Learning Gaps in Chemistry: A Strand-Based Analysis of Senior High School Students

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ABSTRACT

This study examined the level of mastery in chemistry competencies among 81 Grade 12 students from the Accountancy, Business, and Management (ABM), Humanities and Social Sciences (HUMSS), and Information and Communication Technology (ICT) strands in a public senior high school in Dumingag, Zamboanga del Sur, Philippines. The study aimed to identify strand-specific learning gaps that could inform the development of targeted instructional interventions. A descriptive research design was employed, utilizing a validated 30-item achievement test aligned with Bloom's Taxonomy to assess students' conceptual understanding across selected chemistry competencies. The results revealed a statistically significant difference in performance across academic strands. ABM students demonstrated the highest level of proficiency, attaining a Mean Percentage Score (MPS) of 78.73%, which corresponds to the "Moving Towards Mastery" classification. In contrast, ICT and HUMSS students obtained lower MPS values of 59.80% and 55.15%, respectively, both categorized under the "Average" mastery level. Across content domains, students performed more strongly in contextualized and macroscopic topics, such as star formation (79.01%) and the identification of active ingredients in household cleaning products (76.54%). However, substantial difficulties were observed in abstract and theory-intensive concepts. Notably, the synthesis of new elements based on atomic number yielded a low mastery level of 28.40%. These findings highlight persistent conceptual gaps in chemistry learning, particularly among non-STEM academic strands, and underscore the limitations of uniform instructional approaches. The study emphasizes the need for strand-responsive and differentiated instructional strategies, supported by contextualized learning materials and visual representations, to enhance students' understanding of abstract chemical principles and reduce performance disparities within the senior high school chemistry curriculum.

Keywords: Academic Strands, Chemistry Competencies, Mastery Level, Physical Science

INTRODUCTION

Chemistry serves as a foundational discipline within the Philippines' Senior High School (SHS) curriculum under the K–12 framework, integrating core concepts from chemistry and physics to foster scientific literacy, critical thinking, and problem-solving skills among Grade 12 learners (Department of Education [DepEd], 2016). Within this curriculum, key chemistry topics including atomic theory, chemical bonding, stoichiometry, chemical equilibrium, reaction kinetics, and molecular polarity equip students with the competencies necessary to interpret natural phenomena, engage with technological innovations, and address pressing societal challenges related to health, environmental sustainability, and industry (CPD Singapore, 2024). These competencies are aligned with national educational objectives, aiming to produce globally competitive citizens capable of informed decision-making in science-related domains (DepEd, 2016).

Despite the curricular emphasis on Physical Science, proficiency in chemistry exhibits substantial variation across SHS academic strands, influenced by differences in prior academic preparation, instructional exposure, and strand-specific focus (Dita & Velasco, 2025). Empirical evidence indicates that students in STEM strands consistently achieve higher median grades in chemistry relative to peers in non-STEM tracks such as ABM, HUMSS, and ICT, suggesting disparities in scientific rigor and preparedness (Dita & Velasco, 2025; Farillon, 2022). These performance gaps are further reflected in international assessments, with Filipino students averaging 357 on PISA science tests, a score markedly below the OECD mean, highlighting persistent challenges in chemistry-related scientific literacy (De La Fuente, 2022).

Although prior studies have documented general science performance differences across SHS strands, few have provided strand-specific diagnostic assessments of Physical Science chemistry topics. This paucity of evidence constrains understanding of learners' conceptual strengths and weaknesses in areas such as reaction mechanisms, acid-base equilibria, and molecular polarity, thereby limiting the development of targeted instructional interventions (DepEd, 2016; Farillon, 2022). Moreover, the relationship between strand specialization and mastery of chemistry competencies remains underexplored, restricting the capacity for evidence-based reforms aimed at promoting equitable science education. Addressing these gaps, the present study evaluates Grade 12 students' mastery of Physical Science chemistry competencies across ABM, HUMSS, and ICT strands using rigorous diagnostic measures. The study's findings are intended to provide empirical evidence for educators, administrators, and policymakers to refine instructional strategies, design strand-responsive interventions, and enhance professional development. Ultimately, this research contributes to advancing scientific literacy and fostering inclusive excellence in SHS chemistry education, consistent with national curriculum objectives and broader international educational benchmarks (DepEd, 2016; Farillon, 2022).

METHODOLOGY

Research Design and Setting. This study employed a descriptive research design to assess Grade 12 students' mastery of selected Physical Science chemistry competencies, including stellar nucleosynthesis, molecular polarity, intermolecular forces, and the chemical properties of household products. A validated standardized achievement test was used to identify specific areas of learning difficulty. The study was conducted in a public senior high school in Dumingag, Zamboanga del Sur, Philippines, offering the Accountancy, Business, and Management (ABM), Humanities and Social Sciences (HUMSS), and Information and Communication Technology (ICT) strands. This context allowed for meaningful comparison of strand-based differences in chemistry proficiency and the generation of empirical evidence to inform targeted, strand-responsive instructional intervention.

Participants. Participants were selected through purposive sampling, consisting of 81 Grade 12 students from the ABM, HUMSS, and ICT strands. Grade 12 students were chosen because they had already completed the Physical Science chemistry competencies, unlike the Grade 11 students during the 2025–2026 school year. Prior to the main data collection, the achievement test underwent pilot testing with 150 students from a public high school in Josefina, Zamboanga del Sur. Only items that met acceptable difficulty and discrimination indices were retained. Other academic strands were excluded due to time constraints. Data were gathered using pen-and-paper assessments, and informed consent was obtained from all participants in accordance with ethical research standard.

Instrument. The research instrument was initially developed as a 50-item multiple-choice achievement test aligned with the Senior High School Physical Science curriculum and structured according to Bloom's Taxonomy of the Cognitive Domain, allowing assessment across varying levels of cognitive demand. Content validity was established through evaluation by three subject-matter experts, whose feedback guided revisions to improve item clarity and curricular alignment. Following pilot testing, a detailed item analysis was conducted to examine reliability, difficulty, and discrimination indices. Based on these results, items were systematically revised or eliminated, resulting in a final 30-item validated instrument. The test covered key chemistry concepts such as atomic structure, chemical bonding, chemical equilibrium, kinetics, and molecular polarity. This refined instrument provided the empirical basis for identifying learning gaps and informing the development of evidence-based, strand-responsive instructional interventions.

Table 1. Parameters of Item Validation

Content Validity	Accurately represents key concepts (e.g., rows = periods, columns = groups).
Clarity of Wordings	Question and options are clearly, concisely, and grammatically stated.

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Appropriateness of Difficulty	Well-matched to students' level; neither too easy nor too hard.
Quality of Distractors	(Options). All distractors are plausible and conceptually sound.
Format and Consistency	Consistent format and parallel structure (A–D, uniform style).
Alignment with Learning Objectives	Directly aligned with the intended learning outcome.

Data Analysis. The study employed a combination of descriptive and diagnostic statistical methods to evaluate both student performance and the quality of the research instrument. Descriptive statistics, including mean (M) and percentage (%), were used to determine the overall level of understanding and to examine the distribution of student responses across the targeted chemistry competencies.

To ensure the reliability and validity of the achievement test, a comprehensive item analysis was conducted. This process involved calculating the Index of Difficulty (p) to assess the cognitive complexity of each item and the Index of Discrimination (D) to differentiate between high- and low-performing students. These indices guided systematic decisions regarding item retention, revision, or elimination. Item selection and interpretation were further supported by a cross-tabulation matrix, adapted from Dela Peña et al. (2011), providing an objective framework for evaluating the statistical performance of each item.

Student achievement was categorized into seven mastery levels, following DepEd Memorandum No. 160, s. 2012, ranging from "Mastered" (96%–100%) to "Absolutely No Mastery" (0%–4%). This framework allowed for a qualitative interpretation of quantitative scores and facilitated comparisons across the ABM, HUMSS, and ICT strands. For inferential analysis, normality of the data was assessed using the Shapiro-Wilk Test, which indicated that scores for the ABM and ICT strands significantly deviated from a normal distribution. Consequently, the Kruskal-Wallis Test, a non-parametric alternative, was employed to determine whether observed differences in mastery levels among the academic tracks were statistically significant, thereby addressing the central research hypothesis regarding strand-specific performance disparities.

Table 2**.** Achievement Level Interpretation

ACHIEVEMENT LEVEL	
MPS	**Descriptive Equivalent**
96-100	**Mastered**
86-95	**Closely Approximating Mastery**
66-85	**Moving Towards Mastery**
35-65	**Average Mastery**
15-34	**Low Mastery**
5-14	**Very Low Mastery**
0-4	**Absolutely No Mastery**

(Adapted from DepEd Memorandum No. 160, s. 2012)

Table 3**.** Interpretation on Students' Performance in the Achievement Test

Percentage	**Remarks**
90-100	Passed

85-89	Passed
80-84	Passed
75-79	Passed
Below 75	Failed

Reference: DepEd Order No. 8 s, 2015

RESULTS AND DISCUSSIONS

Mastery Level of Grade 12 Learners on Physical Science Chemistry Competencies

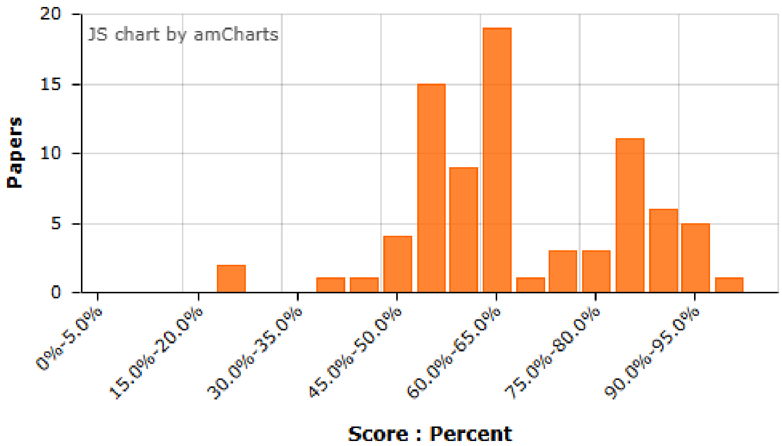

Figure 1. Total Point Distribution

The assessment of student performance in Physical Science chemistry competencies revealed a non-uniform, bimodal distribution, indicating the presence of two distinct tiers of achievement within the cohort. The primary concentration of scores was observed within the 60.0%–65.0% range, representing the modal class. This finding suggests that while most students successfully attained foundational conceptual knowledge, they encountered significant challenges in progressing toward advanced mastery. A secondary cluster of high-achieving students was identified in the 80.0%–95.0% range, creating a notable performance gap between the 65.0% and 80.0% intervals. This “intermediate void” underscores a clear divide between students demonstrating basic proficiency and those achieving higher-level competencies. Encouragingly, low scores (below 40.0%) were minimal, indicating that the instructional approach effectively supported baseline competency across the majority of participants.

Table 4. Mastery Level of Grade 12 Learners on Physical Science Chemistry Competencies

Learning Competencies	MPS	Mastery Level
Give evidence for and describe the formation of heavier elements during star formation and evolution	79.012	Moving Towards Mastery
Explain how the concept of atomic number led to the synthesis of new elements in the laboratory	28.40	Low
Determine if a molecule is polar or non- polar given its structure	61.32	Average

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Relate the polarity of a molecule to its properties	65.84	Average
Describe the general types of intermolecular forces	48.15	Average
Explain the effect of intermolecular forces on the properties of substances	51.03	Average
Explain how the structures of biological macromolecules determine their properties and functions	70.37	Moving Towards Mastery
Use simple collision theory to explain the effects of concentration, temperature, and particle size on the rate of reaction	74.69	Moving Towards Mastery
Define catalyst and describe how it affects reaction rate	67.90	Moving Towards Mastery
Describe how energy is harnessed from different sources: A. Fossil fuels B. Biogas C. Geothermal D. Hydrothermal E. Batteries F. Solar cells G. Biomass	59.26	Average
Determine the limiting reactant in a reaction and calculate the amount of product formed	63.58	Average
From product labels, identify the active ingredient(s) of cleaning products used at home	76.54	Moving Towards Mastery
Give the use of the other ingredients in cleaning agents	70.37	Moving Towards Mastery
Total	63.75	Average

Legend: (96% – 100% Mastered) (86% – 95% Closely Approximating Mastery) (66% – 85% Moving Towards Mastery) (35% – 65% Average Mastery) (15% – 34% Low Mastery) (5% – 14% Very Low Mastery) (0% – 4% Absolutely No Mastery)

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The assessment of student performance in Physical Science chemistry revealed a non-uniform, bimodal distribution, indicating a clear divide between higher- and lower-achieving competency groups. A primary cohort of competencies fell within the Moving Towards Mastery range (66%–85%), particularly those grounded in coherent conceptual frameworks and real-world applications. High proficiency was observed in the structures of biological macromolecules (82.72%) and stellar evolution (79.01%), suggesting that students perform better when abstract scientific ideas are embedded within explanatory narratives. Similarly, strong performance in household chemistry (70.37%–76.54%) and reaction kinetics (67.90%–74.69%) indicates that context-based learning and observable phenomena effectively reduce abstraction, thereby supporting engagement and conceptual understanding.

In contrast, a substantial number of competencies clustered within the Average Mastery range (35%–65%), reflecting a conceptual ceiling in which students demonstrate surface-level understanding but struggle with deeper reasoning. These difficulties were most evident in competencies requiring submicroscopic interpretation and mathematical reasoning. For instance, mastery levels remained moderate for molecular polarity (61.32%) and intermolecular forces (51.03%), aligning with established findings that students experience difficulty transitioning between macroscopic observations and submicroscopic explanations in chemistry. Similarly, calculation-based competencies such as determining limiting reactants (63.58%) remained within the average tier, suggesting that mathematical abstraction becomes a barrier when foundational conceptual links are insufficiently developed.

The most pronounced instructional gap emerged in the Low Mastery category (15%–34%), particularly in the competency addressing the role of atomic number synthesis of new elements in the laboratory, which yielded a mean score of only 28.40%. A closer examination of the conceptual framing of these competencies in Table 4 reveals a clear relationship between cognitive demand and student performance, moving the analysis beyond descriptive score reporting. The synthesis of new elements mapped to the Understanding level of Bloom's Taxonomy requires learners to explain how the sequential nature of atomic numbers predicts gaps in the periodic table. The very low mastery suggests a profound disconnect between the symbolic representation of atomic number and the submicroscopic logic of nuclear synthesis, indicating that students tend to view atomic number as a static label rather than a functional explanatory construct.

A similar pattern was evident in the competency on intermolecular forces, mapped to the Analyzing level of Bloom's Taxonomy, which yielded mastery levels between 48.15% and 51.03%. Students struggled to relate molecular-level features such as polarity to macroscopic properties like boiling point, underscoring persistent challenges in multi-level chemical reasoning. In contrast, competencies aligned with lower cognitive demands, such as Remembering for example, identifying active ingredients in household products (76.54%) demonstrated comparatively higher mastery. This gradient in performance across Bloom's cognitive levels confirms that student achievement declines as tasks require higher-order analytical reasoning, reinforcing the presence of a conceptual ceiling within the chemistry curriculum.

Collectively, these findings suggest that the abstract and logic-intensive nature of selected chemistry competencies may not be sufficiently supported by existing instructional approaches, particularly for students in non-STEM strands, whose curricular exposure to formal scientific reasoning frameworks is more limited. Addressing this gap requires a pedagogical shift from predominantly expository instruction toward inquiry-based, learner-centered strategies. The integration of visualization tools, scaffolded reasoning tasks, and contextualized representations may help students bridge macroscopic observations and submicroscopic explanations, enabling progression from basic recall toward genuine conceptual mastery of complex chemical principles.

Mastery Level of Physical Science Chemistry Competencies Among Grade 12 Students

Table 5. Mastery Level of Physical Science Chemistry Competencies Among Grade 12 Students in Different Strands

Learning Competency	MPS	Mastery Level

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	ABM	HUMSS	ICT	ABM	HUMSS	ICT
Give evidence for and describe the formation of heavier elements during star formation and evolution	81.82	74.29	83.33	Moving Towards Mastery	Moving Towards Mastery	Moving Towards Mastery
Explain how the concept of atomic number led to the synthesis of new elements in the laboratory	45.45	20	29.17	Average	Low	Low
Determine if a molecule is polar or non- polar given its structure	74.24	52.38	62.5	Moving Towards Mastery	Average	Average
Relate the polarity of a molecule to its properties	81.81	61.90	56.94	Moving Towards Mastery	Average	Average
Describe the general types of intermolecular forces	59.09	40	50	Average	Average	Average
Explain the effect of intermolecular forces on the properties of substances	72.72	44.76	41.67	Moving Towards Mastery	Average	Average
Explain how the structures of biological macromolecules determine their properties and functions	77.27	67.14	68.75	Moving Towards Mastery	Moving Towards Mastery	Moving Towards Mastery
Use simple collision theory to explain the effects of concentration, temperature, and particle size on the rate of reaction	81.82	73.57	69.79	Moving Towards Mastery	Moving Towards Mastery	Moving Towards Mastery
Define catalyst and describe how it affects reaction rate	95.45	60	54.17	Closely Approximating Mastery	Average	Average
Describe how energy is	83.33	47.62	54.17	Moving	Average	Average

harnessed from different sources: A. Fossil fuels B. Biogas C. Geothermal D. Hydrothermal E. Batteries F. Solar cells G. Biomass				Towards Mastery		
Determine the limiting reactant in a reaction and calculate the amount of product formed	90.91	51.43	56.25	Closely Approximating Mastery	Average	Average
From product labels, identify the active ingredient(s) of cleaning products used at home	97.73	62.83	77.08	Mastered	Average	Moving Towards Mastery
Give the use of the other ingredients in cleaning agents	81.82	60.95	73.61	Moving Towards Mastery	Average	Moving Towards Mastery
Overall	78.73	55.15	59.80	Moving Towards Mastery	Average	Average

Legend: (96% – 100% Mastered) (86% – 95% Closely Approximating Mastery) (66% – 85% Moving Towards Mastery) (35% – 65% Average Mastery) (15% – 34% Low Mastery) (5% – 14% Very Low Mastery) (0% – 4% Absolutely No Mastery)

Table 5 reveals pronounced strand-based disparities in science competency mastery, with ABM students consistently achieving higher performance than their HUMSS and ICT counterparts. ABM learners obtained the highest overall Mean Percentage Score (MPS) of 78.73%, classified as Moving Towards Mastery, whereas ICT (59.80%) and HUMSS (55.15%) students remained within the Average mastery level. While the data shows significant performance gaps between strands, these differences may reflect variations in prior curricular exposure, specific student interests, or the alignment of the assessment with the analytical strengths of the ABM strand, rather than being a definitive measure of instructional effectiveness alone. The nearly 20-percentage-point gap highlights substantial differences in conceptual understanding across academic strands, consistent with findings from prior Philippine studies (Ramirez, 2025; Tabamo, 2024).

Across all strands, students demonstrated stronger performance in competencies anchored in concrete, macroscopic, and contextually meaningful concepts. Topics such as star formation, stellar evolution, and biological macromolecular structures emerged as areas of relative strength, with all strands reaching the Moving Towards Mastery benchmark. Notably, ABM students excelled in applying scientific concepts to everyday contexts, achieving a Mastered level (97.73%) in identifying active ingredients in household cleaning products. This pattern supports earlier research indicating that contextualized and real-world applications enhance science learning more effectively than abstract instruction (Tabamo, 2024; Torres & Calim, 2024).

In contrast, abstract and theory-intensive competencies posed significant challenges for all groups. Low mastery levels were observed in concepts such as atomic number, element synthesis, and intermolecular forces, which

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require integration of macroscopic, submicroscopic, and symbolic representations. ABM students attained only Average mastery (45.45%), while HUMSS (20.00%) and ICT (29.17%) students remained within the Low mastery range. These findings mirror documented difficulties in chemistry learning related to representational transitions and abstract reasoning (Ojastro et al., 2025; Rahmawati, 2024; Orbe et al., 2018).

Collectively, the results emphasize the need for strand-responsive instructional interventions, particularly for HUMSS and ICT learners who require additional support in abstract chemistry concepts. Although ABM students generally demonstrated higher mastery, these disparities should not be attributed solely to instructional effectiveness. Differences in **c**urricular exposure, prior academic preparation, student interest, and assessment alignment especially the mathematical and analytical demands of the instrument may have contributed to the observed gaps. Consistent with recommendations from local studies, differentiated instruction that integrates visual models, contextualized examples, and hands-on demonstrations is essential to strengthening conceptual understanding and reducing strand-based disparities in chemistry mastery (Ramirez, 2025; Tabamo, 2023; Mangubat & Picardal, 2023).

Mastery Level of Physical Science Chemistry Competencies Among Grade 12 Students Across Strands.

Table 6. Normality Test Using Shapiro-Wilk

	ABM		HUMSS		ICT
N	22	N	35	N	24
Shapiro-Wilk W	0.893	Shapiro-Wilk W	0.943	Shapiro-Wilk W	0.898
Shapiro-Wilk p	0.022	Shapiro-Wilk p	0.070	Shapiro-Wilk p	0.020

To determine the appropriate method for comparative analysis, quiz scores from the ABM, HUMSS, and ICT strands were first subjected to the Shapiro-Wilk test of normality (Table 6). The results indicated significant deviations from normality for the ABM ($p = 0.022$) and ICT ($p = 0.020$) strands, whereas the HUMSS strand met the assumption of normality ($p = 0.070$). Given that two of the three groups violated the normality assumption, the application of a parametric One-Way ANOVA was deemed inappropriate. Consequently, the Kruskal-Wallis H-test, a non-parametric alternative, was employed to compare performance across strands. This test evaluates differences in the mean ranks of groups rather than raw scores, thereby providing a robust and statistically valid comparison for non-normally distributed data. The analysis revealed a statistically significant difference in total quiz scores among the three strands ($\chi^2(2) = 26.7$, $p < .001$), confirming that strand membership is associated with differential mastery levels in Physical Science chemistry competencies. The use of the Kruskal-Wallis H-test thus ensured a rigorous assessment of inter-strand performance disparities while accommodating the non-normal distribution of the dataset.

Kruskal-Wallis

	X^2	df	p
TOTAL SCORE	26.7	2	<.001

Figure 2**.** Mastery Level of Physical Science Chemistry Competencies Among Grade 12 Students Across Strands

The Kruskal–Wallis test revealed a highly significant difference in mastery levels of Physical Science chemistry competencies among Grade 12 students across the HUMSS, ABM, and ICT strands ($H = 26.686$, $p < .001$). The p-value, substantially below the conventional 0.05 threshold, indicates that the observed disparities are unlikely to be due to chance and are systematically associated with students' academic strand, confirming a pronounced "strand effect" in chemistry achievement. ABM students consistently outperformed their peers, reflecting strand-specific differences in curricular emphasis, including analytical reasoning, mathematical rigor, and exposure to abstract scientific concepts. In contrast, HUMSS and ICT learners exhibited lower performance in topics demanding submicroscopic reasoning or quantitative manipulation. Learner-related factors, such as motivation, self-efficacy, and perceived relevance of the subject matter, may further exacerbate these differences, as students tend to engage more deeply with content aligned with their academic interests and future career goals (Magpantay & Malabrigo, 2025; Mangubat, 2023; Ojastro et al., 2025; Tabamo, 2024).

These findings challenge the effectiveness of a "one-size-fits-all" instructional approach to Physical Science across diverse strands and underscore the need for differentiated, strand-responsive teaching. Contextualizing chemistry concepts to align with students' academic orientations—for instance, linking chemical reactions to technological applications for ICT learners or to production and consumer products for ABM learners—can enhance engagement, reduce abstraction, and improve conceptual mastery. Empirical evidence supports that such learner-centered strategies promote equitable understanding of chemistry competencies and help bridge performance gaps across academic tracks, reinforcing calls for pedagogical designs that are both contextualized and responsive to the unique needs of each strand (Dacles, 2024; Tabamo, 2023; Torres & Calim, 2024).

CONCLUSION AND RECOMMENDATION

The findings of this study indicate that Senior High School students generally demonstrate an average level of mastery in Physical Science chemistry competencies, with marked variation across both content domains and academic strands. Analysis of overall score distributions revealed a non-uniform, bimodal pattern, indicating the presence of two distinct achievement tiers within the cohort. While most students attained baseline conceptual knowledge, a noticeable performance gap persisted between learners demonstrating surface-level proficiency and those achieving higher-order mastery, suggesting a conceptual ceiling that limits progression toward advanced chemical reasoning.

Students exhibited relatively stronger performance in conceptually structured, macroscopic, and contextually grounded topics, including stellar evolution, biological macromolecules, and household chemistry. These competencies benefitted from real-world relevance and observable phenomena, which appear to mitigate abstraction and support conceptual understanding. In contrast, abstract, theory-intensive, and submicroscopic competencies notably atomic number in element synthesis and intermolecular forces remained persistent areas of difficulty. Mapping these competencies to Bloom's Taxonomy revealed a clear decline in performance as cognitive demand increased, with higher mastery in Remembering tasks and significantly lower achievement in Understanding and Analyzing tasks. This pattern confirms that many learners struggle to integrate symbolic, submicroscopic, and macroscopic representations, resulting in fragmented rather than meaningful understanding.

A pronounced strand-based disparity was likewise observed. ABM students consistently outperformed their HUMSS and ICT counterparts, achieving an overall mastery level classified as Moving Towards Mastery, while HUMSS and ICT students remained within the Average mastery range. Non-parametric analysis using the Kruskal–Wallis H-test confirmed that these differences were statistically significant, indicating that strand membership is strongly associated with differential chemistry achievement. However, these disparities should not be interpreted solely as evidence of instructional effectiveness. Rather, they likely reflect differences in curricular exposure, prior academic preparation, cognitive orientation, student interest, and the alignment of the assessment with analytical and mathematical reasoning emphasized in the ABM strand.

Collectively, these findings underscore the limitations of uniform, one-size-fits-all instructional approaches in Senior High School Physical Science. They highlight the urgent need for strand-responsive and cognitively scaffolded instruction, particularly for HUMSS and ICT learners who require additional support in abstract and logic-intensive chemistry concepts. Instructional strategies that integrate visualizations, simulations, physical and digital models, contextualized problem-solving, and guided inquiry are strongly recommended to help learners bridge macroscopic observations and submicroscopic explanations, thereby fostering deeper conceptual integration.

Despite limitations related to strand coverage and uneven sample sizes, this study provides empirical evidence that can inform instructional design, curriculum development, and policy decisions. Curriculum planners and school administrators are encouraged to support professional development initiatives that emphasize differentiated instruction and cognitive scaffolding aligned with Bloom's Taxonomy. Future research should expand participation to include all academic strands, utilize larger and more balanced samples across multiple school contexts, and explore longitudinal designs to better capture the development of chemistry mastery over time. Such efforts will contribute to a more equitable and conceptually robust implementation of Physical Science education in Senior High School.

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