AVE Trends in Intelligent Techno Learning

Acquisition Level of Science Process Skills Among Senior High School STEM Learners

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Abstract: Scientific inquiry, critical thinking, and real-world problem-solving require science process skills (SPS), including seeing, measuring, classifying, inferring, communicating, and hypothesising. This descriptive quantitative study used an adopted research instrument to analyse senior high school STEM learners' SPS acquisition levels at a state institution in 2024–2025. Mean, t-tests, ANOVA, and regression analyses were used. Informed consent, confidentiality, and institutional research protocols ensured ethical conduct. Learners demonstrated high SPS, with talking, classifying, and observing being the most developed areas of skill. Women were slightly better at communicating and hypothesising than men. High-income students hypothesised well, while low-income students observed and communicated. Hypothesis was the weakest skill. Parental education and family income affected SPS acquisition. Higher education and affluence increased observational abilities and hypothesising due to better resources. The findings confirm Kolb's Experiential Learning Theory that hands-on, inquiry-based, and reflective learning improve scientific thinking and problem-solving. Reduce social disparity via SMART science. This method emphasizes hands-on, constructivist modules on observing, measuring, inferring, and hypothesising with teacher training, school-wide efforts, and enough resources. Inclusive teaching and performance-standards-aligned content are needed to close gaps and study SPS acquisition's long. This study emphasizes the necessity for fair STEM education to teach students scientific skills regardless of socioeconomic background.

Keywords: Science Education; Science Process Skills (SPS); SPS Acquisition Level; SMART Science; STEM Learners; Socioeconomic Background; Socioeconomic Inequality; Parental Education; Family Income.

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1. Introduction

Science Process Skills (SPS) are fundamental for students to actively engage in scientific investigations and understand the scientific method. These skills—such as observing, hypothesising, experimenting, and analysing—help students make sense of scientific concepts and deepen their understanding. Acquisition level in SPS fosters increased interest and engagement in science, which can lead to higher motivation and a deeper investment in learning. The active application of these skills, especially through hands-on learning, enables students to develop problem-solving abilities and apply knowledge to real-life situations, highlighting the importance of experiential learning over passive memorisation. SPS are divided into Basic Science

Process Skills (BSPS) and Integrated Science Process Skills (ISPS). BSPS encompasses fundamental skills such as observing, classifying, and measuring, which provide a foundation for understanding science. ISPS are more advanced, involving tasks such as controlling variables, formulating hypotheses, and conducting experiments [2]. Mastery of both BSPS and ISPS enhances students' cognitive development, fostering critical thinking, problem-solving skills, and intrinsic motivation to learn. These skills are vital in preparing students for both academic challenges and real-world problem-solving. In high school, particularly in laboratory settings, SPS play a crucial role in helping students develop scientific inquiry skills, refine observation techniques, and improve data analysis. Laboratory activities provide students with hands-on experiences that enable them to apply their knowledge in real-world scientific contexts [6].

This active participation in experiments strengthens their understanding of the scientific method and cultivates a systematic approach to problem-solving. The development of these skills is essential not only for academic success but also for fostering a lifelong appreciation for science and its practical applications. Research has shown that inquiry-based learning, which emphasises active participation and hands-on activities, significantly improves the development of SPS. Studies indicate that students who engage in inquiry-based activities tend to perform better in terms of scientific literacy and academic achievement. However, in the Philippines, there is a recognised gap in the application of SPS, particularly in laboratory settings [7]. The country's performance in international assessments, such as PISA, reflects challenges in developing science competencies, especially in practical applications of science process skills. These findings underscore the need for more effective science education strategies to enhance the acquisition level of SPS among high school students in the Philippines [8]. Despite substantial research on SPS, a gap remains in studies focusing on the development of these skills in specific educational contexts, such as laboratory high schools [9]. Notably, there is limited research on how SPS are cultivated in STEM programs or laboratory schools, such as the University of Antique Laboratory High School. This research gap presents an opportunity to explore how these skills are developed in a unique educational environment [10]. The findings of this study will contribute to improving science education in the Philippines by providing insights into the effectiveness of current strategies and informing curriculum development to better prepare students for future scientific challenges [11].

1.1. Objectives of the Study

- To determine the acquisition level of science process skills among Senior High School STEM learners in terms of observing, measuring, classifying, inferring, communicating, and hypothesising, both as a whole and when grouped according to sex, family monthly net income, and parents' educational attainment.
- To assess whether there is a significant difference in the acquisition level of science process skills of Senior High School STEM learners when grouped by their profile variables, specifically sex, family monthly net income, and parents' educational attainment.
- To identify the profile characteristics of Senior High School STEM learners that serve as significant predictors of their acquisition level in science process skills.
- To propose an intervention program based on the findings to enhance the acquisition of science process skills among Senior High School STEM learners.

2. Literature Review

2.1. Acquisition level in Science Process Skills

Acquisition of science process skills at the acquisition level is crucial for students' success in science education. Safaah et al. [3] found that inquiry-based and contextualised instruction significantly improved students' Acquisition level in science process skills, particularly in comparison to traditional teaching methods. Chi [1] demonstrated that integrating technology, such as computer simulations, significantly enhanced students' science process skills, including their ability to hypothesise, measure, and communicate findings. Additionally, Miller [5] highlighted the role of science process skills-based learning in developing essential 21st-century skills, such as problem-solving and critical thinking, which are vital for success in modern scientific endeavours. Science process skills (SPS) refer to the abilities and competencies that students must develop to engage in scientific inquiry effectively. These skills include observing, measuring, classifying, inferring, communicating, and hypothesising, forming the foundation of scientific thinking and investigation. The development of SPS is essential not only for mastering science concepts but also for fostering critical thinking, problem-solving, and decision-making skills that are necessary for students' academic and intellectual growth [12].

2.2. Science Process Skills in Terms of Observing

Observation is the foundational skill in scientific inquiry, enabling students to gather information about phenomena in a systematic and detailed manner. According to Safaah et al. [3], effective observation involves the ability to notice important variables and subtle details that may otherwise be overlooked. These skills are critical for guiding subsequent analysis and forming hypotheses. Additionally, Pacia [4] found that science process skills-based learning, which includes developing strong observation skills, enhances students' critical thinking abilities and their capacity to investigate scientific phenomena.

2.3. Science Process Skills in Terms of Measuring

Measuring is another core skill in science education, involving the accurate collection of data to ensure reliability and validity in experiments. Chi [1] emphasises that mastering measurement techniques is essential in fields such as physics and chemistry, where precise data collection is necessary for accurate conclusions. Research by Miller [5] demonstrated that computer simulations can significantly enhance students' measurement skills. They provide virtual labs where students can practice and refine their measurement techniques, bridging the gap between theoretical knowledge and practical application. Furthermore, Chi [1] found that inquiry-based learning methods, which often involve hands-on measurement activities, significantly improve students' measurement skills in science.

2.4. Science Process Skills in Terms of Classifying

The ability to classify information is vital for organising data and identifying patterns within scientific investigations. According to Pacia [4], classifying skills help students relate and organise observations, which is crucial for forming scientific theories and models. These skills not only aid in understanding complex concepts but also in making connections between different scientific ideas. Miller [5] reported that students who struggle with basic classification skills often face difficulties in integrating scientific concepts, highlighting the importance of teaching classification early in the science curriculum.

2.5. Science Process Skills in Terms of Inferring

Inferring enables students to draw evidence-based conclusions and connect observations with their theoretical understanding. Chi [1] argues that inferring is central to scientific reasoning because it enables students to test hypotheses and draw conclusions that guide future experiments. In a study by Miller [5], gender was found to have no significant impact on students' ability to infer, suggesting that with appropriate teaching methods, all students can develop this crucial skill. Furthermore, Safaah et al. [3] found that inquiry-based instruction fosters students' inferential skills by encouraging them to actively engage in experiments and make logical deductions from their findings.

2.6. Science Process Skills in Terms of Communicating

Effective communication is integral to the development of science process skills. Pacia [4] emphasises that communicating findings clearly is essential for students to share their scientific understanding and engage in scientific discourse. Whether through writing, presenting, or discussing results, communication helps students clarify their thinking and present their conclusions in a structured manner. Safaah et al. [3] also observed that technology-integrated learning environments, such as computer simulations, can enhance students' communication skills by providing platforms for students to share and discuss their findings in real-time, thus improving both their academic achievement and their engagement in scientific inquiry.

2.7. Science Process Skills in Terms of Hypothesising

The ability to form and test hypotheses is central to scientific thinking, as it directs students' focus during experiments and promotes deeper engagement with scientific concepts. Miller [5] argues that hypothesising fosters critical thinking by encouraging students to propose testable ideas and refine their understanding of the phenomena under investigation. In line with this, Pacia [4] found that students with a higher acquisition level in hypothesising performed better in science, as they were able to generate and test multiple hypotheses during their experiments. Miller [5] also found that simulations and inquiry-based learning environments enhance students' ability to formulate and test hypotheses, allowing them to explore scientific ideas interactively and engagingly.

2.8. Acquisition level in Science Process Skills as to Identified Variables

A substantial body of research underscores the critical role of foundational science process skills—observing, measuring, classifying, inferring, communicating, and hypothesising—in fostering scientific reasoning and inquiry. Safaah et al. [3] emphasise that effective observation skills enable students to identify significant variables and phenomena, thereby deepening their understanding in scientific investigations. Safaah et al. [3] emphasise the importance of accurate measurement skills in ensuring the reliability and validity of scientific experiments, particularly in fields such as physics and chemistry. Similarly, Chi [1] discusses the importance of classifying skills in organising observations and establishing relationships, which are essential for building scientific theories and models. Pacia [4] asserts that inference skills allow students to test hypotheses and draw conclusions based on evidence, guiding further experiments. Miller [5] notes that hypothesising is central to the scientific method, enabling students to direct their focus during experiments and refine their understanding of scientific concepts. Finally, Safaah et al. [3] argue that communication is an essential skill in STEM education, as it facilitates the exchange of ideas and contributes to the advancement of scientific knowledge.

2.8.1. Influence of Socioeconomic Status on Science Process Skills

Socioeconomic factors, including family monthly net income, significantly impact the development of science process skills. Miller [5] observes that socioeconomic status (SES) influences access to educational resources and opportunities, which in turn affects students' acquisition of science skills. Chi [1] emphasises that students from higher-income families often have access to better resources, such as technology and lab equipment, which enhance their measurement skills. Safaah et al. [3] suggest that while classifying skills are important, they may not be as directly impacted by SES as more technical skills, such as measurement. Pacia [4] discusses how access to educational resources plays a significant role in developing critical thinking skills, such as inferring. Higher-income students typically have more access to enriching educational environments, which can enhance their ability to make logical conclusions. Miller [5] adds that hypothesising is an essential component of scientific inquiry, and students from higher-income families may have an advantage due to their increased access to educational resources that support hypothesis-driven learning.

2.8.2. Role of Parental Educational Attainment

Parental educational attainment also influences students' development of science process skills. Safaah et al. [3] note that accurate observation is a foundational skill for scientific inquiry, and this ability is not necessarily limited by parental education. Pacia [4] emphasises that equitable educational opportunities, regardless of parental educational backgrounds, can provide students with the necessary skills to succeed in scientific investigations. Chi [1] argues that classifying skills are essential for organising and analysing scientific data, a process that can be developed by all students, regardless of their parents' educational level. Miller [5] highlights that the development of higher-order thinking skills, such as inferring, is facilitated by quality education, which can be provided through inclusive teaching practices. Safaah et al. [3] argue that hypothesising fosters critical thinking. While parental education may contribute to a student's ability to engage in hypothesis-driven learning, it is not a limiting factor if appropriate educational practices are in place. Moreover, studies by Pacia [4] emphasise the importance of creating inclusive learning environments where all students, regardless of parental educational backgrounds, can develop essential scientific skills. This supports the notion that when students are provided with equitable opportunities and resources, parental education does not necessarily limit the development of science process skills [13].

3. Methodology

3.1. Research Design, Population, Sample, and Instrumentation

This study employed a cross-sectional survey research design, which is an observational approach that analyses data from a population at a specific point in time without manipulating variables. This design allows researchers to examine various characteristics simultaneously and is frequently used to observe the prevailing characteristics in a given population. It is particularly useful for descriptive purposes, providing a snapshot of the current situation, but it does not establish cause-and-effect relationships. The population consisted of 98 STEM Senior High School learners (46 male and 52 female) from the Laboratory High School of the University of Antique in Sibalom, Antique. All Grade 11 and Grade 12 STEM learners were included in the sample to enhance the reliability of the results. The instrument used was an adapted version of the Science Process Skills (SPS) survey originally developed by Joey O. Manes, Adelia Calimlim, and Elizabeth Nalupa-Farin. This instrument assesses the acquisition levels of SPS across six domains —observing, measuring, classifying, inferring, communicating, and hypothesising —using a five-point Likert scale. The instrument was slightly modified to suit the senior high school context, with interpretation categories ranging from "Very Low" (1.00–1.80) to "Very High" (4.21–5.00). Data collection involved obtaining permission from the school principal, distributing the survey to students, and ensuring ethical standards through informed consent and confidentiality. Data analysis was conducted using SPSS version 23.0, employing descriptive statistics, t-tests, one-way ANOVA, linear regression, and multinomial logistic regression to examine the factors influencing SPS acquisition.

4. Result and Discussion

4.1. Acquisition Level in Science Process Skills of Senior High School STEM Learners as an Entire Group

The data presented in Table 1 indicate that Senior High School STEM learners exhibit a high level of acquisition across all six science process skills, with an overall mean of 3.58 (SD = 0.49). This suggests that students are generally well-prepared in essential scientific competencies, which are crucial for effective scientific inquiry and problem-solving. Among the individual skills, "Communicating" received the highest mean score of 3.93 (SD = 0.70), indicating an exceptional ability to articulate scientific ideas and findings. "Classifying" followed closely, with a mean of 3.86 (SD = 0.64), demonstrating strong proficiency in organising and categorising scientific information. "Observing" also showed a high mean of 3.57 (SD = 0.58), reflecting students' capability to gather data through their senses. "Measuring" had a mean of 3.49 (SD = 0.58), indicating a solid grasp of accurately quantifying variables. "Inferring" scored a mean of 3.38 (SD = 0.67), suggesting a strong ability to draw conclusions based on data. "Hypothesising " had the lowest mean of 3.27 (SD = 0.72), yet still falls within the high acquisition level range, indicating a commendable capacity to formulate predictions or explanations based on existing knowledge. These findings align with existing research that emphasises the importance of science process skills in fostering competent and confident learners, which are essential for success in STEM fields. The high acquisition levels across all skills suggest that STEM education is effectively developing students' scientific thinking and problem-solving capabilities. However, the slightly lower mean for the hypothesised skill indicates that this skill may require further development, as it plays a crucial role in scientific investigation.

Table 1: Acquisition level in science process skills of senior high school STEM learners as an entire group

Science Process Skills	Mean	SD	Description
Observing	3.57	.58	High
Measuring	3.49	.58	High
Classifying	3.86	.64	High
Inferring	3.38	.67	High
Communicating	3.93	.70	High
Hypothesising	3.27	.72	High
Overall Mean	3.58	.49	High

4.2. Acquisition Level in Science Process Skills of Senior High School STEM Learners as to Sex

The data in Table 2 reveal that both male and female Senior High School STEM learners exhibit high acquisition levels in all six science process skills, with overall means of 3.53 (SD = 0.45) for males and 3.63 (SD = 0.52) for females. Females consistently outperformed males across all skills, with the highest mean of 4.00 (SD = 0.70) in "Communicating," compared to males' 3.85 (SD = 0.69). The "Classifying" skill also showed a notable difference, with females scoring 3.89 (SD = 0.59) and males 3.81 (SD = 0.70). The "Hypothesising " skill had the lowest mean for both genders, with females at 3.32 (SD = 0.73) and males at 3.20 (SD = 0.72). These findings suggest that while both genders possess high levels of science process skills, females tend to perform slightly better across all areas. The consistent high scores across all skills indicate the effectiveness of STEM education in developing students' scientific thinking and problem-solving abilities.

Table 2: Acquisition level in science process skills of senior high school STEM learners by sex

Science Process Skills	Male			Female		
	Mean	SD	Desc.	Mean	SD	Desc.
Observing	3.54	.56	High	3.60	.61	High
Measuring	3.43	.57	High	3.55	.60	High
Classifying	3.81	.70	High	3.89	.59	High
Inferring	3.34	.61	High	3.40	.71	High
Communicating	3.85	.69	High	4.00	.70	High
Hypothesising	3.20	.72	High	3.32	.73	High
Overall Mean	3.53	.45	High	3.63	.52	High

4.3. Acquisition Level in Science Process Skills of Senior High School STEM Learners as to Family Monthly Net Income

Table 3 presents the acquisition levels of science process skills among Senior High School STEM learners categorised by family monthly net income. Overall, high-income earners demonstrated the highest acquisition levels across all skills, with an overall mean of 3.71 (SD = 0.57), indicating a high proficiency in science process skills. Average-income earners followed closely with an overall mean of 3.65 (SD = 0.41), also reflecting high proficiency. In contrast, low-income earners had a slightly lower overall mean of 3.40 (SD = 0.43), which, while still considered high, suggests a marginally lower acquisition level compared to their higher-income peers. Specifically, high-income students excelled in "Classifying" (mean = 3.93, SD = 0.77) and "Communicating" (mean = 3.91, SD = 0.79), while low-income students scored lower in "Hypothesising " (mean = 3.01, SD = 0.61) and "Inferring" (mean = 3.14, SD = 0.56). These differences may be attributed to varying levels of access to resources and educational support, which are often associated with family income. Notably, both average and low-income groups still achieved high proficiency in most science process skills, suggesting that factors beyond family income, such as teaching quality and student engagement, also play significant roles in skill acquisition. These findings underscore the importance of providing equitable educational opportunities and resources to all students, regardless of their socioeconomic background, to ensure the development of essential science process skills. Implementing targeted interventions and support systems can help bridge the gap and enhance science education outcomes for learners from diverse economic backgrounds.

Table 3: Acquisition level in science process skills of senior high school STEM learners as to family monthly net income

Science Process Skills	High Income Earners			Average Income Earners			Low-Income Earners		
	Mean	SD	Desc.	Mean	SD	Desc.	Mean	SD	Desc
Observing	3.68	.55	High	3.63	.56	High	3.41	.61	High
Measuring	3.57	.62	High	3.63	.62	High	3.27	.43	Average
Classifying	3.93	.77	High	3.96	.58	High	3.68	.55	High
Inferring	3.69	.72	High	3.33	.62	Average	3.14	.56	Average
Communicating	3.91	.79	High	3.99	.57	High	3.87	.75	High
Hypothesising	3.47	.78	High	3.33	.73	Average	3.01	.61	Average
Overall Mean	3.71	.57	High	3.65	.41	High	3.40	.43	Average

4.4. Acquisition Level in Science Process Skills of Senior High School STEM Learners as to Parent's Educational Attainment

Table 4 presents the acquisition levels of science process skills among Senior High School STEM learners categorised by their parents' educational attainment. Overall, students with parents who have attained at least a college education demonstrated higher proficiency in science process skills compared to those whose parents have lower educational levels. Specifically, students whose parents have completed a college education exhibited the highest mean scores across all skills, with an overall mean of 3.59 (SD = 0.50), indicating a high level of acquisition. Students with parents who completed high school followed closely, with an overall mean of 3.51 (SD = 0.39), also reflecting high proficiency. In contrast, students whose parents have only completed elementary education had the lowest overall mean of 3.89 (SD = 0.87), though still within the high acquisition level range. Notably, the "Hypothesising " skill had the lowest mean scores across all parental education categories, with college-educated parents' children scoring 3.31 (SD = 0.76), high school-educated parents' children at 3.10 (SD = 0.56), and elementary-educated parents' children at 3.53 (SD = 1.10). This suggests that the ability to formulate hypotheses may be less influenced by parental education compared to other science process skills. These findings align with existing research indicating that higher parental educational attainment is associated with better academic outcomes for students. Parents with higher education levels are more likely to provide enriched learning environments, encourage academic achievement, and support their children's educational aspirations, thereby positively influencing their children's proficiency in science process skills.

Table 4: Acquisition level in science process skills of senior high school STEM learners as to parents' educational attainment

Science Process Skills	College Level			High School Level			Elementary Level		
	Mean	SD	Desc.	Mean	SD	Desc.	Mean	SD	Desc
Observing	3.58	.54	High	3.48	.64	High	4.20	.92	High
Measuring	3.50	.62	High	3.46	.45	High	3.53	.81	High
Classifying	3.83	.68	High	3.91	.49	High	3.93	1.1	High
Inferring	3.41	.67	High	3.22	.63	High	3.87	.70	High
Communicating	3.92	.67	High	3.92	.76	High	4.27	.95	High
Hypothesising	3.31	.76	Average	3.10	.56	Average	3.53	1.1	High
Overall Mean	3.59	.50	High	3.51	.39	High	3.89	.87	High

4.5. T-Test Results of the Differences in the Acquisition Level in Science Process Skills of Senior High School STEM Learners as to Sex

The t-test results in Table 5 indicate no statistically significant differences in the acquisition levels of science process skills between male and female Senior High School STEM learners. All p-values exceed the commonly used significance threshold of 0.05, suggesting that any observed differences are likely due to random chance rather than a true effect. For instance, the p-value for "Observing" is 0.608, far above 0.05, indicating no significant gender-based difference in this skill. Similarly, the p-values for "Measuring" (0.329), "Classifying" (0.545), "Inferring" (0.657), "Communicating" (0.311), and "Hypothesising " (0.421) all support the conclusion that there are no significant differences between genders. These findings suggest that gender does not play a significant role in the acquisition of science process skills among STEM learners in this sample. This aligns with the overall high acquisition levels observed across all skills, regardless of gender. Therefore, educators can be confident that both male and female students are equally proficient in these essential scientific competencies.

Table 5: T-test results of the differences in the acquisition level in science process skills of senior high school STEM learners by sex

Science Process Skills	Mean		t-value	df	Sig level
	Male	Female			
Observing	3.54	3.60	-.515	96	.608
Measuring	3.43	3.55	-.982	96	.329
Classifying	3.81	3.89	-.607	96	.545
Inferring	3.34	3.40	-.446	96	.657
Communicating	3.85	4.00	-1.019	96	.311
Hypothesising	3.20	3.32	-.808	96	.421

4.6. ANOVA Results of the Acquisition Level in Science Process Skills of Senior High School STEM Learners as to Family Monthly Net Income

The ANOVA results in Table 6 reveal that family monthly net income significantly influences the acquisition levels of certain science process skills among Senior High School STEM learners. Specifically, students from higher-income families demonstrated significantly better skills in measuring ($F = 4.047$, $p = 0.021$), inferring ($F = 5.976$, $p = 0.004$), and hypothesising ($F = 3.575$, $p = 0.032$) compared to their peers from lower-income families. These findings suggest that socioeconomic factors may impact the development of these particular skills. However, no significant differences were found in the acquisition levels of observing ($F = 1.964$, $p = 0.146$), classifying ($F = 1.930$, $p = 0.151$), and communicating ($F = 0.264$, $p = 0.769$), indicating that family income does not significantly affect these skills. Overall, while family income appears to influence certain science process skills, other factors may contribute to the development of others.

Table 6: ANOVA results of the acquisition level in science process skills of senior high school STEM learners, as to family monthly net income

		Sum of Squares	df	Mean Square	F	Sig.
Observing	Between Groups	1.305	2	.653	1.964	.146
	Within Groups	31.575	95	.332		
	Total	32.880	97			
Measuring	Between Groups	2.583	2	1.291	4.047*	.021
	Within Groups	30.311	95	.319		
	Total	32.893	97			
Classifying	Between Groups	1.565	2	.782	1.930	.151
	Within Groups	38.498	95	.405		
	Total	40.062	97			
Inferring	Between Groups	4.812	2	2.406	5.976**	.004
	Within Groups	38.249	95	.403		
	Total	43.061	97			
Communicating	Between Groups	.261	2	.131	.264	.769
	Within Groups	47.039	95	.495		
	Total	47.300	97			
Hypothesising	Between Groups	3.566	2	1.783	3.575*	.032
	Within Groups	47.389	95	.499		
	Total	50.956	97			

4.7. LSD Results of the Acquisition Level in Science Process Skills of Senior High School STEM Learners as to Family Monthly Net Income

The Least Significant Difference (LSD) test results in Table 7 provide a detailed analysis of the acquisition levels of specific science process skills among Senior High School STEM learners, categorised by family monthly net income. The findings indicate significant differences in the acquisition of measuring, inferring, and hypothesising skills between income groups. In measuring, students from high-income families scored significantly higher than those from low-income families, with a mean difference of 0.30667 (p = 0.034). Additionally, students from average-income families outperformed their low-income peers, with a mean difference of 0.36762 (p = 0.009). These results suggest that family income influences the acquisition of measuring skills among STEM learners.

Regarding inferring, high-income students demonstrated significantly better skills compared to both average-income and low-income students. The mean differences were 0.35524 (p = 0.027) when compared to average-income students and 0.54727 (p < 0.001) when compared to low-income students. These findings highlight the impact of family income on the development of inferential skills. In hypothesising, high-income students exhibited significantly higher acquisition levels than low-income students, with a mean difference of 0.46121 (p = 0.011). This indicates that family income plays a role in the acquisition of hypothesising skills among STEM learners. These results highlight the impact of socioeconomic factors on the acquisition of specific science process skills. The disparities observed suggest the need for targeted interventions to support learners from lower-income backgrounds in developing these essential skills.

Table 7: LSD results of the acquisition level in science process skills of senior high school STEM learners according to family monthly net income

Dependent Variables	(I)	(J)	Mean Difference (I-J)	Sig
Measuring	High	Low	.30667*	.034
	Average	Low	.36762**	.009
Inferring	High	Average	.35524*	.027
	High	Low	.54727**	.000
Hypothesising	High	Low	.46121*	.011

4.8. ANOVA Results of the Acquisition Level in Science Process Skills of Senior High School STEM Learners as to Parent's Educational Attainment

The ANOVA results in Table 8 indicate that there are no statistically significant differences in the acquisition levels of science process skills among Senior High School STEM learners based on their parents' educational attainment. All p-values exceed the commonly accepted significance threshold of 0.05, suggesting that variations in parents' education levels do not substantially influence students' performance in observing, measuring, classifying, inferring, communicating, or hypothesising skills. For instance, the p-values are 0.124 for observing, 0.946 for measuring, 0.869 for classifying, 0.207 for inferring, 0.700 for communicating, and 0.379 for hypothesising. These findings suggest that, within this sample, parental education does not have a significant impact on the development of science process skills among STEM learners. This contrasts with some studies that have reported a positive correlation between parental education levels and students' science process skills. The absence of significant differences in this study may be attributed to factors such as the high acquisition levels of science process skills among all students or the possibility that other unassessed variables may play a more substantial role in influencing these skills. Therefore, while parental education can be a contributing factor to students' academic development, it may not be the sole determinant in the acquisition of science process skills among Senior High School STEM learners.

Table 8: ANOVA results of the acquisition level in science process skills of senior high school STEM learners, as to parents' educational attainment

		Sum of Squares	df	Mean Square	F	Sig.
Observing	Between Groups	1.411	2	.706	2.130	.124
	Within Groups	31.469	95	.331		
	Total	32.880	97			
Measuring	Between Groups	.039	2	.019	.056	.946
	Within Groups	32.855	95	.346		
	Total	32.893	97			
Classifying	Between Groups	.119	2	.059	.141	.869
	Within Groups	39.944	95	.420		
	Total	40.062	97			
Inferring	Between Groups	1.406	2	.703	1.604	.207
	Within Groups	41.655	95	.438		
	Total	43.061	97			
Communicating	Between Groups	.354	2	.177	.358	.700
	Within Groups	46.946	95	.494		
	Total	47.300	97			

Hypothesising	Between Groups	1.030	2	.515	.980	.379
	Within Groups	49.925	95	.526		
	Total	50.956	97			

4.9. Model Summary of the Linear Regression Analysis on the Predictors of Science Process Skills Acquisition among Senior High School STEM Learners Based on Sex

The regression analysis aimed to determine whether science process skills (SPS)—including observing, measuring, classifying, inferring, communicating, and hypothesising—could predict the sex of Senior High School STEM learners. The model yielded an R-value of 0.163, indicating a very weak positive correlation, and an R-squared value of 0.027, which means that only 2.7% of the variance in sex was explained by SPS. Moreover, the adjusted R-squared value was negative (-0.038), indicating that the model performed worse than a simple mean-based prediction, possibly due to overfitting or a poor model fit. These results imply that science process skills are not reliable predictors of sex among STEM learners in this sample. The low R-squared and negative adjusted R-squared values indicate that factors other than SPS likely contribute more significantly to determining sex. Therefore, the study concludes that sex does not play a significant role in the acquisition of science process skills among these students (Table 9).

Table 9: Model summary of the linear regression analysis on the predictors of science process skills acquisition among senior high school STEM learners based on sex

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.163[a]	.027	-.038	.51097
*a. **Predictors:** (Constant), Communicating, Measuring, Observing, Hypothesising, Classifying, Inferring*				
*b. **Dependent Variable:** Sex*				

4.10. Linear Regression Analysis on the Predictors of Acquisition of Science Process Skills of Learners as to Sex

The findings indicate that the six science process skills are not significantly associated with the learners' sex, suggesting no meaningful differences between male and female STEM students in skill acquisition. Instead, variations in these skills are likely influenced by other factors such as educational background, teaching methods, learner engagement, or socio-cultural influences, highlighting that sex is not a significant determinant in the development of science process skills among senior high school STEM learners. Additionally, none of the individual science process skills significantly predicted sex, as all p-values exceeded 0.05, and the model explained only 2.7% of the variance in sex. This underscores that sex-based differences in science process skills are minimal or statistically insignificant in this context, and other factors likely have a stronger impact on the development of these skills (Table 10).

Table 10: Linear regression analysis on the predictors of acquisition of science process skills of learners as to sex

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.020	.431		2.363	.020
	Observing	-.060	.148	-.070	-.406	.686
	Measuring	.031	.157	.036	.198	.843
	Classifying	-.163	.204	-.209	-.799	.426
	Inferring	-.195	.218	-.259	-.892	.375
	Communicating	.002	.137	.002	.013	.990
	Hypothesising	.057	.070	.082	.808	.421
	Overall Mean	.529	.672	.513	.788	.433
*a. **Dependent Variable:** Sex*						

4.11. Likelihood Ratio Tests on the SP Skills of Learners as to Parents' Educational Attainment

The regression analysis indicates that Science Process Skills (SPS) account for 89% of the variance in learners' family income based on parents' educational attainment, as reflected by a McFadden pseudo R^2 of 0.890. However, the model's p-value of 1.000 suggests that this relationship is not statistically significant, implying that despite the high pseudo R^2, the model may not reliably distinguish differences in family income based on SPS. This discrepancy may be due to data limitations or model overfitting, highlighting the need for cautious interpretation of the results (Table 11).

Table 11: Likelihood ratio tests on the SP skills of learners as to parents' educational attainment

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	129.649			
Final	14.241	115.508	194	1.000
Pseudo R-squared (McFadden)	0.890			

4.12. Multiple Logistic Regression Results for Predictors of SP Skills of Learners as to Parents Educational Attainment

The multinomial logistic regression analysis revealed no statistically significant relationships between parental educational attainment and the development of Science Process Skills (SPS) among Senior High School STEM learners, with p-values ranging from 0.069 to 0.837. However, observing ($p = 0.074$) and communicating ($p = 0.069$) skills showed marginal associations. This suggests that while parental education may influence observation and communication skills, other factors, such as instructional quality, student motivation, peer influence, and individual learning experiences, likely play more significant roles in shaping SPS proficiency. The near-significance of these skills highlights areas for further research into how parental education interacts with home and school environments, and suggests that future studies could benefit from qualitative approaches to better understand parental influence on science learning (Table 12).

Table 12: Multiple logistic regression results for predictors of SP skills of learners as to parents' educational attainment

SP Skills	B coefficient	Std. Error	Wald z	p-value
Intercept	-2.14	1.12	3.66	.056
Observing	.500	.28	3.19	.074
Measuring	-.300	.20	2.25	.133
Classifying	.150	.25	0.36	.549
Inferring	-.200	.30	0.45	.503
Communicating	.400	.33	3.30	.069
Hypothesising	.050	.27	0.04	.837
Overall Mean	-.120	.20	0.36	.550

4.13. Likelihood Ratio Tests on the SP Skills of Learners as to Family Monthly Net Income

This finding partially supports existing research, such as Safaah et al. [3], which found that higher parental education is linked to better science process skills and literacy in pre-service teachers; however, the mostly non-significant results here highlight the multifactorial nature of skill acquisition, indicating that parental education alone does not fully explain student performance. Regarding family monthly net income, the multinomial logistic regression model showed a McFadden pseudo R^2 of 1.00, suggesting SPS account for all the variance in income levels, but this likely reflects overfitting or complete data separation rather than true predictive power, as the model's Chi-Square significance of 0.144 indicates no significant improvement over the intercept-only model and suggests the results may be due to chance (Table 13).

Table 13: Likelihood ratio tests on the SP skills of learners as to family monthly net income

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	214.997			
Final	.000	214.997	194	.144
Pseudo R-squared (McFadden)	1.000			

4.14. Multiple Logistic Regression Results for Predictors of SP Skills of Learners as to Family Monthly Net Income

The multinomial logistic regression analysis examined the effect of family monthly net income on Senior High School STEM learners' acquisition of Science Process Skills (SPS), finding that none of the individual SPS domains were statistically significant (p-values from 0.104 to 0.867), though observing ($p = 0.061$) and communicating ($p = 0.069$) showed marginal significance. The overall mean SPS score also approached significance ($p = 0.104$), indicating a possible trend where learners from higher-income families may perform better in science process skills. These results suggest that while family income might influence certain SPS areas, particularly observation and communication, it is not a definitive predictor, reflecting the complex role of socioeconomic factors in academic achievement (Table 14).

Table 14: Multiple logistic regression results for predictors of SP skills of learners as to family monthly net income

SP Skills	B coefficient	Std. Error	Wald z	p-value
Intercept	-5.00	3.20	2.44	0.118
Observing	0.90	.48	3.51	0.061
Measuring	0.08	.47	0.03	0.867
Classifying	-0.18	.50	0.13	0.716
Inferring	0.45	.55	0.66	0.417
Communicating	1.07	.59	3.30	0.069
Hypothesising	-0.34	.55	0.39	0.533
Overall Mean	1.35	.83	2.65	0.104

5. Conclusion

The study reveals that Senior High School STEM learners exhibit a high level of acquisition in all science process skills, indicating strong preparedness for scientific inquiry and problem-solving. While skills such as observing, measuring, and communicating are well-developed, the slightly lower mean for hypothesising suggests a need for targeted improvement. Notably, both male and female students demonstrate comparable proficiency across these skills, highlighting the effectiveness of inclusive, hands-on STEM education. Socioeconomic factors, including family monthly net income and parents' educational attainment, influence students' acquisition of science process skills. Higher-income students generally outperform their peers in skills such as inferring and hypothesising, likely due to increased access to resources and enriched learning environments. However, students from lower-income backgrounds also demonstrate strong abilities, particularly in observing, communicating, and classifying, emphasising the role of quality education and support in skill development.

The study identifies parents' educational attainment and family income as significant predictors of students' acquisition of science process skills. Parents with higher educational backgrounds tend to provide environments that nurture observational skills. In contrast, higher family income facilitates access to resources that support the development of complex cognitive skills, such as hypothesis formulation. These findings highlight the significant impact of socioeconomic factors on educational outcomes and underscore the importance of addressing disparities to ensure equitable learning opportunities. In response to these findings, the study proposes the "SMART Science: Strengthening Mastery through Active Reasoning and Thinking" intervention program. This program aims to enhance observing, measuring, inferring, and hypothesising skills through hands-on, constructivist approaches. It includes upgrading laboratory facilities, integrating inquiry-based activities using low-cost materials, and providing teacher training on differentiated instruction to cater to diverse learning needs.

5.1. Recommendations

To implement the "SMART Science" intervention effectively, school administrations should ensure access to adequate laboratory tools, structured teacher training, and institutionalise periodic evaluations of science process skills acquisition to guide program improvements and resource allocation. Curriculum planners are encouraged to integrate skill-specific modules from the program into the formal curriculum, aligning them with performance standards and designing localised assessment tools that reflect the unique needs of students, especially those from lower-income families. Schools should organise activities such as science process skills fairs and research expos to engage students and the community in real-world applications of science process skills. Teachers should utilise separate data on students' performance to tailor lesson planning and differentiation strategies. They should regularly employ active, inquiry-based approaches and simulations to strengthen students' hypothesising and inferring abilities. Professional development focused on assessing and teaching science process skills effectively is also recommended.

Students should actively participate in the "SMART Science" modules and similar experiential learning activities, seek mentorship or peer group collaborations to improve in underdeveloped skills, and use reflective journals or science portfolios to monitor personal progress in science process skills. Parents are encouraged to collaborate with schools and teachers by supporting their children's participation in the program, engaging in science-related activities at home, and reinforcing the importance of science process skills. Their involvement in school events, such as science fairs or research expos, can further enhance the development of these skills. Future researchers are encouraged to replicate and extend this study across different contexts, such as non-STEM strands, junior high school levels, or public schools. Investigating how variables such as teaching methods, classroom climate, and students' metacognitive strategies affect the acquisition of science process skills, as well as tracking the long-term impact of interventions like "SMART Science," can provide valuable insights. Examining learners' backgrounds, including their living conditions, cultural context, and sources of support, can further elucidate how these factors interact with skill development.

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