# Profiling Least Mastered Competencies among Grade 11 Non-Stem Learners: A Basis for Targeted Instructional Intervention

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## ABSTRACT

This study aimed to identify the least mastered Chemistry competencies from Grades 7 to 10 among Grade 11 non-STEM learners in selected public high schools in Iligan City, with the goal of informing targeted instructional interventions. Recognizing Chemistry's foundational role in scientific literacy and the persistent underperformance of Filipino learners in national and global science assessments, the study aligns with Sustainable Development Goal 4 (SDG 4), which promotes inclusive and equitable quality education. A quantitative-descriptive design was employed involving 100 non-STEM learners aged 16–18. A researcher-made 50-item needs assessment, aligned with the Department of Education's Most Essential Learning Competencies (MELCs), was validated and pilot-tested. Reliability testing yielded a Cronbach's Alpha of 0.778, with a difficulty index of 0.46 and a discrimination index of 0.246, indicating acceptable psychometric properties. To further enrich the data and contextualize learner performance, qualitative feedback from 52 learners was thematically analyzed. Findings showed that 89% of learners did not meet the 60% mastery benchmark. Organic Chemistry, Chemical Reactions, and Chemical Bonding were the most difficult domains. Thematic analysis revealed instructional challenges such as lack of content reinforcement, difficulty with abstract concepts, minimal access to hands-on learning tools, and a strong preference for engaging and visual strategies. These results confirm the value of competency-based profiling as a needs assessment tool. The study recommends the integration of game-based learning approaches to enhance engagement and conceptual understanding in Chemistry, especially among non-STEM learners.

**Keywords:** Chemistry Education, Competency Profiling, Needs Assessment, Non-STEM Learners

## INTRODUCTION

Chemistry is a foundational discipline within science education, fostering learners' understanding of matter, energy transformations, and the interactions that govern the natural world. In the Philippine junior high school curriculum (Grades 7 to 10), Chemistry topics are introduced through a spiral progression, providing opportunities to gradually deepen conceptual understanding (Manlangit et al., 2018). The major topics include classification of matter, atomic structure, chemical bonding, gas laws, chemical reactions, and organic compounds. The proficiency in these skills is important to develop scientific literacy and prepare learners to move on to more advanced learning in senior high school and higher education (Mangubat et al., 2023).

Despite this systematic progression, many learners enter senior high school with limited conceptual mastery in Chemistry. These challenges are more pronounced among non-STEM learners, whose curriculum offers

fewer opportunities for hands-on scientific exploration and critical analysis (Ullah et al., 2023). Such limitations directly impact their ability to retain and apply fundamental Chemistry knowledge, especially in abstract domains such as chemical bonding, chemical reactions, and organic compounds. This concern is echoed in both national and international assessments—including the National Achievement Test (NAT) and the Program for International Student Assessment (PISA)—which have consistently highlighted the difficulties Filipino learners face in interpreting scientific phenomena and applying Chemistry concepts to real-world contexts (DepEd-BEA, 2024; OECD, 2023).

To uncover the specific learning deficiencies that hinder Chemistry mastery, a needs assessment offers a strategic and diagnostic approach. It enables educators to pinpoint the most challenging competencies, allowing for data-informed instructional planning and targeted remediation. This approach is particularly beneficial for non-STEM learners, whose academic track may not adequately reinforce cumulative science learning. Moreover, competency profiling supports the objectives of Sustainable Development Goal 4 (Quality Education) by advancing inclusive and equitable learning opportunities and aligns with DepEd Order No. 8, s. 2015, which promotes the use of assessment to guide instruction and learner development.

This study was therefore conducted to profile the least mastered Chemistry competencies among Grade 11 non-STEM learners, with the aim of recommending targeted instructional interventions. Through the analysis of student performance using a validated, researcher-made needs assessment tool, this research intends to establish a ranked profile of conceptual deficiencies and contribute to more responsive, inclusive, and differentiated instruction in Chemistry education.

# METHODOLOGY

## Research Design

This study employed a quantitative-descriptive research design supported by qualitative data to identify and analyze the least mastered Chemistry competencies of Grade 11 non-STEM learners. Quantitative data provided a statistical profile of conceptual mastery, while qualitative feedback offered contextual insights into learners' experiences and perceptions.

## Research Setting and Participants

The study was conducted in selected public high schools in the Division of Iligan City during School Year 2024–2025. A total of one hundred (100) Grade 11 non-STEM learners, aged 16–18, were purposively selected to participate in the needs assessment. In each participating school, two (2) Grade 11 non-STEM sections were selected, and all learners within those sections were included as respondents.

This sampling approach was chosen to ensure a representative and manageable group of participants while minimizing selection bias. All respondents had completed Grades 7–10 Chemistry under the K to 12 curriculum from mixed-gender and heterogeneous classes. No demographic data (e.g., gender, socioeconomic status, or academic performance history) were collected in this study, as there was no intention to compare learners based on these variables. The focus of the research was strictly on identifying the least mastered Chemistry competencies to inform instructional planning. Additionally, one hundred and fifty (150) learners from a separate school participated in the pilot testing of the instrument to establish its reliability.

## Research Instrument

Data were collected using a researcher-made 50-item multiple-choice needs assessment questionnaire to assess mastery of key chemistry concepts from the junior high school curriculum (Grades 7–10). Each test item was aligned with the Most Essential Learning Competencies (MELCs) issued by the Department of Education, covering the following domains:

- Grade 7: Scientific Investigation and Classification of Matter
- Grade 8: Solutions and Concentrations, and States of Matter,
- Grade 9: Atomic Structure and Periodicity, Chemical Bonding, and Organic Chemistry
- Grade 10: Gas laws, Chemical reactions, and Biomolecules

The researcher-made 50-item multiple-choice needs assessment test underwent content validation by Chemistry educators and curriculum experts to ensure alignment with the Most Essential Learning Competencies (MELCs) and to verify item clarity and relevance. Following validation, the instrument was pilot tested on one hundred and fifty (150) learners from another public school to assess its statistical reliability and item quality. Results from the reliability testing and item analysis showed a Cronbach's Alpha of 0.778, indicating acceptable internal consistency for classroom-based assessment (George & Mallery, 2019). The test had an average difficulty index of 0.46, interpreted as moderately difficult, suggesting it appropriately challenged learners across performance levels. Additionally, the average discrimination index was 0.246, classified as acceptable, meaning the items effectively distinguished between high- and low-performing learners (Nitko & Brookhart, 2014). These metrics collectively confirmed that the needs assessment test was a valid and reliable instrument for identifying Chemistry competency levels among the participants.

In addition, an open-ended qualitative question was included at the end of the assessment to gather learners' reflections on the challenges they encountered in learning Chemistry and their suggestions for improving instruction. This qualitative data was thematically analyzed to provide contextual support and interpretation for the quantitative findings.

### Data Collection Procedure

After securing ethical clearance and permissions from school authorities, the validated test was administered during scheduled class periods under standardized testing conditions. Learners were briefed on the purpose of the study, and participation was voluntary and anonymous. Test papers were retrieved, scored manually, and analyzed per competency. Competencies were identified as least mastered when the class average for a given MELCs-linked item or cluster of items fell below 60%. Descriptive statistics, including frequency counts, percentages, and rankings, were used to summarize and interpret the data.

To support quantitative data, qualitative responses to the open-ended questions were also analyzed. These responses were coded, grouped, and thematically analyzed to uncover patterns in learners' instructional challenges and preferences. The emerging themes were used to support the interpretation of the quantitative findings, ensuring that the study's instructional recommendations were grounded in both statistical trends and learners' perspectives.

## RESULTS AND DISCUSSION

### Assessment Results and Statistical Analysis

This section presents the results of the needs assessment administered to Grade 11 non-STEM learners to identify learning gaps in Chemistry competencies acquired from Grades 7 to 10. The 50-item researcher-made test, aligned with the Department of Education's Most Essential Learning Competencies (MELCs), measured student performance across ten core Chemistry topics. Competencies with mastery scores below 60% were classified as "least mastered," indicating areas in need of further instructional support. The analysis includes descriptive statistics, topic-level mastery rankings, and inferential tests using nonparametric methods. A Kruskal-Wallis H test and subsequent post hoc comparisons were conducted to determine statistically significant differences in performance across the ten topics.

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TABLE I Learners' Performance in Needs Assessment

| Score Range | Frequency | Percentage | Descriptors | Interpretation |
|---|---|---|---|---|
| 45-50 | 0 | 0 | Outstanding | Passed |
| 43-44 | 0 | 0 | Very Satisfactory | Passed |
| 40-42 | 0 | 0 | Satisfactory | Passed |
| 38-39 | 11 | 11 | Fairly Satisfactory | Passed |
| 0-37 | 89 | 89 | Did not meet expectations | Failed |
| **Total** | **100** | **100** | | |
| | **Mean 27.48** | **Std. Dev 5.351** | **Did not meet expectations** | **Failed** |

Table 1 presents the overall performance of one hundred (100) respondents on the assessment. The mean score of 27.48 and standard deviation of 5.351 suggest that most learners performed poorly. 89% of participants scored between 0 and 37, falling into the "Did not meet expectations" category and failing the assessment. Only 11% of participants achieved scores in the "Fairly Satisfactory" range (38-39), passing the assessment but still not reaching a satisfactory level. This performance data underscores the significant challenges learners faced in learning the chemistry concepts.

TABLE II Ranking of Least Mastered Topics

| TOPICS | PERCENTAGE | RANKING |
|---|---|---|
| I. Scientific Investigation | 14.41% | 9th |
| II. Classification of Matter | 8.04% | **5th** |
| III. Solutions and Concentrations | 14.01% | 8th |
| IV. States of Matter | 16.82% | 10th |
| V. Atomic Structure and Periodicity | 10.18% | 6th |
| VI. Chemical Bonding | 6.53% | **3rd** |
| VII. Organic Chemistry | 5.97% | **1st** |
| VIII. Gas Laws | 10.22% | 7th |
| IX. Biomolecules | 7.66% | **4th** |
| X. Chemical Reactions | 6.21% | **2nd** |

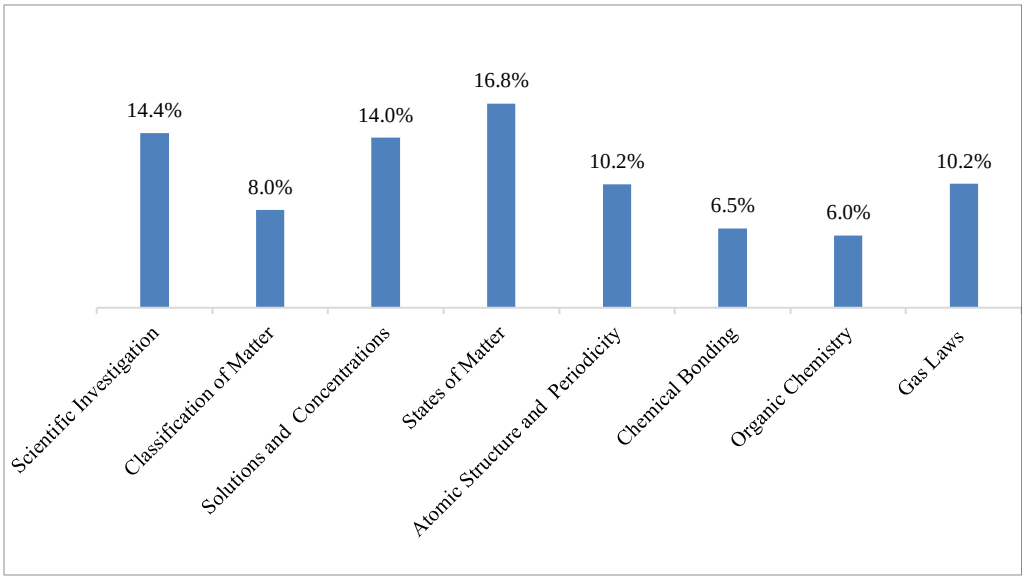


FIGURE 1 Bar Chart Ranking of Least Mastered Topics

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Table 2 and Figure 1 present ranking the least mastered competencies among Grade 11 non-STEM learners. The domain with the lowest performance was Organic Chemistry, with a mean mastery rate of only 5.97%. Learners demonstrated substantial difficulty in explaining the structure of the carbon atom and in recognizing the general classes and uses of organic compounds. These results show similarities to the study of Salame et al. (2020), which suggests limited exposure to this content area or a lack of foundational understanding of molecular structures and chemical functionality. The inherently abstract and representational nature of organic chemistry likely contributed to this performance, particularly among learners with minimal laboratory experience or visual learning support (Salame et al., 2020; Gendjova & Chakarov, 2023).

The second least mastered area was Chemical Reactions, with a mean score of 6.21%. Learners struggled to apply the Law of Conservation of Mass and to explain variables affecting reaction rates. This indicates conceptual challenges in understanding the behavior of reactants and products, balancing equations, and interpreting reaction mechanisms—skills fundamental to both scientific literacy and real-world application (Hamerská et al., 2024). Similarly, in Chemical Bonding, where the average mastery was 6.53%, learners had difficulty distinguishing between compound types and explaining ion formation. These findings reflect possible gaps in learners' understanding of particle interactions and symbolic representations of atomic behavior (Widarti et al., 2024). This suggests a need for instructional methods that integrate models, analogies, and guided simulations to strengthen conceptual clarity.

In Biomolecules (7.66% mastery), learners exhibited low retention in identifying the categories and functions of macromolecules. This performance is attributed to limited reinforcement of biochemistry in earlier grade levels and a disconnection between molecular concepts and everyday relevance. The study of Tumolva et al. (2024) evaluated a game-based learning app and found a significant improvement in student conceptual understanding. Furthermore, despite being introduced early in the curriculum, Classification of Matter remained a weak area with a mastery rate of 8.04%. Learners showed persistent confusion in distinguishing between elements, compounds, and mixtures, which points to superficial understanding or regression over time (Risqi et al., 2021). Although Scientific Investigation and States of Matter were the most mastered domains, with mean scores of 14.41% and 16.82% respectively, these rates still fell well below acceptable mastery levels. The relatively higher performance in these domains suggests some retention of basic observational skills and conceptual familiarity with particle behavior, yet mastery remains far from the expected threshold.

TABLE III One Sample Kolmogorov-Smirnov Test (n=100)

| **Mean** | **SD** | **Statistics** | **Sig. value** | **Conclusion** |
|---|---|---|---|---|
| 24.32 | 3.222 | .154 | <0.001 | The data is not normally distributed. |

The Kolmogorov-Smirnov test (Table 3) confirmed that the data were not normally distributed ($p < 0.001$), justifying the use of nonparametric statistical procedures.

TABLE IV Results on the Assessment Scores Across Ten Topics

| **Test** | **Statistics** | **df** | **p-value** | **Conclusion** |
|---|---|---|---|---|
| Kruskal-Wallis H Test | 490.731 | 9 | <0.001 | There is a significant difference in scores across the ten topic groupings. |

The Kruskal-Wallis H test (Table 4) revealed significant differences in performance across the ten Chemistry topics ($H(9) = 490.731$, $p < .001$), indicating that learner scores varied significantly among the topic groupings.

TABLE V Post Hoc Pairwise Comparisons Among the Three Least Mastered Chemistry Topics (Using Mann-Whitney U Test with Bonferroni Correction)

| Topic 1 | Topic 2 | p-value | Adjusted p-value | Significant |
|---|---|---|---|---|
| Organic Chemistry | Chemical Reactions | 0.0003 | < 0.001 | Yes |
| Chemical Reactions | Chemical Bonding | 0.6302 | 0.0147 | No |
| Chemical Bonding | Organic Chemistry | 0.0049 | 1.000 | Yes |

Note. P-values were adjusted using the Bonferroni correction. A significance level of $p < .05$ was used to determine statistically significant differences in learner performance between topic pairs.

Post hoc analysis using the Mann-Whitney U test with Bonferroni correction (Table 5) confirmed that learners exhibited a markedly reduced level of performance in the subject of Organic Chemistry compared to Chemical Reactions ($p < 0.001$) and Chemical Bonding ($p = 0.0147$). No significant difference was found between Chemical Reactions and Chemical Bonding ($p = 1.000$), suggesting a similar level of difficulty.

These statistical results reinforce the descriptive data, confirming that Organic Chemistry presents the greatest challenge. The overlap in scores between Chemical Reactions and Chemical Bonding suggests shared conceptual demands such as atomic interactions and symbolic representation (Hamerská et al., 2024; Widarti et al., 2024). These patterns reflect systemic issues, including curriculum pacing or limited instructional scaffolding for abstract content.

Overall, only three out of ten topics surpassed the 10% mastery threshold, revealing widespread learning gaps. The prevalence of learning gaps in advanced Chemistry topics indicates a gradual decline in conceptual understanding over time. Contributing factors may include limited laboratory access, insufficient instructional time, or misaligned assessments (Seid et al., 2022). These results highlight the extent of conceptual deficiencies among non-STEM learners and emphasize the need for competency-based profiling as a strategic instructional tool.

Moreover, these findings align with national data from assessments such as NAT and PISA, reinforcing calls for contextualized, inclusive, and learner-responsive instruction in support of Sustainable Development Goal 4 (Quality Education).

**Thematic Analysis of Learner Responses**

To support the quantitative results, open-ended responses from 52 learners were analyzed using thematic analysis. Learners were asked the question:

“What challenges did you face when learning Chemistry in junior high school, and what do you think could help improve your understanding of the subject?”

TABLE VI Thematic Analysis of Learner Responses

| Theme | Description | Representative Quotes |
|---|---|---|
| **Lack of Reinforcement and Spiral Review** | Chemistry topics were introduced once with little review, weakening long-term retention. | “We only studied bonding once in Grade 9, and we didn't review it again in Grade 10.” “We were expected to remember topics we barely discussed.” |
| **Cognitive Overload from Abstract Concepts** | Learners struggled to grasp abstract content such as equations and symbolic representations. | “I get confused when I see symbols and numbers in equations.” “I didn’t understand chemical |

| | | |
|---|---|---|
| | | reactions because it's hard to imagine atoms changing." |
| **Limited Access to Practical and Visual Tools** | Learners lacked hands-on laboratory experiences and visual aids that support conceptual learning. | "We had no lab. We just watched videos."<br>"I learn best when I see and do. We didn't get that chance." |
| **Preference for Game-Based and Interactive Learning** | Learners suggested that interactive tools could improve learning. | "Playing something like a Chemistry game might help me remember more."<br>"Flashcards and activities help me learn better." |

The first theme, lack of reinforcement and spiral review, reflected learners' concerns that Chemistry topics were taught in isolation and not revisited. This implies, as supported by the findings of Campbell et al. (2022), a breakdown in vertical curriculum integration and supports the quantitative findings showing low retention in earlier-introduced topics.

The second theme, cognitive overload from abstract concepts, captured learners' difficulty with symbolic and theoretical content, particularly in interpreting chemical equations and reactions. This directly supports the low mastery scores in Chemical Bonding and Chemical Reactions, which require high abstraction (Hamerská et al., 2024; Widarti et al., 2024).

The third theme, limited access to practical and visual tools, underscored the lack of laboratory experiences and interactive visuals. Learners reported relying heavily on lectures and videos, with few opportunities for hands-on engagement. This limited exposure likely hindered a deeper understanding of complex concepts. In this light, the study of Putra and Zainul (2024) indicated that interactive virtual lab significantly enhanced the students' visualization of abstract chemical concepts, thus improving their engagement and understanding in chemistry.

The final theme, preference for game-based and interactive learning, revealed learners' desire for more engaging learning methods. Many respondents cited games, flashcards, and interactive activities as effective tools for improving memory and motivation. The study findings of Hesser et al. (2023) show that educational escape games enhanced student engagement, team and scientific problem-solving, thus aligning with the study's recommendation to integrate game-based approaches in Chemistry instruction, particularly for non-STEM learners.

Together, these qualitative insights contextualize the quantitative data and highlight the urgent need for differentiated, visually supported, and learner-centered Chemistry instruction.

## CONCLUSION

This study successfully identified key areas for instructional enhancement in Chemistry education by profiling the least mastered competencies among Grade 11 non-STEM learners. Using a validated diagnostic tool aligned with the Department of Education's Most Essential Learning Competencies (MELCs), the research illuminated specific domains—such as Organic Chemistry, Chemical Reactions, and Chemical Bonding—where additional support can significantly boost learner success.

Despite the challenges observed, the results present an opportunity to strengthen foundational science education through informed, targeted strategies. Even modest mastery in topics like Scientific Investigation and States of Matter indicates a promising base from which learners can build. These findings affirm the value of competency-based profiling as a practical tool for guiding instructional planning, allowing educators to better meet learners where they are and move them forward with confidence.

Learners' reflections provided valuable insight, highlighting a clear desire for more engaging, interactive, and visually supported learning experiences. When combined with the assessment data, these perspectives point to a hopeful path forward—one where thoughtful, differentiated instruction and meaningful student engagement can close existing learning gaps and nurture scientific curiosity. Aligning with Sustainable Development Goal 4 (Quality Education), this study offers a data-driven foundation for designing inclusive and empowering Chemistry instruction for all learners.

In conclusion, the findings highlight the need for responsive and evidence-based Chemistry instruction, especially for non-STEM learners who may have had limited exposure to in-depth science instruction. These insights provide a foundation for designing targeted interventions and fostering more inclusive Chemistry instruction moving forward.

## RECOMMENDATION

Based on the findings and conclusions of this study, the following recommendations are proposed to address the identified learning gaps in Chemistry among Grade 11 non-STEM learners and to enhance instructional effectiveness across the junior high school science curriculum:

1. **Implement Targeted Remedial Instruction.** Schools should design and implement structured remediation programs focused on the least mastered Chemistry competencies, particularly in Organic Chemistry, Chemical Reactions, and Chemical Bonding. These interventions may include small-group tutorials, review sessions, and enrichment modules tailored to the specific needs of non-STEM learners.
2. **Incorporate Game-Based Learning Approaches.** To increase engagement and improve conceptual understanding, integrating game-based learning strategies into Chemistry instruction is recommended. Educational games—whether card-based, board-based, or digital—can provide dynamic, interactive opportunities for learners to explore abstract concepts such as bonding, reaction mechanisms, and molecular structures in a more accessible and motivating format (Tarigan & Wiji, 2023). These approaches are especially beneficial for non-STEM learners who struggle with traditional, lecture-based methods. When aligned with curriculum standards, game-based learning can promote active learning, peer collaboration, and deeper retention of complex scientific ideas (Putera & Hadi, 2024; Hesser et al. 2023).
3. **Strengthen Teacher Professional Development on Abstract Chemistry Instruction.** To support effective content delivery in conceptually demanding areas, it is recommended that schools and educational institutions invest in continuous professional development for Chemistry teachers. Specialized training sessions, workshops, and learning communities can help educators develop strategies for simplifying abstract topics such as Organic Chemistry, Chemical Reactions, and Chemical Bonding. Through exposure to research-based pedagogies, such as the use of analogies, models, simulations, and visual aids, teachers will be better equipped to make complex concepts more accessible and engaging for non-STEM learners (Nandani & Raturi, 2024). Strengthening teacher capacity in this way promotes long-term improvements in classroom instruction and learner outcomes.

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