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Assessing Proficiency in Science Process Skills among Senior High School Students

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This study assessed senior high school biology students' proficiency in selected science process skills (SPS) in Ghana. The study aimed to (1) determine the extent of students' proficiency in science process skills in biology learning and (2) examine differences in students' proficiency across three basic SPS: observation, classification, and measurement. The study was guided by two research questions. A descriptive cross-sectional quantitative design was employed. Using simple random sampling, two senior high schools were selected, and 118 Senior High School Two (SHS 2) biology students participated in the study. Data were collected using a Science Process Skills Achievement Test (SAT) consisting of 15 items assessing observation, measurement, and classification skills. The instrument was pilot-tested and yielded a Cohen's kappa reliability coefficient of 0.76, indicating substantial inter-rater agreement. Descriptive statistics (frequencies and percentages) and one-way ANOVA were used for data analysis. The results showed high proficiency in observation (86.44%) and classification (74.58%) skills, but low proficiency in measurement skills (72% of students scored in the low category). ANOVA results indicated a significant difference in performance across the three skills. The findings highlight the need for increased practical activities and instructional strategies to improve students' measurement skills in biology.

Keywords: science process skills, biology education, senior high school, students' assessment, observation, classification, measurement

INTRODUCTION

Science process skills are various psychomotor and cognitive skills required to undertake meaningful scientific enquiry. They are developed rather than innate and include both basic and integrated skills that reflect the behaviour of scientists. Science process skills (SPS) are key qualities that enable students to conduct successful scientific inquiry and problem solving. These skills, include observation, classification, inference, prediction, measurement, and testing, are critical for understanding and applying scientific concepts (Apeadido et al., 2024). It also refers to the procedural skills, experimental and investigative science mindsets, or scientific inquiry abilities that science

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students are expected to possess. Thus, the primary goal of science education is to provide students with science process skills (Ekici & Erdem, 2020). These skills or abilities include scientific effort which are required for learning, solve problems and applying them in everyday life (Diego et al., 2020). Science is viewed as both a process and a product, requiring observation, classification, and measurement to reach conclusions such as scientific theories, hypotheses, and laws.

In the context of senior high school (SHS) biology instruction, developing and accessing these skills 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 Safkolam et al. (2024) assertion that teaching students through an inquiry method 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. Succinctly put, improving science process skills may aid students in acquiring the skills and mindsets of scientists (scientific attitudes) in order to meet technical learning objectives.

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 needed in a variety of future situations. When performing science, people apply basic scientific process skills. Students who exercise the same skills are more engaged in their study than those who do not. Those who engage these skills utilise their senses to study things and occurrences, and then seek for patterns in their discoveries. They 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 (Fernando et al., 2021).

According to Suryanti et al. (2020), science process skills can be classified into two groups they are the basic and integrated science process skills. The basic process skills include observation, classifying, measuring, drawing conclusions, and making predictions. Also, the 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 hypothesizing, conducting examinations, and drawing conclusions. Science process skills are used to solve problems and conduct experiment 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 (Astalini et al., 2023).

Synonymously, science education is built on reasoning, problem solving, and methods. As a result, one method for boosting students' scientific ability is to introduce them to science process skills (Hernawati et al., 2018). Biology as a science subject studies both products and processes aim at helping 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). Studying biology depends on experiments employing scientific techniques, sometimes known as the scientific processes. The process includes observation, grouping (classification), interpretation, prediction, conclusion, and communication.

Students are required to learn these 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 (Wirayuda et al., 2013). This relationship is critical for a scientific call to change society.

Biology's prominence in Ghana's educational curriculum, from elementary to senior high school, is reasonable given its essential role in the 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 (Darmaji, 2019). To conduct scientific tasks, you must possess the appropriate abilities. During the learning process, biology students must actively uncover the key concepts of the subject through observation, experimentation, the creation of visuals, graphs, and tables, and the presentation of their results to others.

To determine senior high school Biology students' scientific inquiry and problem-solving abilities, it is critical to assess the existing science process skills embedded in the current curriculum. 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).

In Ghana, the Curriculum Research and Development Division [CRDD] of the Ghana Education Service [GES] determines the substance of the teaching curriculum, while the West African Examinations Council [WAEC] assesses senior high schools. Both organisations value hands-on activities, science 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 (CRDD, 2010). The Ministry of Education's curriculum document prioritises the development of science process skills such as equipment handling, experiment planning and design, observation, manipulation, classification, sketching, measuring, interpretation, recording, reporting, and laboratory practice by 30%.

The WAEC SHS biology examination consists of three parts: 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 (CRDD, 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 (3) question measures students' knowledge and familiarity with a biological specimen via drawing, a prescribed practical activity in the biology syllabus. This firmly confirms that practical work as it is called, is an important part of the biology curriculum at Ghana's Senior High School (SHS) level, since it helps students develop the various science process skills.

Observation, classification, and measurement, as part of the fundamental science process skills that enable students to engage effectively in scientific inquiry and problem-solving. In order to understand how well senior high school Biology students in Ghana develop these specific skills, it is necessary to conduct research assessing their proficiency in observation, classification, and measurement within the biology curriculum.

Purpose of the Study

The purpose of the study was to use science process skills (observation, measuring and classification) of biology students in SHS in Ghana.

Research Questions

1. What is the extent of students' proficiency in science process skills in the learning of biology in senior high schools?
2. What are the differences in biology students' proficiency levels between observation, classification, and measurement skills?

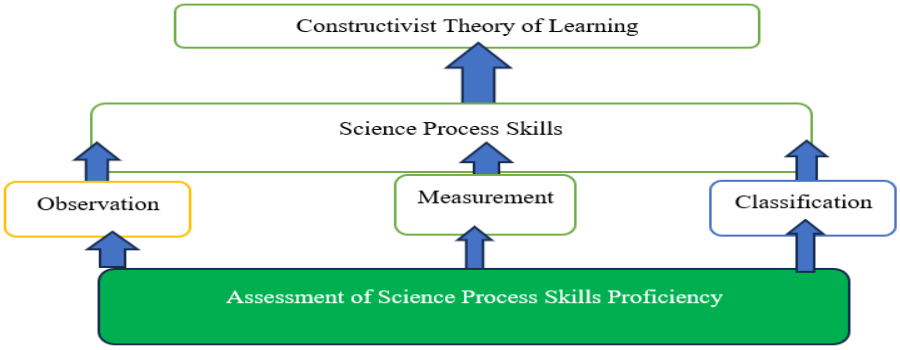
LITERATURE REVIEW

Conceptual Framework of the Study

This study is grounded in the constructivist theory of learning, which posits that learners actively construct knowledge through interaction with their environment and meaningful engagement in tasks (Tan et. al, 2020). In the learning of science, such engagement is best demonstrated through science process skills (SPS), which serve as the foundational abilities for inquiry and problem-solving. For this study, the focus is limited to three SPS observation, classification, and measurement since these are emphasized in the Ghanaian senior high school biology curriculum and can be systematically assessed through achievement tests (CRDD, 2010; Dah, 2020).

Observation enables students to apply their senses and scientific tools to identify features of biological phenomena, forming the basis for accurate description and data collection (Tilakaratne & Ekanayake, 2017). Classification allows learners to organize organisms, objects, and concepts based on shared characteristics, fostering critical thinking and logical reasoning in scientific contexts (Abbas et al., 2021). Measurement, on the other hand, connects qualitative observations to quantitative reasoning by requiring the use of standardized tools and units, thus enhancing precision and validity in scientific investigations (Lombardi et al., 2021).

These three SPS are particularly significant because they underpin higher-order scientific competencies and practical assessments such as those conducted by the West African Examinations Council (WAEC, 2018, 2020). However, studies indicate that while students often demonstrate strong proficiency in observation and classification, they tend to struggle with measurement, largely due to limited hands-on practice and weak integration of mathematical reasoning in science classrooms (Apeadido et.al., 2024).



Source: Developed by Researchers

Science process skills

The significance of science process skills in biology education has been underlined in a number of research. According to Pathoni et al. (2020), 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 Husna et al. (2022). Science process skills are essential for training students for real-world applications, according to.

According to Astalini et. (2023) 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. Gizaw and Sota (2023) asserts that these process skills are instruments used by scientists to carry out scientific research and that students 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 Gale (2022), 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 Maison (2020). 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 et al., 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 (Duda, 2020) 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 (Romadona et al., 2021).

Classification of Skills in 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.

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. 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).

Measurement skills in science process skills

Measurement is a pivotal science process skill that underpins empirical inquiry and supports the development of scientific literacy. It enables learners to quantify observations, compare variables, and validate experimental outcomes using standardized units and calibrated instruments. In secondary science education, particularly within biology and physics, measurement skills encompass the use of tools such as thermometers, balances, and rulers, as well as the ability to estimate, record, and interpret data with precision. Recent studies highlight persistent challenges in students' mastery of measurement. Aydoğdu et al. (2022) found that secondary students often struggle to understand the purpose and application of measurement within scientific texts and experimental contexts, leading to superficial engagement with data and reduced inquiry depth. These difficulties are compounded by limited exposure to hands-on experimentation and a lack of integration between mathematical reasoning and scientific practice.

Moreover, the psychometric rigor of instruments used to assess measurement skills remains uneven. A systematic review by Lombardi et al. (2021) revealed that while internal consistency is frequently reported, other forms of validity such as test–retest reliability and discriminant validity are rarely addressed, limiting the interpretability and generalizability of findings. This gap underscores the need for more robust instrument development and validation in STEM education research.

Pedagogically, fostering measurement competence requires inquiry-based environments where students actively engage with tools and reflect on their data collection processes. Advocate for coordinated use of common measures across science education interventions to enhance comparability and support evidence-based improvements. Such approaches not only strengthen technical proficiency but also promote interdisciplinary collaboration and equity in learning outcomes.

In under-resourced contexts, disparities in access to laboratory equipment and teacher expertise can hinder students' development of measurement skills. Addressing these inequities calls for innovative strategies such as low-cost experimental kits, peer-led demonstrations, and differentiated instruction that democratize access to scientific inquiry and empower all learners to participate meaningfully in the scientific process.

METHOD

Research Design

This study used a descriptive cross-sectional design with a quantitative approach embedded in a positivist paradigm to evaluate the science process skills of biology students in senior high schools. 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 what we want to achieve.

From a population of 4 public senior high schools in the Mampong Municipal of the Ashanti region in Ghana, two schools were selected using simple random sampling. A total of 118 form 3 students participated, with 58 students from School A and 60 students from School B. In each school, students were randomly selected from about a total of 2,000 form 3 students using simple random sampling to ensure each student had an equal chance of being included in the study.

Research Instruments

The instruments used in this study was a standard achievement test (SAT) on students' development of science process skills designed by the researchers according to GES syllabus. 15 questions on the students' achievement test (SAT) evaluated three higher order science process abilities that are pertinent to the GES and SHS curriculum. Each science process skill had five questions. Observation (questions 1–5), measurement (questions 6–10), and classification (questions 11–15) are the science process abilities that were examined at a sitting (See Appendix).

Pilot Test

The instrument was pilot tested in a different SHS in that did not partake in the study but had similar characteristics of those in the study in order to check for the reliability of the instrument.

Reliability of the instrument.

The SAT's internal consistency and dependability was determined using inter-rater reliability of a score of 0.76.

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 0.76 indicates substantial agreement among raters, which is sufficient for many research or therapeutic contexts that need human judgment.

Data Collection Procedure

The SAT instrument took an average of forty (40) minutes to complete. Students were given the test and a specimen to look at and fill in the blanks. Students were urged to complete the test as best they could on their own. To guarantee a 100% return rate, the researchers collected the test at the conclusion of 40 minutes.

Data analysis Procedure

Descriptive analysis (Frequencies and Percentages) was used to in analysing the research question 1 and inferential statistics (One-way ANOVA) was also used to analyse the research question 2. The Statistical Package for the Social Sciences (SPSS) version 27 was used to compile, sort, code, and analyse the participant data.

FINDINGS

The results and findings of the investigation are presented in section. The study questions serve as the basis for the findings. The following research questions serve as the basis for the findings:

- What is the extent of students' proficiency in science process skills in the learning of biology in senior high schools?
- What are the differences in biology students' proficiency levels between observation, classification, and measurement skills?

The extent of students' proficiency in science process skills in the learning of biology in senior high schools?

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

Table 1
Frequency distribution table on biology students' proficiency in observation skills at the senior high school level

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 1, 13.56% of students exhibited low competence in observation skills, whereas a sizable majority (86.44%) showed highcompetency. 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.

Table 2
Frequency distribution table on biology students' proficiency in classification skills at the senior high school level

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

According to the distribution of students' competency in classification skills from Table 2 above, the majority (74.58%) of them performed well, while 25.42% found it difficult. This implies that although most students toto 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.

Table 3
Frequency distribution table on biology students' proficiency in measurement skills at the senior high school level

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

Students seem to struggle with their measurement skills, in contrast to observation and classification skills. According to the findings from Table 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 to 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.

The difference in the learning outcome of biology students in science process skills in senior high schools

To determine the differences in the biology students' proficiency level between Observation, Measurement, and Classification skills, a one-way ANOVA was performed to compare the differences. The result is presented on Table 4.

Table 4
ANOVA table on the science process skills of biology students

Source	df	SS	MS	F	*P*
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< since α =0.05

The one-way analysis of variance (ANOVA) Table 4 was used to assess whether there are statistically significant differences between the three skill sets of the biology students: Observation, Classification, and Measurement. The results showed a statistically significant difference between their skills groups, F (2, 351) = 133.31, 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 5
Post-Hoc table (Tukey HSD) on the ANOVA table

Comparison	Mean Difference (I-J)	Std. Error	Sig	95% Cl (lower Bound)	95% Cl (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

From the 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 6
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 their Observation results were the best, while the Measurement results were the least among the three-skill set.

DISCUSSIONS

Discussion of Results for Findings 1

To what extent are the biology students in senior high schools proficient of science process skills in the learning of biology?

A key scientific skill is observation, which is paying close attention to and documenting occurrences with the use of scientific tools or the senses (Rybska, 2024). Only 13.56% of students had low competence in observation skills, compared to 86.44% who demonstrated high proficiency, according to the study. 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, even though the majority can do so successfully. This suggests that they may not have had enough exposure to classification problems or conceptual comprehension before 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 studies, students frequently don't 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).

Discussion of Results for Findings 2

Differences in biology students' proficiency levels between observation, classification, and measurement skills

The ANOVA findings 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 huge 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. 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 et al., 2016).

The mean scores provided 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 et al. (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 are the least effective. These findings are consistent with educational theories emphasizing the value of active, experiencing learning in science education (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.

CONCLUSION

This study provides compelling evidence that while Ghanaian senior high school students demonstrate moderate proficiency in certain science process skills, particularly observation and classification, their performance in measurement remains low. This imbalance underscores a critical gap in the current biology curriculum and instructional practices, which tend to emphasize descriptive over quantitative inquiry. Based on the analysis and discussion of findings, it can be concluded that there is the need for a more deliberate integration of SPS into both teaching and assessment frameworks, especially in ways that promote equity and authentic scientific engagement. Educators can foster deeper cognitive engagement and skill acquisition, enabling students to not only understand biological concepts but also apply scientific reasoning in real-world contexts. Moreover, the study highlights the importance of resource availability, teacher preparedness, and assessment reform in shaping students' SPS development. Addressing these systemic factors is essential for cultivating scientifically literate graduates who are equipped for higher education and STEM careers.

Ultimately, this research contributes to the growing body of literature advocating for evidence-based, skill-centered science education. It calls on stakeholders' curriculum developers, policymakers, and educators to reimagine biology instruction as a platform for nurturing critical thinking, precision, and inclusive learning experiences. Future studies should explore longitudinal impacts of SPS-focused interventions and examine how gender-responsive strategies can further enhance equitable outcomes in science education.

RECOMMENDATIONS

- Curriculum Developers should embed SPS explicitly in learning outcomes and ensure that core SPS especially measurement, classification, and inference are not just implied but clearly stated in curriculum objectives across grade levels.
- Assessment bodies should reframe biology curricula to integrate SPS development alongside conceptual knowledge, using real-world contexts to make skills meaningful.
- Policy makers should mandate SPS integration in national standards and require that SPS be taught and assessed systematically across science subjects, with clear benchmarks for performance.
- Educators should allocate resources for practical work and invest in basic lab equipment and low-cost experimental kits, especially in underserved schools, to support hands-on learning.

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