Biology Achievement and Critical Thinking Skills: A Case among STEM Senior High School Learners

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ABSTRACT

Critical thinking is a core competency emphasized in senior high school science education. However, its relationship with academic performance remains inconclusive in local contexts. This study examined the levels of critical thinking skills and Biology achievement among STEM senior high school learners and determined the relationship between these two variables. This quantitative study used researcher-modified test and survey questionnaires and were participated by 269 senior high school learners from both public and private schools. Results showed that only 13% of learners demonstrated high levels of critical thinking skills, while the majority were classified as average (43%) or low (43%), indicating limited higher-order reasoning proficiency among most learners. In terms of Biology achievement, most students performed at a Satisfactory level (59.90%), followed by Very Satisfactory (19.00%), with only a minimal proportion attaining Outstanding performance (0.40%). A notable 20.80% of learners did not meet academic expectations. Pearson product-moment correlation analysis revealed a very weak and non-significant relationship between critical thinking skills and Biology achievement ($r = 0.058$, $p = 0.342$), suggesting that critical thinking did not significantly predict academic performance in General Biology 2. The findings imply that Biology achievement may be more strongly influenced by instructional practices, assessment methods, and contextual factors than by critical thinking skills alone. The study underscores the need to align teaching strategies and assessment practices with curriculum goals to ensure that the development of critical thinking is meaningfully reflected in academic outcomes among learners.

INTRODUCTION

The cultivation of critical thinking skills has emerged as a major priority in modern science education, as learners are increasingly required to engage in complex cognitive processes such as analysis, evaluation, and logical reasoning. In the field of Biology, critical thinking plays a vital role because the subject demands conceptual comprehension, interpretation of evidence, and scientific problem-solving. For senior high school students enrolled in the STEM strand, competence in Biology is essential, as it provides a strong foundation for advanced scientific studies and future careers in science-related disciplines.

Biology achievement is commonly used as a measure of students' understanding and performance in the life sciences. However, success in Biology is not limited to memorizing factual information; it is also shaped by learners' higher-order cognitive abilities, particularly critical thinking. Critical thinking refers to a deliberate and

reflective process that involves interpretation, analysis, evaluation, inference, and explanation of information (Facione, 2015). Students who possess well-developed critical thinking skills are more capable of understanding complex biological concepts, analyzing experimental results, and applying scientific knowledge to unfamiliar situations.

Previous research has consistently demonstrated a positive relationship between critical thinking skills and academic achievement in science disciplines. Findings from correlational and meta-analytic studies indicate that teaching strategies designed to enhance critical thinking contribute to improved academic performance and deeper conceptual learning (Abrami et al., 2015; Ennis, 2011). In Biology education, critical thinking supports inquiry-based instruction and encourages active engagement with scientific practices, both of which are fundamental to effective science learning.

In the Philippine context, the K to 12 curriculum highlights the importance of developing higher-order thinking skills, especially among STEM learners, to prepare them for higher education and global competitiveness (Department of Education [DepEd], 2016). Despite this emphasis, variations in students' Biology achievement and critical thinking skills continue to be observed among senior high school learners. Moreover, there remains a scarcity of localized empirical studies examining the interaction between these variables within specific STEM learning environments, indicating the need for further investigation.

This study focuses on examining the levels of Biology achievement and critical thinking skills among senior high school STEM learners. By exploring the relationship between these two variables, the study seeks to contribute to existing literature in science education and provide evidence-based insights that may guide instructional strategies and curriculum enhancement in senior high school Biology.

Objectives

This study aimed to determine the levels of achievement in General Biology II and the critical thinking skills of senior high school learners. It also sought to examine the relationship between critical thinking skills and Biology achievement among STEM senior high school students.

Scope and Limitations

This study focused on analyzing the relationship between critical thinking skills and Biology achievement among senior high school learners. Data were gathered through adopted, modified, and researcher-developed survey questionnaires and assessment tools. Specifically, the study was limited by the following factors:

Geographical Scope – the respondents were drawn from selected public and private senior high schools, which may not represent learners from other regions or diverse socioeconomic and cultural backgrounds;

Sample Size – the number of participants was limited, which may affect the generalizability of the findings;

Data Collection Instruments – some variables relied on self-reported data, which may be influenced by response bias;

Subject Focus – academic performance was measured only in the General Biology II subject;

Time Frame – the study employed a cross-sectional design, capturing data at a single point in time rather than examining changes over an extended period.

METHODOLOGY

Research Design

The study utilized a quantitative research design to examine the relationship between senior high school learners' critical thinking skills and their achievement in Biology. Researcher-developed and modified standardized tests, along with survey questionnaires, were used to assess students' critical thinking abilities and academic

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performance. These instruments were constructed to align with the curriculum standards and learning competencies of General Biology II.

Research Participants

The participants of the study were senior high school learners from selected public and private schools during the second semester of School Year 2024–2025 under the Department of Education–Division of Misamis Oriental. A purposive sampling technique was employed in selecting the respondents. Only Grade 12 learners enrolled in the Science, Technology, Engineering, and Mathematics (STEM) strand and currently taking General Biology II were included in the study.

Data Analysis

The collected data were analyzed using quantitative statistical methods. Descriptive statistics, such as mean and standard deviation, were utilized to describe learners' levels of critical thinking skills and Biology achievement. Inferential statistics were applied to determine the relationship between the variables. To ensure content validity, the research instruments were reviewed by experts in education. Factor analysis and reliability testing using Cronbach's alpha were conducted to establish construct validity and internal consistency. Statistical analysis was performed using appropriate software such as SPSS.

Ethical Considerations

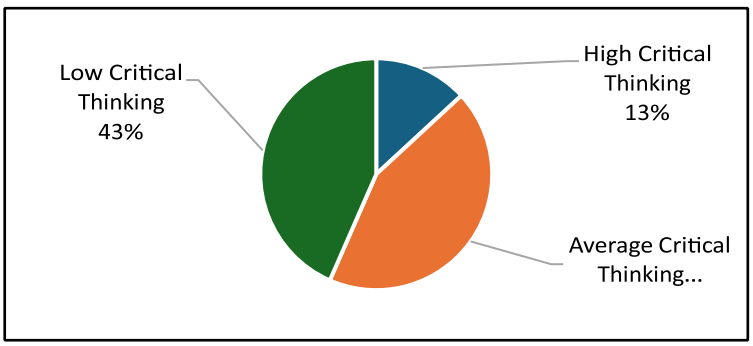
Ethical standards were strictly observed throughout the conduct of the study. The confidentiality of the participants was upheld by ensuring that all personal information was kept private and securely stored. Participation in the study was voluntary, and respondents were informed of their right to withdraw at any stage without any penalty or consequences. Furthermore, the study ensured that no form of harm—physical, emotional, or psychological—was inflicted upon the participants, adhering to the principle of non-maleficence.

RESULTS

Senior High School Learners' Critical Thinking Skills Level

Figure 1 indicates distribution of learners' critical thinking performance. Only 13% of learners demonstrated high levels of critical thinking skills, while 43% were classified as average, and another 43% showed low levels of critical thinking. This suggests that while a small portion of students are capable of higher-order reasoning and analytical thinking, a substantial majority remain at basic or developing levels. Critical thinking is a core competency for 21st-century learning, and limited proficiency among a large segment of learners presents instructional and developmental concerns (Facione, 2015).

Figure 1. Critical Thinking Skills Level of Senior High School Learners



The dominance of average and low performance (a combined 86%) reflects a pattern commonly reported in Philippine educational research, where students often excel at knowledge recall but struggle with higher-level reasoning, evaluation, and problem-solving (Bernardo, 2019; Boholano, 2021). Studies have suggested that such outcomes may stem from learning environments that remain heavily reliant on traditional, teacher-centered approaches emphasizing content delivery rather than inquiry, metacognition, and student-led exploration (Dizon

& Aure, 2018; Penetrante, 2017). As a result, many learners are not consistently exposed to instructional activities that would allow for deeper critical reasoning development.

The small proportion of learners achieving high critical thinking (13%) may indicate that only a subset of students has internalized the habits of reflection, analysis, and justification that define strong critical thinking performance. Philippine research has shown that higher-level cognition improves when learners engage in inquiry-based learning, performance tasks, and problem-based instruction that require them to question, analyze, and defend ideas (Antolin & Buenviaje, 2022; Malaluan & Penano-Ho, 2020). Thus, limited opportunities for such experiences may contribute to the observed performance patterns.

On the other hand, the considerable 43% performing at low levels signals the need for targeted pedagogical intervention. Factors such as limited home academic support, insufficient access to learning resources, and weak foundational knowledge may hinder students' ability to engage in critical reasoning (Bolok, 2019; Caballes & Almario, 2021). Additionally, educational outcomes may be shaped by school-level support and teacher competence, as studies note that teachers who model higher-order questioning and scaffold thinking strategies significantly improve students' reasoning capabilities (Schunk & DiBenedetto, 2020).

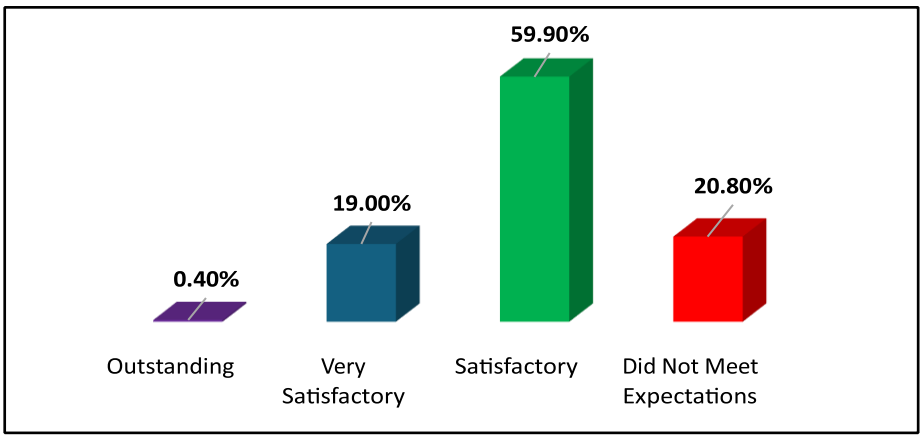
Conclusively, the distribution of results suggests that while some learners have begun to develop strong critical thinking competencies, most remain in need of more structured exposure to learning activities that strengthen cognitive engagement, metacognitive skills, and analytical reasoning. These findings underscore the need for schools to enhance teaching strategies, resource support, and learning environments to better cultivate critical thinking in line with contemporary educational demands.

Senior High School Learners' Level of Biology Achievement

The findings as shown in Figure 2 reveal that the overall academic performance of learners in Biology is concentrated within the mid-performance range. A majority of students obtained ratings classified as Satisfactory (59.90%), followed by Very Satisfactory (19.00%), while only 0.40% attained Outstanding performance. Conversely, 20.80% of learners did not meet expectations, indicating that a substantial portion of students require additional instructional and academic support. This performance pattern suggests that while most learners demonstrate basic competency in Biology, relatively few reaches advanced levels of mastery.

Academic achievement in science subjects, including Biology, is understood to be influenced by a complex interaction of instructional practices, learner characteristics, and environmental support systems (Glynn & Muth, 2017). In the Philippine context, research similarly highlights that student performance in science is often shaped by the availability of school resources, quality of instruction, and the learning environment at home and in school (Bernardo, 2019; Cabansag, 2020). These factors may contribute to the currently modest level of high achievement and the notable proportion of low-performing learners.

Figure 2. Senior High School Learners' Biology Achievement



The low percentage of Outstanding performance (0.40%) may reflect limited opportunities for advanced engagement, higher-order thinking, and inquiry-based learning experiences which are critical for deeper

scientific understanding. Studies in the Philippines have shown that inquiry-driven and laboratory-based instruction positively influence student engagement, conceptual mastery, and performance in science (Antolin & Buenviaje, 2022; Penetrante, 2017). The limited number of top-performing learners may therefore signal the need to further enrich instructional approaches that promote critical thinking, application of scientific concepts, and authentic learning tasks.

On the other hand, the 20.80% of learners who did not meet expectations point to challenges that may include difficulties in foundational knowledge, access to learning materials, or gaps in instructional support. Local studies report that underachievement in science is frequently associated with inadequate home learning environments, limited exposure to functional laboratories, and low self-efficacy in scientific learning (Bolok, 2019; Caballes & Almario, 2021). Such findings underscore the need for targeted interventions, including remediation programs, structured academic support, and differentiated instructional strategies.

Finally, the results suggest that while most learners meet minimum academic expectations in Biology, there is significant room for improvement in both raising the proportion of high-achieving students and reducing the number of those who fall below standards. As Schunk and DiBenedetto (2020) emphasize, achievement in science is strongly linked to coordinated support from the home, school, and social environment. Therefore, improving instructional quality, expanding access to learning resources, and strengthening learner support systems may contribute to enhanced performance in Biology and better preparation for higher-level scientific learning.

Relationship between Learners' Critical Thinking Skills and Biology Achievement

A Pearson product-moment correlation was performed to determine the relationship between learners' critical thinking skills and their General Biology 2 achievement as shown in Table 1. The analysis revealed a correlation coefficient of $r = 0.058$, with a significance level of $p = 0.342$, indicating a very weak positive correlation that is not statistically significant. This suggests that, within the present sample, critical thinking skills did not demonstrate a meaningful linear association with senior high school learners' achievement in General Biology 2 subject. In other words, learners with higher critical thinking scores were not necessarily more likely to obtain higher academic performance in the subject.

Table 1. Correlation of the Learners' Critical Thinking Skills and Biology Achievement.

Variables	*r* value	*p* value	Interpretation*
Critical Thinking Skills and Biology Achievement	**0.058**	**0.342**	**Weak Positive Correlation**

*Significant at $p<0.05$

The absence of a significant relationship may be attributed to several contextual factors observed in Philippine educational settings. Research in the country suggests that the development of critical thinking skills is often influenced by instructional methods that remain heavily teacher-centered and content-driven rather than inquirybased (Bernardo, 2017; Salazar & Maravilla, 2020). When teaching practices emphasize rote memorization and coverage of content, critical thinking may not directly translate into improved academic scores, especially in standardized or summative tests that focus on factual recall rather than analytical reasoning.

Studies among Filipino learners have also demonstrated that academic performance in science subjects is affected by external variables such as access to learning resources, school facilities, and socio-economic environment (Bautista, Bernardo, & Ocampo, 2023; De Guzman & Tan, 2021). Thus, the weak relationship observed in this study may indicate that learners' performance in General Biology 2 is more influenced by these external academic and environmental conditions rather than cognitive factors alone. This is consistent with the findings of Castillo (2019), who reported that students' grades in science subjects were significantly shaped by availability of school resources and study habits rather than higher-order thinking skills.

Nonetheless, while critical thinking remains a central goal of senior high school education under the K–12 curriculum, the current findings show that its presence does not necessarily predict improved academic outcomes

in General Biology 2. This highlights the need to strengthen alignment between curriculum goals, instructional practices, and assessment strategies to ensure that the development of critical thinking is authentically linked to academic performance.

SUMMARY

This study explored the association between senior high school learners' critical thinking skills and their Biology achievement. The findings reveal that higher-level critical thinking skills were evident in only a small segment of the learner population, and similarly, outstanding performance in Biology was attained by very few students.

Notably, the analysis showed no statistically significant relationship between critical thinking skills and Biology achievement, suggesting that academic performance in Biology may be influenced by factors beyond cognitive reasoning skills alone. These results highlight the need to examine instructional practices, assessment approaches, and contextual variables that may mediate the development and academic expression of critical thinking in senior high school science education.

CONCLUSION

Assessment Implications – The observed very weak correlation between critical thinking skills and Biology achievement suggests that current assessment practices may not effectively capture or incentivize higher-order thinking. This finding points to a misalignment between the intended educational objectives, which emphasize the development of critical thinking, and the classroom assessments, which appear to focus primarily on factual recall and lower-level cognitive tasks.

Such a gap underscores the need for assessment strategies that better reflect and promote analytical reasoning, problem-solving, and conceptual understanding in Biology education.

RECOMMENDATION

Based on the findings of this study and the observed gaps, the following are highly recommended to improve critical thinking skills and Biology achievement among senior high school learners:

1. Prioritize Collaborative Learning - teachers must intentionally integrate structured collaborative activities (e.g., Problem-Based Learning, debates, peer review, small-group inquiry) into all lessons, particularly in Biology, to maximize the positive impact of Peer Interaction on CT.
2. Revise Assessment Tools - Teachers must urgently reform assessment instruments to align with the goal of fostering critical thinking. Assessments must move beyond simple recall to require analysis, evaluation, and synthesis (e.g., using open-ended problem sets, case studies, and argument-based essay questions).
3. Conduct qualitative studies to explore the mechanisms behind the relationship of critical thinking skills and biology achievement.
4. Explore other cognitive and non-cognitive factors influencing biology achievement in future research.
5. Use mixed-methods approaches to gain deeper insight into learners' challenges and instructional gaps.

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