noting similarities and differences, classification tasks might involve classifying items according to their usefulness for various uses.

Biology students in their senior year of high school should be able to arrange samples and objects according to their observations. Order may be established by classifying things and events according to their similarities, distinctions, and relationships with one another. This is a significant step towards gaining a greater comprehension of different things and

occurrences in the world. Different categorisation techniques exist (Tilakaratne & Ekanayake, 2017). Ordering in series is perhaps the simplest method. Based on their attributes, objects are rated. For instance, you may arrange pupils according to their height or arrange various morning cereals according to how many calories each serving has. Multilevel classification and binary classification are her two other classification techniques. The collection of objects is just split into two subsets in a binary categorisation scheme. Usually, this is carried out according to whether or not each item possesses particular attributes. Fruits, for instance, fall into two categories: moist fruits and dry fruits. Additionally, binary classification based on several attributes at once is possible. All necessary attributes must be present in the group's objects. It belongs to other groupings otherwise. A collection of items is first subjected to binary classification, followed by each successive subset, to provide multilevel classification. A categorisation system with layers or levels is the end result. When every item in the original set is assigned to a distinct category, multilevel categorisation is complete. Multilevel categorisation is exemplified by the well-known division of the kingdoms of plants and animals (Tilakaratne & Ekanayake, 2017).

A range of classification skills are modified for use with varying grade levels in Virginia Science SOL. Kindergarteners are expected to arrange certain items based on their size. Additionally, kindergarteners are required to divide a collection of items into two categories according to a particular physical attribute. Students in the first grade must classify and arrange events and objects based on a variety of features and characteristics (Yockey, 2001). Students in the second grade were required to group items according to

two or more characteristics (Goldston et al., 2001). According to Stein and Butcher (2001), third-grade children must organise natural occurrences chronologically and classify things with comparable properties into at least two sets and two subsets. Students must classify data and generate frequency distributions in the fourth grade (Checkovich, 2001).

Fifth-grade students are required to use classification keys to identify rocks, minerals, and creatures. Additionally, sixth-grade students must create a categorisation system based on certain characteristics (Checkovich, 2001).

2.8.3 Inferences and Prediction Skills

Inferences are interpretations or explanations drawn from observations, as opposed to observations, which provide direct proof of an object. When an insect is observed to produce a black, sticky material from its mouth, for instance, we may conclude that the insect is disturbed and attempting to defend itself, which is why it releases the liquid. You can evaluate your environment more effectively if you can make inferences and analyse, analyse, and explain events that occur around you. Inferences from studies serve as the foundation for scientists' theories about why certain occurrences occur the way they do (Becker, 2017).

The same observation can easily lead to many conclusions. Additional observations may potentially affect the findings. When our observations match past experience, we are more likely to be confident in our findings. Also, when we gather more supporting data,

we gain confidence in our judgements. When students attempt to form a conclusion, they frequently need to return and make further observations to acquire confidence in their decision. For example, if you witness an insect produce a black, sticky substance multiple times while picking it up and holding it, you may be certain that it is angry and attempting to protect itself (Tilakaratne & Ekanayake, 2017).

Additional observations may reinforce a conclusion, but they may also modify or disprove an earlier conclusion. In science, conclusions about how things operate are continuously drawn, revised, and even abandoned as new data emerge. Making a forecast is an educated estimate regarding the result of a future occurrence. Forecast future observations. The capacity to foresee future occurrences enables us to engage more effectively with our surroundings. Predictions are based on both accurate observations and inferences drawn from observed occurrences. Predictions, like inferences, are based on both what we see and our prior experiences, as well as the mental models we construct from those experiences. Thus, projections are more than simply guesses. Predictions based on findings or hypotheses about events allow you to put them to the test. If the forecast is correct, we are quite confident in our conclusion/hypothesis. This is the cornerstone of the scientific process, allowing scientists to ask and answer questions by integrating the six basic skills of the scientific method (Becker, 2017). Integrating scientific process skills into classroom instruction and field research can enrich and contextualise students' learning experiences. Students learn scientific skills and material. Students actively participate in the science they are studying, developing a deeper understanding of the subject.

Finally, actively practicing science process skills may increase kids' interest in science and favourable attitudes. Science process skills are visible behaviours that may be learnt via the use of tools, equipment, and machines. This is accomplished through hands-on learning experiences. According to Oriafor (2013), an internship is a hands-on activity that allows you to gain practical or observable skills, information, and attitudes. These are science process skills, or the broad intellectual abilities required to understand scientific concepts and principles.

Prior to the beginning of the 18th century, labs had little to do with teaching science disciplines like biology, chemistry, and physics. Indeed, laboratory work became an essential aspect of high school scientific teaching in the nineteenth century, when Thomas Graham established Britain's first school laboratory at the Royal College of Technology in 1830. Laboratories have long been the most distinguishing aspect of science education. This will remain a primary component of the new scientific curriculum, which emphasises engaging students in science teaching and learning via hands-on activities (Gooday, 2008).

Skills are particular activities or tasks that students can accomplish successfully, such as drawing and language abilities. Skills can be organised into distinct competences. De Guzman (2007) emphasised the necessity of recognising students' strengths so that learning programs may be tailored to maximise their natural abilities.

The cognitive theory of attitude formation takes a more grounded and informative approach to attitude formation. "Attitudes are formed on the basis of cognitions when individuals come to believe that the attitude object has (undesirable) characteristics or that the attitude object produces (undesirable) outcomes." (Hogg & Cooper, 2007). As Hebrío (2013) mentioned, Yara defines attitude as an individual's way of thinking, acting, and behaving. This has significant implications for students, teachers, the social groupings with which individual students engage, and the entire educational system. Specific occurrences influence our attitudes and behaviours. This imitation has an influence on the teaching and learning environment. In this aspect, students rely on the teacher's attitude to form their own conclusions, which might influence learning results. Teaching and learning are lifelong activities, and the goal of teaching at any level is to implant fundamental change in the learner. Such rewards might include learning new skills, problem solving, and developing positive attitudes and values. Teachers employ a range of ways to assist students gain information, skills, and experiences (Pacia, 2014). As a result, it is in the public's interest, as well as the educators' obligation, to enhance students' attitudes towards science and prepare them for living in a highly technological society. Citizens who understand and can influence the complex consequences of science and technology on the environment will shape our society's future. Citizens who understand and shape the complex effects of science and technology on our planet will determine our society's future (Ungar, 2010).

Considering this importance of SPS, it is necessary to consider the application of SPS in learning, especially in Indonesia. Several studies have shown that SPS is useful

in biology (Handayani et al., 2018; Lepiyanto, 2014; Suryaningsih, 2017; Wulandari, Masjhudi, & Balqis, 2014), and physics (Irwanto, Rohaeti, Widjajanti & Suyanta, 2017; Nirwana, Nyeneng & Maharta, 2014). Some researchers have stated that this PLC can be considered when students learn inquiry-based learning (Lati, Supasorn & Promarak, 2015; Ramdan & Hamidah, 2015) & Nst, 2017; Şimşek & Kabapinar, 2010), hands-on learning (Cigrik & Ozkan, 2015; Suryaningsih, 2017; Wulandari et al., 2014), problem-based learning (Sagala, Rahmatsyah & Simanjuntak, 2017) in part studies state that PLC can be considered through the media used in the learning process (Pratono & Sumarti, 2011; Sole-Russa, Aguilar & Ibáñez, 2019; Vebriant & Osman, 2011).

However, assessing how learning objectives are attained when students already have scientific process skills is also important achieving the learning objectives. Students' cognitive learning outcomes might be used to evaluate one of these (Anderson & Krathwohl, 2001). Students' conceptual understanding is evaluated using cognitive learning outcomes (CLOs) (Anderson & Krathwohl 2001; Sinatra & Mason 2013). Memorisation, comprehension, application, analysis, evaluation, and creation are all components of conceptual knowledge, which is a learning outcome. To overcome everyday challenges, students must have cognitive skills (Osborne, 2013; Wang, Wu, Kinshuk, Chen, & Spector, 2013). The relationship between students' SPS and CLO has been examined in a number of biology education studies (Nirwana et al., 2014; Santiani, 2014; Wahyuni, 2019; Siswono, 2017; Syafriyansyah et al., 2013). While Santiani

(2014) claims that there is little correlation between students' SPS and CLO, Sinuraya et al. (2019) argue that students' SPS has an influence on their CLO.

Additionally, as there is no study on how to improve students' SPS while learning biology using different learning techniques, it is important to look at the link between biology CLO and students' SPS (Hayati, Bintari, & Sukaesih, 2018; Suryaningsih, 2017; Wahyuni et al., 2017; Wulandari et al., 2014). Knowledge and skill transmission alone cannot be the only focus of education. The development of children's attitudes, behaviours, and motives is crucial nowadays. Because without these broader skills and abilities, pupils will be prepared to handle the challenges that the world and themselves will encounter (Miller, 2017). Students that have a favourable attitude towards science are more eager to learn about the scientific method, claim Zeidan and Jayosi (2015). Put another way, kids get more interested in science and cultivate positive attitudes towards it as they acquire science process skills. A student that is highly motivated has a positive outlook on the material they are studying. Teachers must inspire students via their instruction and demonstrate how the subjects they are studying relate to real-world circumstances in order to improve their attitudes towards science.

Furthermore, we need to establish a learning atmosphere that motivates students to desire to study as well as attend class (Movahedzadeh, 2011). To further understand and solve the issue, more research on students' attitudes towards science is required, as the number of students opting to study it is dropping. The definition of attitudes towards science and the difficulties in measuring them are covered at the outset, along with information on

students' attitudes towards science and the many influencing factors, including gender, curriculum, teachers, cultural elements, and other variables (Osbourne & Chin, 2003). At its core, biology research is a process of uncovering facts, concepts, and principles that necessitates more than just learning the science. However, you must understand how to gather information using scientific methods. Biology is an essential component of science and offers several possibilities to gain information through various scientific process skill tasks such as study, observation, and experimentation. The emphasis of biology education must be on the process of constructing knowledge from the learning activities that students do. Biology education should be intended to give students opportunity to study facts, develop concepts, and find new values as scientists acquire information. Learning biology is an attempt to improve cognitive skills, attitudes, and processes (Putro et al., 2018).

In relation to process standards, learning objectives are said to include the development of areas of skills, knowledge and attitudes. Process skill is one of the abilities that students must build when studying biology. The abilities assessed in science classroom activities are known as scientific process skills. This talent connects the development of concepts with the development of attitudes and values, helping pupils to apply concepts more effectively while addressing issues. Students can obtain a full grasp of their process abilities by completing the learning tasks assigned (Duda & Susilo, 2018).

Science process skills are used to solve issues and conduct experiments. Science process skills focus on cognitive and psychomotor abilities for conducting scientific enquiries, discovering concepts, principles, and theories, and developing existing notions (Akani, 2015).

SPS are critical hands-on skills that enable students acquire scientific knowledge and comprehend the nature of science directly (Ondowo & Indoshi, 2013; Erkol & Ugulu, 2014). It is therefore necessary to assess whether pupils have acquired these abilities. Several tests have been created in the literature to accomplish this goal.

2.9 Importance of Science Process Skills

In Ghana, the Ministry of Education has acknowledged the significance of science process skills in the biology curriculum (Ministry of Education, 2019). However, research indicates that instructors in Ghana lack the essential training and resources to successfully assess science process abilities (Agyei & Voogt, 2012). This emphasises the need for professional development opportunities for instructors to improve their assessment procedures.

Science process skills are crucial because they help students build the tools and attitudes required for effective scientific investigation (McComas, 2014). These abilities allow students to develop conceptual frameworks, study new material, and solve scientific challenges.

Science process skills must be regarded as lifetime talents, as well as the development of understanding for everyday life and problem solving. People who learn scientific process skills will be able to apply the scientific method to difficulties they face in everyday life. For example, a biology student studying animal husbandry may conduct numerous nutrition tests, gather data, and learn about how animals are reared in nations and throughout the world to get the maximum milk production.

In reality, today's scientific achievement is proportionate to students' capacity to apply what they learn in school to real-world situations. In the PISA study (on scientific literacy), high levels of competence show students' capacity to utilise scientific knowledge creatively and autonomously in a variety of situations (OECD, 2019). Because scientific process skills are vital in science education, nations expressly include the development of process skills into their science education programs.

2.10 Science Process Skills and Academic Achievement

Ekon and Eni's (2015) SPS study found that most students had just slightly above-average knowledge of basic scientific process abilities. We also discovered that pupils who completed the SPS outperformed those who did not. According to Aydogdu (2006) and Öztürk, Tezel, and Acat (2010), the student has a weak PLC. Beaumont-Walters and Soyibo (2001) discovered that high school pupils' development of scientific process skills was limited and poor. Other investigations, such as those of Aydın (2007), mentioned in Gürses, Çetinkaya, Doğar, and Şahin (2015), Büyük, Tanık, and Saraçoğlu (2011), and

Oztürk, Tezel, and Acat (2010), revealed significant variations in SPS regarding certain demographic factors.

Oloyede and Adeoye (2012) found that SPS is connected with student academic achievement. His findings indicate that pupils who utilise SPS do better than those who do not employ these skills. He also noted that those with weaker levels of reasoning ability struggled to grasp topics, resulting in worse grades and performance. Furthermore, children with SPS may think smarter by successfully addressing difficulties and circumstances, resulting in higher grades.

Furthermore, learners with SPS help are more likely to think critically and analytically, resulting in better success rates compared to learners without SPS support. Aktamis, (2008) discovered that students who engaged in SPS training performed better. These findings were consistent with what other researchers had previously discovered. For example, Ardac and Mugaloglu (2002) discovered that taking the SPS increased students' performance.

Several research (Beaumont-Walters & Soyibo, 2001; Farsakoğlu, Şahin, & Karsli, 2012; Oloyede & Adeoye, 2012) suggest a favourable correlation between SPS and academic achievement in science disciplines. Delen and Kesercioglu (2012) looked at the probable link between senior high school pupils and their academic performance. They discovered that pupils' SPS was above average, and there was a positive association between SPS and academic achievement.

2.11 The Nature of SHS Biology Syllabus/Curriculum

The syllabus in Ghana has been developed to offer students with fundamental biology knowledge so that they can comprehend themselves and other creatures, allowing them to make well-informed decisions as they interact with nature (MoE, 2010). The syllabus's material has also been developed to allow students to pursue specialist occupations in biology, as well as to properly equip students who choose to continue their studies in biology at a higher level.

Given the significance of these skills to biologists, this syllabus includes a unit in virtually every part titled scientific enquiry skills to assist the instructor in intentionally teaching and facilitating certain tasks to help students acquire these skills. Practical abilities are defined as the exhibition of manipulative abilities utilising tools, machinery, and equipment to solve practical problems. The CRDD (2010) argues for teaching practical skills through projects, case studies, and field studies in which students are heavily involved in practical work and the search for practical answers to issues and tasks.

Experimental skills involve demonstrating the scientific inquiry process, as well as planning and designing, observing, manipulating, categorising, sketching, measuring, interpreting, documenting, reporting, and carrying out laboratory/field experiments. Teachers must guarantee that pupils have a high degree of proficiency while utilising instruments and equipment for scientific activity.

According to the Science Curriculum Guide (2012), the K-12 curriculum is based on three key areas of science. The first is the scientific basis of scientific knowledge. The last two major components are scientific process skills (SPS) and scientific attitudes and values. All of these might be applied both locally and globally.

2.11 The Model of Practice-based Science Education

Osborne (2014, 2015) argue that the practice-oriented paradigm of science education exemplifies scientific activities. He claims that the model is an important scientific activity since it came from empirical psychology study on practice and normative philosophical research on the behaviour of scientists. This approach is based on the idea that science is practiced through three major processes: hypothesis creation, experimentation, and evidence evaluation. The model is composed of three sections. In the first section, scientists apply scientific process skills to study the actual world. Experiment design, data collection, analysis, and interpretation are all part of the research process.

Higher-level cognitive processes like as world theorising, hypothesis creation, and explanation construction are also used on the right side of the science process (Osborne, 2015). This intersection defines scientific activity as a community of practice that uses critical and argumentative skills to generate knowledge. Scientists "engaged in debates about their data by comparing them with theoretical predictions and identifying errors in both their own and others' ideas" (Osborne, 2015, p. 50).

The paradigm of practice-based scientific education requires students to engage in eight basic practices, which include:

1. identifying problems and asking questions;
2. creating and using models;
3. planning and conducting research;
4. analysing and interpreting data;
5. using computational and mathematical reasoning;
6. creating arguments and solutions;
7. arguing from evidence; and
8. collecting, evaluating, and sharing information.

According to Osborne (2014), engaging students effectively in the following eight practices:

- a. How can we help students develop a more comprehensive understanding of what we know, how we know it, and the procedural and epistemological frameworks that guide scientific practice?
- b. Offers a more realistic representation of the scientific endeavour. The preceding explanation demonstrates that science process skills are crucial for understanding science, irrespective of the method used in scientific education.

2.12 Practical Work in Biology Teaching

Practical work aims to increase students' learning, build problem-solving abilities, and grasp the nature of science by emulating scientists' efforts. According to Sotiriou, Bybee,

and Bogner (2017), "when solving scientific problems, students should act like scientists and follow the scientific process."

Practical work under the supervision of a qualified instructor, with scientific equipment and processes, is an essential component of scientific education. According to Hodson Millar (2004), laboratories assist excite biology students while also allowing professors to test students' knowledge and identify its practical usefulness at the highest level.I did. This further reinforces the notion that practice is the central discipline of science. In this study, "hands-on work" is defined as any teaching and learning activity in which teachers and students see or manipulate physical items and materials (Millar, 2004).

Hands-on employment has several rewards. Practical labour transforms abstract notions into actual experiences. Teachers not only teach the skills needed for scientific inquiry, but also the attitudes and conceptual views required for successful scientific investigation. The Society of Biology (2010) thinks that practical research in science should be supported and promoted for the following reasons:

- Promotes creativity, curiosity, and critical thinking.
- Clarify and explain concepts, information, and principles.
- Encourage student involvement with scientific methods.
- It encourages active learning and problem-solving.
- It promotes teamwork.
- Encourages data collection and analysis, as well as the development of mathematical abilities.

Ausubel (Ango, 2002) believes that practical activity is extremely valuable in generating meaning and comprehension. He believes that hands-on interaction enhances the quality of student learning. Ausubel describes practical labour as a "continuum of discovery and reception" rather than "meaningful memorisation experiences." He thinks that process skills like measuring, observing, classification, and forecasting help students get a better comprehension of scientific concepts and descriptions, as well as making scientific methods more useful for problem solving and applying scientific knowledge in real life. Mentoring should be viewed as the capacity to provide a comprehensive framework in which students may learn with supervision in order to accomplish desired learning outcomes, rather than simply providing counsel or advice. To that purpose, Ango and Guse (Ango, 2002) proposed that professors should not "talk, discuss, and do everything" in scientific lectures. They believe that school teachers should not only act and exhibit their abilities, but also give pupils with important practical work and experience.

According to (Yeboah, 2010), successful teaching and learning need accurate and exact observation, meticulous methodology, and rational data interpretation. He emphasised that practical work is an essential component of biological study and must be carried out alongside theoretical studies. According to Aniodoh (2010), managing natural resources, providing effective health care, an adequate food supply, and a comfortable living environment need a solid theoretical and practical understanding of biology. It also says that it's necessary. The value of practical work in school science is well recognised, but it is critical that this practical work genuinely helps learning and teaching, and that

instructors are able to carry it out in connection to their students' needs and the courses they are taking.

2.12 Performance of Students in Biology and Biology Practical in Senior High Schools

Teaching biology in secondary schools presents several obstacles. The dismal academic performance of biology students, as detailed in the WAEC Chief Examiner's report, has sparked a continuous public uproar over falling biology teaching standards. This is mostly due to the lack of laboratories and other educational institutions equipped with scientific process capabilities, as well as a suitable number of students interested in studying science. Biology is an extremely important topic. We need to prioritise it more. It enables a person to comprehend himself and his immediate surroundings. Nonetheless, information obtained in biology is employed in a variety of sectors, including medicine, biochemistry, pharmacy, microbiology, and agriculture. Biology students have consistently performed poorly in the West African Secondary School Certificate Examination (WASSCE). Scientists have given numerous explanations for this issue. Dinah (2013) concluded that the availability of textbooks, laboratory equipment, and other learning materials greatly influences student performance on biology examinations. She also stated that pupils with good attitudes towards the topic do better than those with negative views. People with a good outlook are more motivated to work hard, which translates into greater exam results.

2.13 Gender and Science Process Skills

Gender schema theory is the most widely accepted cognitive theory of gender, as children gradually develop gender schemas about what is gender-specific and what is inappropriate in their culture states that gender stereotypes emerge (Diego, Nur, & Suprpto, 2020). Gender is a process of articulating or symbolizing behaviors and phenomena that have existed and existed since ancient times in human life (Thoriquttyas & Rohmawati, 2018; Nafi 'ah, Wahyu, & Urami, 2017). Gender has become a very heartfelt conversation and can be a very interesting topic. For reference, the term gender refers to fundamental aspects of sociocultural life between men and women (Nadira, Tawil, & Arsyad, 2020; Fernando, Permana, Zarkasi, Ilhami, 2021). Special needs schools' separate classes by gender (homogeneous classes), whereas most public schools have a mix of boys and girls within classes (heterogeneous classes) (Afriana, Permanasari & Fitriani., 2016). Among the many studies on gender, few have attempted to relate the effects of gender inequality factors (Darmaji et al., 2019). Therefore, gender can be said to be a social concept that distinguishes between male and female roles (meaning: role selection or separation).

Based on the results of a preliminary study on science learning activities in junior high schools, the following information was obtained. We do not use indicators to measure students' science process skills. There are no measurements to determine gender-specific differences in science process skills of students in classes (gender-homogeneous classes). Based on this, researchers are interested in conducting studies to find out: Explaining student science process skills.

Bang and Baker (2013) investigated the effects of single-sex organization in high schools on science performance and attitudes toward science among her tenth-grade students in South Korea. Three schools in each school type, three principals, three science teachers, and 302 of 10th grade students participated in the initial survey, followed by interviews with 11 academically successful students. The results showed that boys and girls in mixed schools performed significantly better in science and had more positive attitudes toward science. Zeidan (2010) studied the association between attitudes towards biology and opinions of the biology learning environment among 190, 11th grade students in the Turkham area of Palestine. This study utilised the 30-item Her Attitudes towards Biology Questionnaire and the 32-item Her Learning Environment Questionnaire. The correlation coefficient between attitude towards biology and biology learning environment was 0.366, indicating a strong association. Research has found that there are considerable gender disparities in views towards biology, with women having an edge. Al-rabaani (2014) evaluated the learning of science process skills among new social studies teachers in Oman. The results demonstrated that they acquired science process abilities at a modest rate, with no gender difference.

2.14 Effect of Integration of SPS in Teaching on Academic Achievement by Gender

According to Eshiwani (1995), girls underperform in science and mathematics at the secondary level. Teacher prejudice contributes to girls' underperformance in science. Teachers give guys special care since they appear to be more difficult to control than girls

who appear to be well-behaved. As a result, girls get less attention, support, and challenges. Similarly, Changeiywo (2002), girls in poor nations have lower access to education than boys. Similarly, girls enrol in KCSE at a lesser rate than boys (KNEC, 2012). Partinson (2008) also asserts that there is gender imbalance in sciences where more boys take science subjects than girls.

Kelly (2001) stated that girls are under-represented in science. In most countries, both developed and developing, female involvement in science beyond the age at which science is compulsory is lower than that of men. The gender gap is often quite significant in Physics, modest in Chemistry, and negligible or non-existent in Biology. According to the research, when students are given the option of choosing between male and female students, their engagement in science studies differs significantly.

2.15 Related Studies on Science Process Skills

Garces et al. (2015) conducted a research to assess the science process abilities of a 10th and 11th grade student. Scientific process skills predict knowledge and how it is obtained. Students from different secondary schools differ significantly in terms of basic incidental and experiential process skills. According to this, there may be considerable disparities in the possible application of science process skills when pupils attend school at a regular academic level or in the sequence of entrance. This condition might be attributed to variations in teaching techniques, instructors' subject-specific expertise, and school efficiency. When comparing 10th and 11th grades in terms of fundamental, incidental, and experienced process abilities, the 10th grade has a better

overall average score than the 11th grade. The only significant changes between 10th and 11th grade pupils are in terms of fundamental process abilities. This condition may hinder their science skills, since Year 11 pupils answer issues using their expertise in preparation for university examinations.

According to Panoy (2013), the purpose of scientific education is to increase students' talents, empower individuals, and help them use these skills in everyday life. These abilities influence an individual's personal, societal, and global existence. Science process skills are the instruments required for producing scientific knowledge, conducting scientific research, and solving issues.

According to Coronado (2016), science encompasses more than merely scientific knowledge. When preparing classes, science process skills should be utilised as benchmarks, but they should not be taught as independent units. These talents must be linked to key concepts. As a result, scientific information can serve as a foundation for lessons, but it should not be the primary focus. These talents must be linked to key concepts. Thus, science knowledge serves as a foundation for teaching but should not be the primary lesson. Instead, greater focus should be placed on activities that help students grasp science topics and build science process abilities. This means that process skills, along with scientific knowledge, help pupils think rationally.

Scientific knowledge encompasses the ideas, concepts, and laws that constitute a significant portion of science. The process of getting knowledge is the way of obtaining

scientific information. One technique to get information is to employ science process abilities. Scientific process skills are key abilities that aid scientific learning, promote active behaviour in students, foster a feeling of responsibility, improve learning perseverance, and give research methodologies (Erturk, 2010).

Science process skills must be incorporated in new national science curricula and textbooks as building blocks for developing relevant science problems. Developing science process skills. Science material presented in science classes should be applied (Nyakiti et al., 2010). Science process skills are fundamental to research-based learning. Learning how to perform science include developing science process skills and applying them to scientific investigations (Ngoh, 2008). Teachers with adequate science process abilities may teach successfully, and students can learn effectively (Miles, 2010).

2.16 Summary of the Review

In addition to offering answers and suggestions for further research, the evaluated literature provides a theoretical context for the study's problem. The research on evaluating senior high school biology students' science process skills. The evaluation of science process skills emphasises the need of understanding and learning about our surroundings, as well as identifying and addressing social problems. This implies that developing science process skills influences developing scientific literacy in secondary school and beyond.

However, operational definitions of science process skills in relation to scientific and social problems are crucial to understanding how these abilities evolve (Akinbobola & Afolabi, 2010). At the SHS level, the Ghanaian demonstrated the need for both fundamental and integrated science process abilities. According to the curriculum and literature analysis, students should study, write, and discuss in addition to working practically and using projects and case studies to solve real-world problems in order to strengthen their scientific process skills. These theoretical perspectives are used to identify variations such as basic and integrated science process skills, teacher, student, and school system perceptions of the value of science process skills, and curriculum experiences such as assessment, teaching and learning activities, and curriculum objectives that drive teaching and learning.

Given the assumptions made, the researcher contends that curricular and instructional efforts should concentrate on exposing children to activities that foster the development of both fundamental and integrated science process abilities, empowering them to solve scientific issues and move beyond conceptual knowledge. This view is produced using the structure depicted in Figure 2.1.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

This section discusses the study approach and procedures used to achieve the various research objectives. The methodology is the collection of guiding principles that comprise a certain topic of research. It provides the researcher with the standard processes required to ensure that the study and its results are repeatable. This approach comprises research design, study location, study population, sample methodologies, research tools, sampling collecting method, data analysis strategy, and ethical consideration.

3.1 Study Area

Mampong is the administrative capital of the Asante Mampong municipality in the Ashanti region of Ghana. Mampong municipality is one of the six municipal areas in the Ashanti region. The Mampong Municipal District, formerly the Sekyere West District is one of the twenty-seven (27) districts in the Ashanti Region of Ghana.

Mampong is about 57 kilometers from Kumasi, the regional capital of the Ashanti region (Dzomeku 2011). The municipal area forms about 2.2% of the total area of the region. The municipal is located within longitude 6.55 degrees Westland latitude 6.55 degrees and 7.30 degrees north which cover the total land area of 2346 km². It has the settlement

of about 220 and the percentage of 70 being rural. Most of the population residing in the community are mainly farmers.

The Municipality has Ninety-Two (92) Primary Schools, Sixty (60) Junior High Schools, and seven (7) Senior High Schools. There are also two (2) Colleges of Education, one (1) Nursing and Midwifery Training School and one (1) University. The Municipality has an estimated number of 9,135 SHS students.



Figure 3.1: The map of Mampong Municipality

3.2 Research Design

Research design is a critical framework that helps researchers perform studies successfully (Sileyew, 2019). This study used a descriptive research design, which comes under the quantitative method. It employs deductive reasoning, in which the researcher develops a hypothesis, collects data during an investigation of the topic, and then utilises the evidence from the inquiry after analysis and findings are communicated to prove true or incorrect.

Creswell (2014) defines research design or approach as strategies and procedures for study that go beyond broad assumptions to extensive data collection and reasoning. This study used a quantitative research technique to evaluate the science process abilities of biology students in senior high schools. Quantitative research approach is a structured way to collect and analyse numerical data to understand patterns, relationships, or trends within a particular subject. This approach relies on measurable data and often involves statistical, mathematical, or computational techniques. Quantitative research is typically used to test hypotheses, establish generalizations, or determine the strength of relationships between variables. The goal of the study is to assess science process skills of biology students in senior high schools. Quantitative is suitable when you aim to provide an accurate portrayal of characteristics, skills, or behaviours within a specific group, without manipulating any variables or establishing cause-and-effect relationships. Oliver and Uche (2012) studied the effectiveness of different assessment methods for science education, including quantitative assessments of process skills. They highlight the importance of using reliable and valid instruments to measure these skills in educational

research. Their findings suggest that using validated questionnaires or standardized tests could provide accurate and actionable data for your study on biology students.

Baker and Mayer (2018) researched the role of assessment in educational settings, focusing on how various assessment types can impact student learning outcomes. They discuss how quantitative assessments can be used to track progress and identify areas for improvement in science education. Their work implies that quantitative research designs, including tests, are effective for assessing science process skills and can help in making informed educational decisions. This research approach was chosen because of its usefulness in gathering data about existing situations, creating criteria with which to compare current conditions, and determining how to proceed after determining where we are and where we want to go. The purpose of this study was to collect information from respondents using a standardised exam on their science process skills. Biology students from several chosen senior high schools in the Mampong municipality were tested.

3.3 Research Paradigm

This research work is embedded in Positivist Paradigm. A paradigm is a common set of beliefs that guides the kinds of information that researchers look for and the way they assess the data they collect (Brierley, 2017). Creswell (2009) defines belief systems in this context as "worldviews". This is how a researcher believes a specific study should be conducted. According to Creswell, a researcher follows this "worldview," which provides a foundation for the study's research and practice. That is, it provides direction for each stage of the investigation process, such as choosing a research topic, formulating research

questions, establishing the nature and variations of reality, knowledge, methodologies, and the relevance of the research endeavour (Khatri, 2020).

Also, Chilisa and Kawulich (2019) argue that no single paradigmatic or theoretical framework is 'right', and it is up to the researcher to identify their own paradigmatic view and how it affects their research designs in order to effectively address the subject under study. Research is conducted from several perspectives or opinions. These include post-positivism, interpretivism, pragmatism, constructivism, and transformative paradigms.

Positivism , acknowledge that, while an objective reality exists, our knowledge of it is influenced by the intricacies of human cognition and perception. This paradigm is well-suited to educational research that collects objective data while considering human aspects such as student variability, learning environments, and evaluation systems. Positivism seeks to approximate a knowledge of reality through scientific data, while accepting the possibility of mistake and bias in findings (Phillips & Burbules, 2000).

The positivist paradigm emphasizes quantitative research approaches, such as the use of numerical data to monitor and assess educational outcomes. In this study, students' competency levels in science process abilities were divided into three categories: low, medium, and high. The collecting and analysis of numerical data enables objective comparisons of pupils' performances. However, positivism emphasizes that findings should be taken with caution, recognizing that outcomes are influenced by the context in which they are collected. For example, while the study demonstrates patterns in

proficiency, the findings may not be fully applicable to all student demographics or learning situations (Guba & Lincoln, 1994).

Furthermore, positivism emphasizes the value of researcher neutrality while acknowledging the possibility of prejudice. Predefined criteria were employed in this study to assess proficiency in order to ensure objectivity when categorizing students' science process skills. At the same time, researchers must be sceptical of their own interpretations and limitations in the study design. While the data provides an empirical foundation for assessing students' proficiency, the positivist paradigm reminds researchers that the findings are preliminary and can be refined via future investigation (Creswell & Creswell, 2017).

3.4 Study Population

Population refers to a group of individuals or units that share at least one characteristic in common (Christen & Schnell, 2023). Two public SHS were selected at random from the Mampong municipality in the Ashanti Region of Ghana. All SHS year 3 students reading elective biology in the selected schools were used. One group of class each was selected from the schools. Each class is made up of an average of 60 students from both General science and Home economics students who offer biology as elective. The target population is estimated to be 120 students offering elective biology from the 2 selected schools.

SHS year 3 biology students were selected for the research study because it is assumed that they had been exposed to at least two years' experience of teaching and learning in biology so they would have gained some science process skills in biology.

3.4.1 Sample Size and Sampling Procedure

The sample size is the number of observations or individual samples drawn from a larger population for analysis (Althubaiti, 2022). The research utilized the purposive sampling technique to choose the students who were willing to participate in the research and were enrolled in it from the population sample in this study. This sampling approach was selected since it has been utilized in several science research studies to gather preliminary primary data on specific concerns such as assessing science process skills in SHS biology students. (Sedgwick, 2015).

Simple random sampling technique was used to select the two schools used in the research. A total of 118 students from two senior high schools were randomly selected to participate in the study. For School A 58 students were selected and 60 were selected from School B, all at random from biology students. It is crucial to note that by adhering to this carefully selected sample size, the research outcomes are primed to offer in-depth insights that encapsulate the diverse experiences and perspectives within biology students.

3.5 Data Collection Instruments

The instruments used in this study was a standard achievement test on students 'development of science process skills according to GES syllabus.

3.5.1 Students' Achievement Test (SAT)

The fifteen (15) questions on the students' achievement test (SAT) evaluate three higher order science process abilities that are pertinent to the GES and SHS curriculum. Each science process skill has five questions. Observation (questions 1–5), measurement (questions 6–10), and classification (questions 11–15) are the science process abilities that were examined.

The construction of the test was modelled based on Ghanaian context (Zeidan & Jayosi, 2015), the test items were therefore made to assess students' knowledge in each science process skills under different contexts in biology.

3.6 Pilot Test

The instruments were pilot tested in the Asante Mampong Municipality in the Ashanti Region of Ghana. 50 students from a public Senior High School with similar characteristics of those in the study were used for the pilot test. These students used for the pilot test were not part of the study.

3.7 Validity of the Instrument

Data validity is a critical notion in data management and analytics, referring to how correctly data represents the phenomenon being measured (Aspers & Corte, 2019). Ensuring data quality is paramount in this study, as it serves as the bedrock that the trustworthiness of the findings on science process skills in biology students processes rests upon. The validity and reliability of a research instrument or scientific measurement are both important in determining its quality (Kimberlin & Winterstein, 2008). The validity of the tools was enhanced by expert judgement. Face validity of the SAT was obtained by giving the test items to professionals in AAMUSTED's Science Department, Mampong, who examined the test items and made suggestions, as well as pointing out and commenting on any grammatical errors. The items demonstrated a link between the concept and the projected outcome.

On the content validity of the SAT, the test items were given to biology instructors at the study's selected senior high schools to see how well the test items represent a representative sample of the whole topic that the exam is supposed to evaluate.

3.8 Reliability of the Instrument

Reliability refers to the accuracy or precision of the measurement instrument (Norland, as mentioned in Al-Mashaqbeh, 2012). In other words, if we use this scale to measure the same construct numerous times, would the findings be almost comparable, as long as the underlying phenomenon remains constant. Bhattacharjee (2012) found that reliability requires consistency but not accuracy. As a result, the taxonomy test's internal

consistency and dependability were determined using inter-rater reliability, specifically Cohen's kappa. Internal consistency dependability measures the consistency of pieces within the same construct. When respondents are given a multiple-item concept measure, the degree to which they rank those items in the same order indicates internal consistency. Inter-rater reliability assesses the level of agreement between two or more raters who evaluate the same item or performance. It is especially important when subjective judgments are involved, such as grading essays, establishing clinical diagnoses, or monitoring behaviour. Cohen's Kappa is a popular measure for assessing inter-rater reliability since it accounts for the agreement expected by chance (Landis & Koch, 1977). A high Kappa value indicates strong agreement among raters, meaning that the exam is reliable across several assessors.

3.8.1 Inter-rater Reliability of Taxonomy Test

The inter-rater reliability of the SAT was examined using Kappa's agreement metric. Mchugh (2012) defines values ≤ 0 as no agreement, 0.01-0.20 = none to slight, 0.21-0.40 = fair, 0.41-0.60 = moderate, 0.61-0.80 = considerable, and 0.81-1.00 = nearly perfect agreement. The Kappa measure of agreement for the SAT is shown in Table 3.1.

Table 3.1: Inter-rater Reliability of Taxonomy test

			Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Measure of Agreement	Kappa	.764	.066	23.542	.005
No of Valid Cases					

The Kappa coefficient is a reliable indicator of inter-rater reliability because, unlike simple percentage agreement, it considers the agreement expected by chance. In this analysis, a score of 0.764 indicates substantial agreement among raters, which is sufficient for many research or therapeutic contexts that need human judgment.

3.9 Data Collection Procedure

According to Hale et al. (2021), the term "data collection method" refers to the systematic approach utilized to collect information from individuals. In this study, a comprehensive and well-designed standardised test served as the primary data collection tool. The test was meticulously crafted to encompass a wide range of important aspects in their observation skills, measuring skills and classification skills procedures. Letter of introduction obtained from the Head of Science Department at the Akenten-Appiah Menka University of Skills and Entrepreneurship Development (AAMUSTED), Mampong was used to seek permission from the heads of the selected Senior High Schools to carry out the study. The headmasters of the schools informed the biology teachers about the plan to involve them and to pre-inform the students for the research. Before the data collection began, the researcher visited the schools selected to meet the teachers.

The initial visit allowed the researcher to explain the goal of the study to the respondents and elicit their full cooperation so that the study's objective could be met. The responders agreed on a date for the exam to be conducted. The second visit was utilised to conduct the exam on the specified dates. The researcher personally conducted the test. This

allowed the researcher to check that the exam was completed directly by the pupils. It also allowed the researcher to elaborate on the study's purpose and any aspects of the exam that the respondents may have found difficult.

The SAT instrument took an average of forty minutes to complete. Students were given the exam and a specimen to look at and fill in the blanks. Those who finished were asked to submit their work after forty minutes. Students were urged to complete the test as best they could on their own, even though they were assured they were not being evaluated. To guarantee a 100% return rate, the researcher collected the test at the conclusion of the 40 minutes. All the respondents were assured that any data collected from them would be held in confidence. They were informed that any identification written on the test papers would not be used in the text and data would be put away in a secured private place.

3.10 Data Analysis Technique

The process of data analysis, crucial for extracting relevant insights and drawing informed conclusions in alignment with the study's objectives as discussed by Li et al. (2023), involves a detailed examination and interpretation of the collected data. In this particular study, the researchers utilized SPSS 27.0, a widely used statistical software package, to carry out a comprehensive analysis of the data. This analytical process commenced by employing descriptive statistics, strategically selected to offer a succinct overview of the participants' demographic characteristics. These demographic profiles encompassed essential variables such as gender distribution

Table 3.2: Data Analysis techniques representation table

Research Questions	Type of Data	Type of Test	Description
Research Questions 1	Scores of SAT	Descriptive Statistics (percentages)	Each of the 3 SPS assessed was described using a frequency table.
Research Questions 2	Scores of SAT	One-way ANOVA (including a Post-hoc Test)	To compare the significant differences between the assessed SPS.
Research Questions 3	Scores of SAT	Independent Sample T-test	To compare the difference in performance of each of the assessed SPS based on gender.

3.11 Ethical Considerations

According to Cassell and Jacobs (quoted in Banu, 2011), ethical codes reflect the will and efforts to uphold the rights of others, carry out obligations, prevent damage, and enhance the subjects' advantages. Consequently, prior to the commencement of the research endeavour, Akenten Appiah Menka University of Skills, Training, and Entrepreneurial Developments provided ethical clearance via the graduate school. After obtaining authorisation from the University, a letter was sent to the Municipal Director of the Asante Mampong Education Department, asking permission to conduct research in chosen senior high schools. In addition, the participating schools' headmasters and instructors provided informed permission.

The researcher concealed the identities and details of the chosen respondents in order to guarantee their full participation, as well as that of their individual schools. In order to do this, respondents were told not to include their names or their schools in their remarks.

This was done in order to stop respondents from acting in ways that were not appropriate in a real-world situation. The head of the Science Department and the chosen headmasters were fully told about the study's details and knew that the research would be conducted in an entirely anonymous manner. Under the guidance and supervision of the headmaster, who voluntarily consented for their schools to take part in the study, the test items were finished during class time and in the typical school setting.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The results and discussion of the study are presented in this chapter. The study questions serve as the basis for the findings. Descriptive and inferential statistics were used to examine the collected data. The Statistical Package for the Social Sciences (SPSS) version 27 was used to compile, sort, and code the participant data. The following research questions serve as the basis for the findings:

1. What is the proficiency of biology students in science process skills in senior high schools in the learning of biology?
2. What is the difference in the learning outcomes of biology students in Science Process Skills in senior high schools?
3. What is the performance of gender in Science Process Skills among biology students in the learning of biology in senior high schools?

4.1 Demographic Data of Participants

This study included 118 SHS 3 Biology students. Among these participants, 58 were chosen from school A and 60 from school B. Figure 4.1 depicts the distribution of their gender.

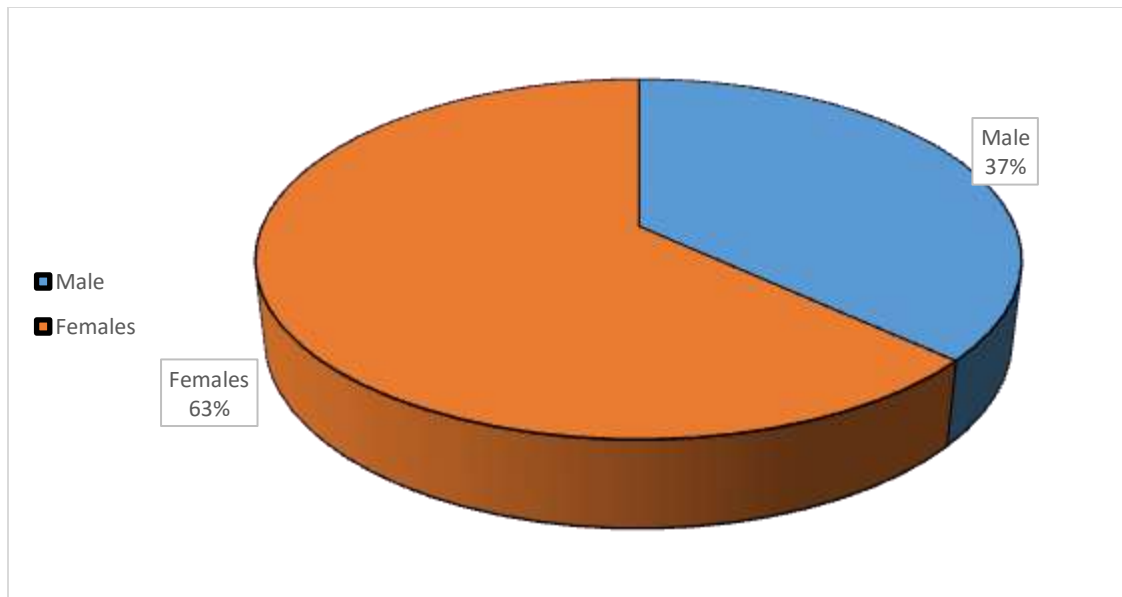


Figure 4.1: A Pie-chart on the gender distribution of participants

Figure 4.1 shows a pie chart of the gender distribution of the 118 SHS 3 Biology students who took part in the study. The data shows that females made up 63% of the sample. Males comprised 37% of the sample, which is significantly smaller than the female group. The increased representation of girls in biology is consistent with previous research, which has found a higher interest in biological sciences among female secondary students (Tshele & Grobler, 2020). However, this does not always translate into superior performance, as demonstrated in Table 4.4, where males scored much higher in SPS.

4.2 Data Suitability

Prior to analysing the study's outcomes, normality tests were performed to ensure that the data was suitable. The findings are presented in the following subsection:

4.2.1 Normality Analysis of the Scores

The scores from both schools' Science Process Skill exams obtained for this study were subjected to a normality test to determine whether parametric or non-parametric tests should be used for hypotheses testing. Normality checks were carried out utilizing the numerical approach. Thus, mathematically, the Kolmogorov-Smirnov and Shapiro-Wilk tests were performed. Normality tests were performed under the “null hypothesis that the data sets are normally distributed” (Pallant, 2011a). This indicates that the null hypotheses are rejected when the Kolmogorov-Smirnov test yields a p-value larger than 0.05. Table 4.1 presents the results of the normalcy tests.

Table 4.1: Results of Normality Tests for Students Scores

	Kolmogorov-Smirnov		
	Statistic	Df	Sig.
School A	0.082	58	0.200*
School B	0.965	58	0.092*

***Insignificant since $p > 0.05$**

As shown in Table 4.1, the p-value of Kolmogorov-Smirnov for both school scores were not significant ($p > 0.05$). With School A (0.2) and School B (0.09). The results in Table 4.1 provide justification for doing parametric tests on the results because other assumptions were already met.

4.3 The Level of Biology Students' Proficiency in Science Process Skills at the Senior High School

From the research question one, in order to describe the current level of biology students' proficiency in science process skills in the municipal, a descriptive analysis was run on their scores in each of the skills and the results have been presented in a frequency table below.

4.3.1: Frequency Distribution Table of Biology Students' Proficiency in Observation Skills at the Senior High School

Table 4.2: Frequency distribution table of biology students' proficiency in observation skills

Proficiency Level	Frequency	Percentage (%)
Low (0-5)	16	13.56
High (6-10)	102	86.44
Total	118	100

According to the findings from Table 4.3.1, just 13.56% of students exhibited low competence in observation skills, whereas a sizable majority (86.44%) showed great competency. This implies that the majority of students are capable of closely observing a scientific phenomenon which is a critical component of scientific investigation. Frequent exposure to practical, hands-on biology activities, where students must make acute observations of biological specimens and experiments, may be the reason for the high level of observational competency.

4.3.2 Frequency Distribution Table of Biology Students' Proficiency in Classification Skills at the Senior High School

Table 4.3: Frequency distribution table of biology students' in their classification skills

Proficiency Level	Frequency	Percentage (%)
Low (0-5)	30	25.42
High (6-10)	88	74.58
Total	118	100

Distribution of students' competency in classification skills from Table 4.3.2, majority (74.58%) of them did well while 25.42% found it difficult. This implies that although most students are able to efficiently arrange and classify scientific data according to common traits, 25% of them struggle with this task. In biology, classification is crucial because organisms and biological processes are categorized according to their similarities and differences. The significant proportion of students who struggle with classification could point to the need for more organized learning projects, and real-world sorting exercises that strengthen classification skills.

4.3.3: Frequency Distribution Table on Biology Students' Proficiency in Measurement Skills at the Senior High School

Table 4.4: Frequency distribution table of biology students' in their measurement skills

Proficiency Level	Frequency	Percentage (%)
Low (0-5)	85	72
High (6-10)	33	28
Total	118	100

Students seem to struggle most with their measurement skills, in contrast to observation and classification skills. According to the findings from the table 4.3.3, 28% of pupils demonstrated high measurement proficiency skills, compared to 72% who demonstrated low proficiency. This implies that a significant number of students have difficulty correctly quantifying observations, utilizing scientific measuring tools, and adequately documenting findings. Experiments, accurate scientific observations, and the interpretation of quantitative data all depend on measurement abilities. Inadequate attention on precision in scientific investigations or a lack of practical exposure to measuring instruments might be the cause of the poor performance in this area. This necessitates additional practical experiments, hands-on training sessions, and reinforcement of measuring ideas in scientific education.

This study, corresponds to the levels outlined by Padilla (1987) in his taxonomy of scientific process abilities. These abilities are necessary for students to engage in scientific research and problem solving. Padilla (1987) divides science process skills into multiple levels of competence, ranging from basic (low proficiency) to advanced (high proficiency), based on the student's ability to use these abilities in practical circumstances.

4.4 The Difference in the Learning Outcome of Biology Students in Science Process Skills in Senior High Schools

To determine the differences in the learning outcomes of biology students in SPS (Observation, Measurement, Classification) in senior high schools in Mampong municipality, one-way ANOVA was performed to compare the differences.

Table 4.5: ANOVA Table on the Science Process Skills of Biology Students

Source	df	SS	MS	F	<i>P</i>
Between Groups	2	1226.31	613.16	133.31	0.001*
Within Groups	351	1614.45	4.60		
Total	353	2840.76			

* Significant at $p < \alpha 0.05$

The one-way analysis of variance ANOVA Table 4.5, was used to assess whether there are statistically significant differences between the three-skill set of the biology students: Observation, Classification, and Measurement. The results showed a statistically significant difference between their skills groups, $F(2, 351) = 133.31$, since the p-value ($p = .001$) is less than the level of significance ($\alpha = 0.05$). This result suggests that at least one of the groups had a significantly different mean score compared to the others. Given the significance of the ANOVA, a post-hoc Tukey HSD test was conducted to examine pairwise comparisons between the groups.

Table 4.6: Post-Hoc Table (Tukey HSD) on the ANOVA Table 4.5

Comparison	Mean Difference (I-J)	Std. Error	Sig	95% CI (lower Bound)	95% CI (Upper Bound)
Observation vs Classification	0.958*	0.279	0.002	0.30	1.61
Observation vs Measurement	4.339*	0.279	0.000	3.68	5.00
Classification vs Measurement	3.381*	0.279	0.000	2.72	4.04

***The mean difference is significant at the 0.05 level**

Following the significant ANOVA result, a post-hoc Tukey HSD test was conducted to determine which specific groups differed from each other. The results show that the Observation group differs significantly from both the Classification and Measurement groups, with a mean difference of 0.958 and $p = 0.002$, between Observation and Classification, and a much larger mean difference of 4.339 a significant difference also $p = 0.000$, between Observation and Measurement. Similarly, the Classification group shows a significant difference compared to the Measurement group, with a mean difference of 3.381 and a significant difference ($p= 0.000$). The 95% confidence intervals for each pairwise comparison further reinforce these findings, indicating that the differences are not only statistically significant but also have a meaningful magnitude. This analysis provides clear evidence that each group is distinct in its performance relative to the others.

Table 4.7: SPS Groups Mean Score and SD on the Science Process Skills of biology students

SPS Groups	Mean Score	SD	N
Measurement	3.56	2.71	118
Classification	6.94	1.75	
Observation	7.90	1.84	

The mean scores for the three groups give additional insight into the nature of the differences observed in the ANOVA and post-hoc tests. The Observation group has the highest mean score at 7.90 (SD=1.84), followed by the Classification group with a mean of 6.94 (SD=1.75), and the Measurement group with the lowest mean score of 3.56 (SD=2.71). These differences in mean scores are consistent with the statistically significant differences found in the previous analyses, illustrating that the Observation group performed the best, while the Measurement group performed the poorest. The pattern in these mean scores suggests that whatever processes or methods are being used in the Observation group yield markedly higher outcomes than those used in the Classification or Measurement groups.

4.5 Gender Performance in Science Process Skills among Biology Students in the Learning of Biology in Senior High Schools

To compare the proficiency of science process skills among the genders in the municipal, an Independent Samples t-test was run on each of their skill scores to determine their differences.

Gender Difference on Observation Skills

Table 4.8: Independent Sample T-test on Performance of Gender in their

Observation Skills

Gender	N	Mean	SD	Df	P
Female	76	7.89	1.733	116	0.04*
Male	42	7.88	2.109		

* Significant at $p < \alpha 0.05$

Results from Table 4.8 depicts that, male and female students' observation skills differ slightly but statistically significantly ($p = 0.04$) since the p-value is less than the level of significance (0.05), according to the findings of the independent samples t-test. Though the mean scores for men (7.88) and women (7.89) are almost the same, however, it is statistically different from each other. This suggests that there exists a difference in the observational skills of both gender, with the female (7.89) students slightly outperforming the male students (7.88) by a mean margin of 0.01.

Gender Difference on Classification Skills

Table 4.9: Independent Sample T-test on Performance of Gender in their

Classification Skills

Gender	N	Mean	SD	Df	P
Female	76	6.92	1.631	116	0.83*
Male	42	7	2.242		

* Insignificant at $p > \alpha 0.05$

Results from the above Table 4.9 indicates that, there is no statistically significant difference between male and female students' classification skills, according to the independent sample t-test results ($p = 0.83$). This is because the p-value ($p = 0.83$) is

greater than level of significance which is 0.05. The results also depict that male students (7.0) slightly performed better than female students (6.92) though the difference was not significant according to their classification skill scores.

Gender Difference on Measurement Skills

Table 4.10: Independent sample T-test on performance of gender in their measurement skills

Gender	N	Mean	SD	df	P
Female	76	3.07	2.44	116	0.001*
Male	42	4.95	3.14		

* Significant at $p < \alpha 0.05$

From Table 4.10, there is a significant gender difference in their measurement skills, since ($p = 0.001$) is less than the level of significance ($\alpha = 0.05$). The male students (mean = 4.95) outperformed female students (mean = 3.07) in their measurement skills.

4.6 Discussion of Results

This section discusses the study's main findings. The findings are explained in relation to the specific research questions.

4.6.1 Discussion of Results for Research Question 1

What is the proficiency of biology students in science process skills in senior high school in the learning of biology?

A key scientific ability is observation, which is paying close attention to and documenting occurrences with the use of scientific tools or the senses (Harlen, 1999).

Only 13.56% of students had low competence in observation skills, compared to 86.44% who demonstrated high proficiency, according to this research. This implies that the majority of students have mastered the critical skills necessary for carrying out experiments and producing scientific discoveries: observing and characterizing scientific phenomena.

Students' high level of observational proficiency may be attributed to a number of things. First, fieldwork and lab activities, which strengthen observational skills, are important components of biology's practical and visual learning approach (Chiappetta & Koballa, 2002). Furthermore, a lot of educational programs have a strong emphasis on hands-on experience with biological specimens, which aids students in honing their capacity to recognize and characterize scientific traits. However, further assistance, including organized inquiry-based activities and guided observation exercises, could be necessary for the 13.56% of students who have low competency.

Classification is also a crucial biological talent for taxonomy and data management. It is the capacity to categorize things, animals, or phenomena according to common traits (Abbas et al., 2021). According to the findings, 74.58% of students exhibited high classification skill competence, compared to 25.42% who showed low proficiency. A significant percentage of students struggle with classifying scientific knowledge, despite the fact that the majority can do so successfully. This suggests that they may not have had enough exposure to classification problems or conceptual comprehension prior to this study.

One possible explanation for the comparatively high success rate in classification skills is the biology curriculum's regular categorization activities, which involve grouping organisms according to their taxonomic classification (Anamuah-Mensah et al., 2020). More interactive classification exercises, such as practical sorting exercises, the use of dichotomous keys, and computer simulations, could be beneficial for the 25.42% of students who struggle with the subject (Abbas et al., 2021).

In contrast to the classification and observation skills, students seem to struggle greatly with measuring abilities. According to the survey, just 28% of pupils showed good measurement competence, while 72% of students exhibited low proficiency. Experiments, good data recording, and correct scientific computations all depend on measurement skills (Baron, 2019). The poor level of competency in this area indicates that many students have trouble correctly documenting numerical data, estimating amounts, or utilizing scientific equipment.

This weakness may be caused by a number of circumstances. According to research, students frequently do not get enough opportunity to use scientific measuring instruments in the classroom, which makes it challenging for them to apply measurement principles in real-world situations (Aydogdu, 2015). Furthermore, measuring skills necessitate mathematical proficiency, which can be difficult for students who struggle with numbers (Chinn, 2020). Schools should promote the use of digital measuring instruments, offer more hands-on training in measurement techniques, and use cross-disciplinary teaching strategies that link science and math education in order to close this gap.

4.6.2 Discussion of Results for Research Question 2

What is the difference in the learning outcomes of biology students in Science Process Skills in senior high schools?

The ANOVA findings (Table 4.5) show substantial variations in learning outcomes across the three groups. The F-value (133.31) is large, and the p-value ($p = 0.001$) indicates statistically significant differences between groups. The sum of squares between groups SS(1226.31) indicates that differences between the Observation, Classification, and Measurement groups account for a significant portion of the variability in scores, whereas the within-group sum of squares SS (1614.45) indicates variability within each group due to individual differences.

These findings lead to the fact that, there are differences in student learning outcomes across these three skills. The big F-statistic also implies that the variation between the skills is significantly greater than the variation within the skills, indicating that the type of SPS (Observation, Classification, and Measurement) has a significant impact on student learning outcomes.

To identify the actual differences, a Tukey HSD post-hoc test was used (Table 4.6). The pairwise comparisons demonstrate that students' Observation skill did much better than the Classification and Measurement skill. The average difference between observation and classification is 0.958 ($p = 0.002$), while the difference between observation and measurement is 4.339 ($p = 0.000$). These findings show that students' Observation skills were superior in their learning outcomes than those in the other two skills. The

Classification and Measurement skill fared significantly differently, with a mean difference of 3.381 ($p = 0.000$). Classification skills of students outperformed their Measurement skills, although not as well as their Observation skills. These data also demonstrate that the changes might be due to the method utilized to teach biology at the various schools may differ. Observation skills, which often requires direct interaction and hands-on learning, appears to assist a better grasp and application of scientific concepts than Classification and Measurement skills, which may rely on abstract or procedural learning (Schwichow, Zimmerman, Croker & Härtig, 2016).

The mean scores (Table 4.7) provide additional insight into the magnitude of these discrepancies. The Observation group got the highest mean score (7.90), followed by the Classification group (6.94) and the Measurement group (3.56). The large difference between the Observation and Measurement groups demonstrates that the students performed better in observational skills than the measurement skills. These findings are consistent with the study of Borgonovi, Ferrara, and Piacentini (2023), on similar conditions.

In summary, this study shows that different skills of Science Process Skills produce significantly diverse learning outcomes among senior high school biology students. The findings strongly indicate that observation skills of students are the most effective on students learning outcomes, followed by classification, while their measurement skills to be the least effective. These findings are consistent with educational theories emphasizing the value of active, experiencing learning in science education (Kolb, 1984; Dewey,

1938; Lombardi et al., 2021). Future research could look into the specific processes by which observation improves learning outcomes and how these methods can be integrated into the larger science curriculum.

4.6.3 Discussion of Results for Research Question 3

What is the performance of gender in Science Process Skills among biology students in the learning of biology in senior high schools?

Table 4.8 indicated that the independent samples t-test showed a statistically significant difference ($p = 0.04$) in the observation skills of male and female students, even though their mean scores were almost similar (Female = 7.89, Male = 7.88). The little difference suggests that gender has appreciable impact on their observation skills, which may be the result of equal access to educational resources and laboratory experiences (Delaney & Devereux, 2019).

According to research, both gender often acquire observational skills at comparable rates, especially in organized learning settings that encourage practical inquiry (Amanat, Kanwal, & Akhter, 2024). It is positive that male and female students do equally well in this area, suggesting that science education is effectively promoting observational abilities across genders. This is because observation is a crucial ability in scientific learning.

Additionally, indication from Table 4.9, shows virtually similar mean scores (Female = 6.92, Male = 7.00), the t-test findings for classification skills revealed no statistically

significant difference ($p = 0.83$) between males and females. This result is consistent with earlier research that found that when given comparable educational chances, both genders perform equally on conceptual and classification tests (Voyer & Voyer, 2014). One explanation for the lack of gender differences might be because classification is a basic cognitive function that both gender acquire early on via practice grouping and sorting items (Piaget, 1952). According to Ceci, Williams and Barnett (2009), biology courses also frequently use organized categorization tasks that promote equitable skill development by not favoring one gender over the other.

Furthermore, the gender difference in measurement skills was statistically significant ($p = 0.001$) from Table 4.10, with males (mean = 4.95) outperforming females (mean = 3.07), in contrast to observation and classification skills. This may be due to social impacts on gendered attitudes toward science and mathematics, variations in spatial thinking, or more exposure to hands-on measuring activities, this result implies that male students have a higher understanding of measurement-related tasks (Varadarajan, & Sanzgiri, 2023). Research suggests that males' greater confidence in solving numerical and spatial issues may be the reason for their superior performance in measurement abilities. Research indicates that women may also have higher levels of anxiety or lower levels of self-efficacy while participating in activities linked to mathematics and measuring, which might potentially affect their performance (Varadarajan, & Sanzgiri, 2023). Teachers should push female students to participate in more hands-on measuring activities, provide safe learning spaces, and include real-world measurement applications to boost confidence and enthusiasm in this ability in order to reduce the gender gap.

CHAPTER FIVE

SUMMARY OF FINDINGS, RECOMMENDATIONS, CONCLUSIONS AND FUTURE RESEARCH DIRECTION

5.0 Overview

This chapter includes summaries of the study's findings. The findings were used to draw conclusions, recommendations, and future research direction.

5.1 Summary of Findings

The study evaluated the science process skills of biology students at senior high schools in the Mampong municipality. Using a quantitative research approach, research questions were answered with quantitative data. The study used a sample of 118 SHS 3 Biology students. The data was collected using a standardized test. After gathering and analysing data, the following findings were discovered:

The study participants were more recast to be female (63%) than male (37%). This unequal representation mirrors trends in scientific courses, where biology attracts more female students. Despite their lesser numbers, males have higher SPS scores, indicating a need to address gender inequalities in science skill development.

According to the study, students struggle greatly with measurement skills (72%) but do well with observation (86.44%) and classification skills (74.58%). Enhancing students' practical activities and providing more hands-on instruction in measuring procedures might improve their overall science process skills.

The study also demonstrated significant differences in learning outcomes among biology students using three Science Process Skills (SPS) methods: Observation, Classification, and Measurement. ANOVA results ($F = 133.307, p = 0.000$) indicate that the type of SPS used significantly impacts student performance. Post-hoc tests show that students' Observation skills performance was the best, with a mean score of 7.90, significantly outperforming both the Classification (mean = 6.94) and Measurement skills (mean = 3.56). These results suggest that students excel in their observation skills in biology than their measurement and classification skills.

There was a considerable gender difference in SPS, with observation skill being slightly significant ($p= 0.04$), classification skills being at the same level ($p= 0.83$) among both male and female students while measurement skills were significantly dominated by male students ($p= 0.001$). This demonstrates that male students in our sample had stronger overall proficiency in the three science process skills than their female counterparts particularly in the measurement skills in biology.

5.2 Conclusions

The study looked at senior high school biology students' proficiency in science process skills (SPS) and how it affected biology learning and gender disparities in the Mampong municipality. The findings revealed that;

- While the majority of students achieved a high level of proficiency in observation and classification skills, a significant number demonstrated low proficiency in

measurement skills, highlighting the need for improvement in educational approaches.

- The study also discovered a gender gap, with male students exceeding female students in SPS proficiency (measurement skills). This underscores the need of gender-sensitive teaching techniques that promote female participation and confidence in measurement and quantitative experiments. Addressing gender discrepancies through mentorship, inclusive teaching practices, and breaking down cultural prejudices will contribute to a fairer educational environment. Overall, developing SPS in all students is crucial not only for academic performance, but also for preparing them for future STEM employment.

5.3 Recommendations

Based on the findings of this study, several recommendations are proposed to improve proficiency in science process skills (SPS) among senior high school biology students and address gender disparities in science education in Asante-Mampong municipality:

1. Special attention should be given to students in Asante- Mampong municipality with low proficiency in SPS. Teachers should provide tailored support to these students, including extra practice sessions and targeted exercises to enhance their basic and integrated science process skills.
2. There is the need for Biology practical guide to equip students in Asante-Mampong municipal more with the use of instruments in measuring biological specimens.

3. Address the identified gender disparities in SPS proficiency of biology students in Asante-Mampong municipal by adopting gender-sensitive teaching methods that deals with more quantitative approaches of studying.

5.4 Future Research Direction

This study's findings suggest a number of significant areas for future research. Future study on science process skills (SPS) and their impact on biology learning, particularly among senior high school students in the Mampong municipal area, should take the following approaches;

1. Future study should conduct similar research at different regions and educational levels in order to generalize the findings easily.
2. An investigation into other science process skills like inference, predicting and planning should be pursued by researchers
3. Stakeholders in education must ensure there is the availability of other teaching resources and laboratory equipment that enhances students SPS.
4. Future research directives could also look at equal number of males against female students in the sample size when conducting similar studies.

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APPENDICES

APPENDIX A

**AKENTEN APPIAH- MENKA UNIVERSITY OF SKILLS TRAINING AND
ENTREPRENEURIAL DEVELOPMENT (AAMUSTED)-MAMPONG**

FACULTY OF SCIENCE EDUCATION

DEPARTMENT OF INTEGRATED SCIENCE EDUCATION

ASANTE MAMPONG

TOPIC

**ASSESSING SCIENCE PROCESS SKILLS OF BIOLOGY STUDENTS IN
SELECTED BIOLOGY TOPICS IN SENIOR HIGH SCHOOL IN ASANTE-
MAMPONG MUNICIPALITY**

Dear Respondent,

This study is purely for academic purposes. You will be contributing to its success if you answer the item as frankly and honestly as possible. Your responses will be kept confidential.

Moreover, your anonymity is assured by neither writing your name nor indicating your school. Kindly read through each of the items carefully and indicate the opinion that is the nearest expression of your view on each of the issues raised.

General instruction

Please tick [✓] the appropriate bracket or column or fill in the blanked spaces where necessary.

SECTION A: BIO DATA

Sex:

Male [] Female []

STUDENTS ACHIEVEMENT TEST

You are provided with **Specimen A-E**, study the specimen carefully and answer the questions in the blank spaces provided below

OBSERVATION SKILLS

Study Specimen A,B and answer the questions

1. Identify specimen A and B

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.....
.....
.....

2. What type of fruit is specimen A and B

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.....
.....
.....

3. Mention two (2) observable features of specimen A

.....

.....

.....

.....

4. Give two (2) physical features of specimen B

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.....

5. Mention two (2) observable differences between specimen A and B

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APPENDIX B

**AKENTEN APPIAH- MENKA UNIVERSITY OF SKILLS TRAINING
AND ENTREPRENEURIAL DEVELOPMENT (AAMUSTED)
FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF INTEGRATED SCIENCE EDUCATION
ASANTE MAMPONG**

TOPIC

**ASSESSING SCIENCE PROCESS SKILLS OF BIOLOGY STUDENTS IN
SELECTED BIOLOGY TOPICS IN SENIOR HIGH SCHOOL IN ASANTE-
MAMPONG MUNICIPALITY**

Dear Respondent,

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

General instruction

Please tick [✓] the appropriate bracket or column or fill in the blanked spaces where necessary.

SECTION A: BIO DATA

Sex:

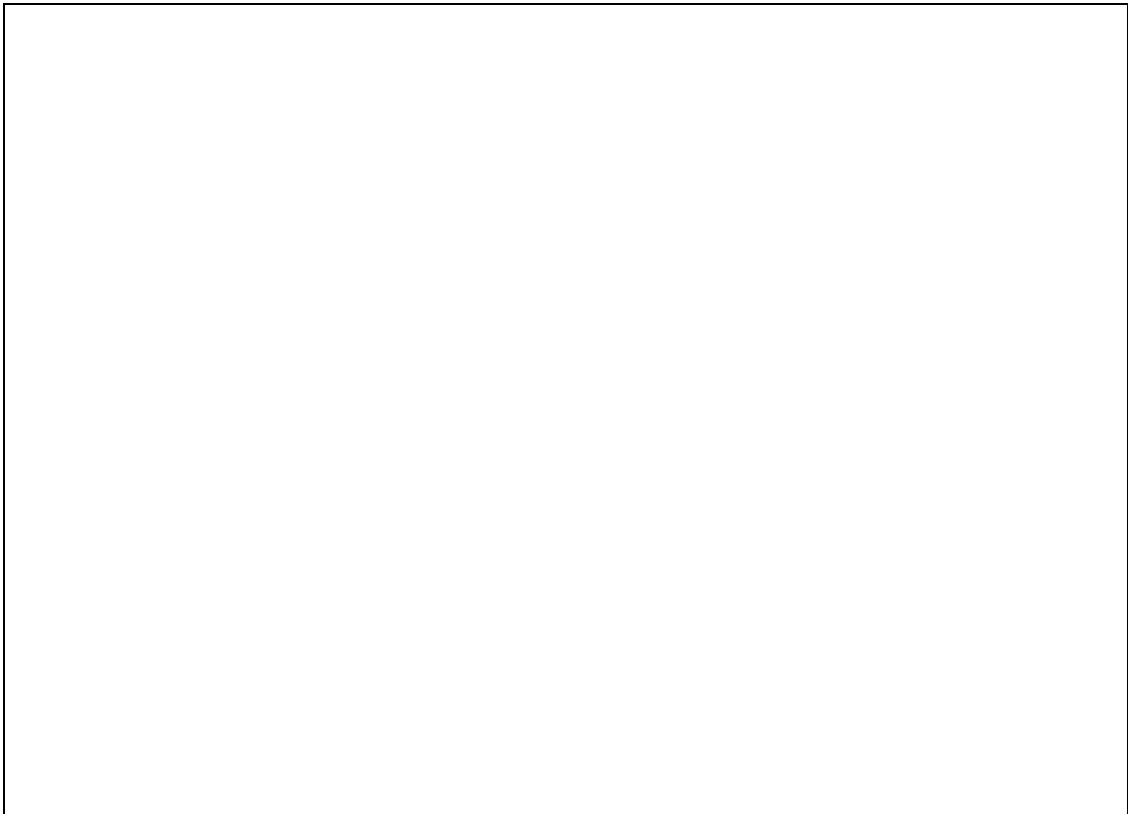
Male [] Female []

STUDENTS ACHIEVEMENT TEST

You are provided with **Specimen A-E**, study the specimen carefully and answer the questions in the blank spaces provided below

MEASUREMENTS SKILLS

6. Make a drawing 8-10cm long of specimen A



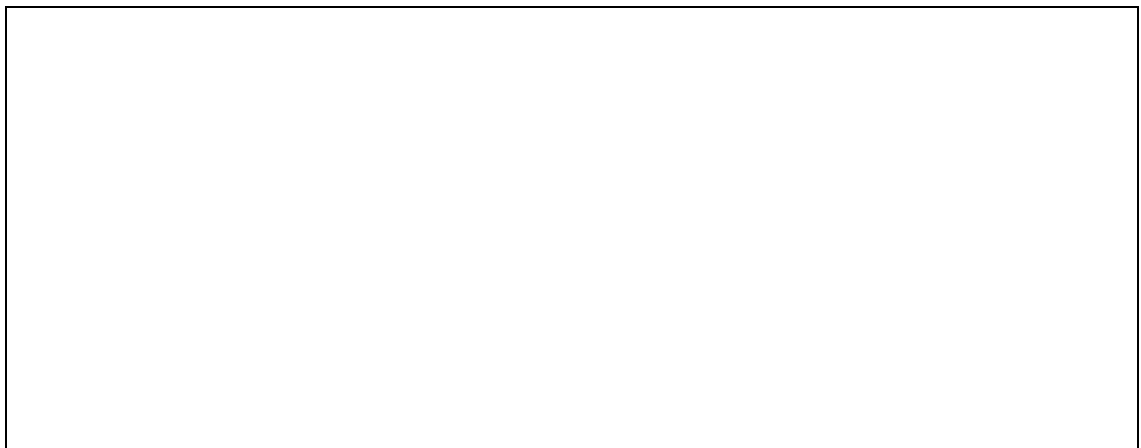
7. A student is provided with 10cm length of specimen A. The student made a drawing of the specimen of length 12cm. Calculate the magnification of the drawing.

.....
.....
.....
.....
.....

8. A student drew specimen B which is five times larger than the drawing. If the drawing is 8 cm long. Calculate the actual length of the specimen

.....
.....
.....
.....
.....

9. Make a drawing 6-8cm long of specimen B



10. The actual length of specimen A and B are 15cm 18cm respectively. How long is specimen B than specimen A.

APPENDIX C

**AKENTEN APPIAH- MENKA UNIVERSITY OF SKILLS TRAINING
AND ENTREPRENEURIAL DEVELOPMENT (AAMUSTED)
FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF INTEGRATED SCIENCE EDUCATION
ASANTE MAMPONG**

TOPIC

**ASSESSING SCIENCE PROCESS SKILLS OF BIOLOGY STUDENTS IN
SELECTED BIOLOGY TOPICS IN SENIOR HIGH SCHOOL IN ASANTE-
MAMPONG MUNICIPALITY**

Dear Respondent,

This study is purely for academic purposes. You will be contributing to its success if you answer the item as frankly and honestly as possible. Your responses will be kept confidential.

Moreover, your anonymity is assured by neither writing your name nor indicating your school. Kindly read through each of the items carefully and indicate the opinion that is the nearest expression of your view on each of the issues raised.

General Instruction

Please tick [✓] the appropriate bracket or column or fill in the blanked spaces where necessary.

SECTION A: BIO DATA

Sex:

Male [] Female []

STUDENTS ACHIEVEMENT TEST

You are provided with **Specimen A-E**, study the specimen carefully and answer the questions in the blank spaces provided below

CLASSIFICATION SKILLS

Group Specimen A, B, C, D and E into the two categories of fruit (Dry/Fleshy fruit) and the Family the specimen belongs

11. Specimen A

The type of fruit(dry or fleshy)	Family name

12. Specimen B

The type of fruit(dry or fleshy)	Family Name

13. Specimen C

The type of fruit(dry or fleshy)	Family Name

14. Specimen D

The type of fruit(dry or fleshy)	Family Name

15. Specimen E

The type of fruit(dry or fleshy)	Family Name

APPENDIX D

OBSERVATION MARKING SCHEME

OBSERVATION MARKING SCHEME

QUESTIONS		EXPECTED ANSWERS TO THE QUESTIONS	
1. Identify specimen A and B	2 MARKS	Specimen A- An orange1mark Specimen B- coconut..... 1 mark	
2.What type of fruit is specimen A and B?	2 MARKS	Specimen A- Berry.....1mark Specimen B- Drupe.....1mark	
3.Mention two observable features of specimen A	2 MARKS	It has thin epicarp It has fleshy mesocarp It has fleshy endocarp It produces many seeds	

4.Mention two physical features of specimen B	2 MARKS	It has grey-brown epicarp It has thick mesocarp It has woody endocarp It is roughly egg-shaped or oval in shape	
5.Two observable difference between specimen A & B	2 MARKS	Specimen A	Specimen B
		It has succulents fleshy fibres	It has hard fibres
		Present of glands	Absent of glands
		It has many chambers	It has one chamber
		It has Axile placentation	It has basal placentation
		It has thin epicarp	It has grey-brown epicarp
		It has fleshy mesocarp	It has thick mesocarp
		It consist of many seeds	It consist of one seed
		It is small in size	It is big in size
	It has many chambers	It has one chamber	

TOTAL MARKS = 10 MARKS

APPENDIX E

MEASUREMENTS MARKING SCHEME (6-10)

QUESTION	MARKS	PERFORMANCE CRITERIA
6 Make a drawing 8-10cm long of specimen A	3MARKS	<p>General marking scheme of a good biological drawing and how it is marked:</p> <ul style="list-style-type: none"> • Accuracy: Marks are awarded for accurately representing the observed specimen • Completeness: Marks are awarded for including all required labels and a title • Neatness: Marks are deducted for smudged lines, erasures and poorly placed labels • Labelling: Marks are awarded for each correctly labeled structure • Magnification: Marks are awarded for correctly stating the magnification (size 8cm-10cm). • Drawing matches with given dimension • Title(TI) : Diagram / Drawing of specimen A/Diagram of an orange fruit • Ruled guidelines must not cross each

		<p>other, bear Arrow heads, must be horizontally parallel and touch the exact part of the orange</p>
<p>7. A student is provided with 10cm length of specimen A. The student made a drawing of the specimen of length 12cm. Calculate the magnification of the drawing.</p>	<p>2MARKS</p>	<p>Magnification=$\frac{\text{length of specimen drawn}}{\text{length drawn}}$</p> <p>Length of specimen drawn =12cm</p> <p>Length drawn=10cm</p> <p>Magnification=$\frac{12\text{cm}}{10\text{cm}}$</p> <p>Magnification =x1.2</p>
<p>8. A student drew specimen B which is five times larger than the drawing. If the drawing is 8 cm long. Calculate the actual length of the specimen</p>	<p>1 MARK</p>	<p>If image length of the drawing of specimen B =8cm,</p> <p>then actual (object) length =5 x 8 cm</p> <p>=40cm</p>
<p>9. Make a drawing 6-8cm long of specimen B</p>	<p>3MARKS</p>	<p>General marking scheme of a good biological drawing and how it is marked:</p> <ul style="list-style-type: none"> • Accuracy: Marks are awarded for accurately representing the observed specimen • Completeness: Marks are awarded for including all required labels and a title

		<ul style="list-style-type: none"> • Neatness: Marks are deducted for smudged lines, erasures and poorly placed labels • Labelling: Marks are awarded for each correctly labeled structure • Magnification: Marks are awarded for correctly stating the magnification (size 8cm-10cm). • Drawing matches with given dimension • Title(TI) : Diagram / Drawing of specimen A/Diagram of an orange fruit • Ruled guidelines must not cross each other, bear Arrow heads, must be horizontally parallel and touch the exact part of the orange
<p>10. The actual length of specimen A and B are 15cm 18cm respectively. How long is specimen B than specimen A</p>	<p>1 MARK</p>	<p>Length of specimen A=15 cm Length of specimen B=18 cm Specimen B longer than specimen A by 18cm - 15cm = 3cm</p>

Total marks=10 marks

APPENDIX F

CLASSIFICATION MARKING SCHEME

Group Specimen A, B, C, D and E into the two categories of fruit and the Family the specimen belongs

SPECIMEN	MARKS	THE TYPE OF FRUIT (DRY OR FLESHY)	CLASSIFICATION OF SPECIMEN ACCORDING TO THE FAMILY IT BELONGS
11.SPECIMEN A (ORANGE)	2MARKS	FLESHY FRUIT	Rutaceae family
12.SPECIMEN B (COCONUT)	2MARKS	DRY FRUIT	Arecaceae family
13.SPECIMEN C (TOMATO)	2MARKS	FLESHY FRUIT	Solanaceae family
14.SPECIMEN D (MAIZE)	2MARKS	DRY FRUIT	Poaceae family
15.SPECIMEN E (BEANS)	2MARKS	DRY FRUIT	Fabaceae family

TOTAL MARKS=10MARKS

APPENDIX G

INTRODUCTORY LETTER



**AKENTEN
APPIAH-MENKA
UNIVERSITY**
*of Skills Training and Entrepreneurial
Development*

**FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF INTEGRATED SCIENCE EDUCATION**

P.O. Box 40, Asante Mampong

0270001890, 0502972415

M/DISE/ADM/STU/01/53

APRIL 4, 2024

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

INTRODUCTORY LETTER FOR MS. GLADYS FOSUAA

We write to introduce Ms. Gladys Fosuaa, who is an M.Phil. (Science Education) student of this Department. Ms. Fosuaa is working on a project titled "Assessing Science Process Skills of Biology Students in Senior High Schools: A Case Study in Asante Mampong" and would like to collect data from your institution for a period of six (6) months to enable her complete her thesis, which is a requirement for graduation.

We would be grateful if you could offer her the needed assistance. We count on your usual cooperation.

Thank you.

Yours faithfully,


PROF. EBENEZER EKOW MENSAH
(AG. HEAD OF DEPARTMENT)



www.aamusted.edu.gh

dise@aamusted.edu.gh

APPENDIX H

GES INTRODUCTORY LETTER

GHANA EDUCATION SERVICE

In case of reply the number and date of the letter should be quoted

My Ref. No:GES/ASH/MPG/EP-40/15

Your Ref. No:.....



REPUBLIC OF GHANA

Municipal Education Office P. O. Box 216,
Mampong-Ashanti
Tel No.: (+233) 0200486266
Email:mampongeducationoffice@yahoo.com
Mampongmunical@ges.gov.gh
AM-0020-0754
24th April, 2024

MS. GLADYS FOSUAA (8221920015)
AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL
DEVELOPMENT
FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE EDUCATION
MAMPONG ASHANTI

RE: PERMISSION TO CONDUCT A RESEARCH STUDY

Following your application to the Municipal Education Directorate, Mampong-Ashanti dated 22nd April, 2024 to carry out research on "*Assessing Science Process Skills of Biology Students in Senior High Schools: A Case Study in Asante Mampong*", I am pleased to inform you that you have been granted permission to conduct your research in the selected Senior High Schools – Amaniampong Senior High School, St. Joseph Seminary Senior High School, St Monica's Senior High School, and Kofiase Adventist Senior High Technical School from 29th April, 2024 to 30th August, 2024.

You are duly advised to report to the authorities of the selected Senior High Schools before embarking on the research. I am by this letter requesting the Heads of the selected schools to kindly give the Student Researcher the needed support to enable her conduct her research.

Note that:

1. All ethical issues in research must be duly observed and applied in the selected Schools in this Municipal Education Directorate.
2. All COVID-19 pandemic protocols must be duly observed in the schools.
3. Consent of the learners and teachers must be sought before conducting your research at the selected sites.
4. Present a copy of this clearance to the school of your choice before collecting your data.
5. On completion of the research project, you are requested to submit one hardcopy of your report to this office.

I wish you good luck in your assignment.

PRINCE OWUSU-ANSAH (MR.)
MUNICIPAL DIRECTOR OF EDUCATION

Cc:
The Ag. Head of Department, Department of Science Education, AAMUTED, **Mampong Ashanti**,
The Headmistress, Amaniampong SHS, **Mampong Ashanti**,
The Headmaster, St. Joseph Seminary SHS, **Mampong Ashanti**,
The Headmistress, St Monica's SHS, **Mampong Ashanti**
The Headmaster, Kofiase Adventist SHS, **Kofiase Ashanti**

HA

APPENDIX I

ETHICAL CLEARANCE



**Kwame Nkrumah
University of Science
and Technology, Kumasi**

**College of Health Sciences
SCHOOL OF MEDICINE AND DENTISTRY**

COMMITTEE ON HUMAN RESEARCH, PUBLICATION AND ETHICS

Our Ref: CHRPE/AP/306/25

12th April, 2025

Miss Gladys Fosuaa
Department of Integrated Science Education
Faculty of Science Education
AAMUSTED-KUMASI.

Dear Madam,

LETTER OF APPROVAL

Protocol Title: *"Assessing Science Process Skills of Biology Students in Selected Biology Topics in Senior High Schools in Asante- Mampong Municipality."*

Proposed Site: *All Public Senior High Schools (SHS) in the Asante Mampong Municipality (Specifically; Biology students in SHS 3).*

Sponsor: *Self-sponsored.*

Students: Miss Gladys Fosuaa.

Supervisor: Dr. Charles Amoah Agyei

Your submission to the Committee on Human Research, Publications, and Ethics on the above-named protocol refer.

The Committee reviewed the following documents:

- A notification letter of 17th March, 2025 from the Talensi District Hospital, Emergency Unit, Upper East (study site) indicating approval for the conduct of the study at the hospital.
- A Completed CHRPE Application Form.
- Participant Information Leaflet and Consent Form.
- Research Protocol.
- Questionnaire.

The Committee has considered the ethical merit of your submission and approved the protocol. The approval is for one year, renewable after that, from **12th April 2025 to 11th April 2026**. The Committee may, however, suspend or withdraw ethical approval at any time if your study is found to contravene the approved protocol.

Data gathered for the study should be used for the approved purposes only. Permission should be sought from the Committee if any amendment to the protocol or use, other than submitted, is made of your research data.

The Committee should be notified of the actual start date of the project and would expect a report on your study, annually or at the close of the project, whichever one comes first. It should also be informed of any publication arising from the study.

Thank you for your application.

Yours faithfully,

Rev. Prof. John Appiah Poku,
**Honorary Secretary
FOR: CHAIRMAN**

Room 7, Block 1, School of Medicine and Dentistry, KNUST, University Post Office, Kumasi, Ghana
Tel: +233 (0) 322 063 248 Mobile: +233 (0) 205 453 785 Email: chrpe.knust.kath@gmail.com / chrpe@knust.edu.gh