Uneven Mastery across Chemistry Competencies: Evidence from Grade 11 Stem Students in General Chemistry 2

Eve Joyce E. Ablin., Cheira M. Tarayao., Christine Joy C. Llaneras., Cathniel L. Verallo., and Edna B. Nabua

Mindana State University – Iligan Institute of Technology, Philippines

DOI: https://doi.org/10.47772/IJRISS.2025.91200251

Received: 25 December 2025; Accepted: 02 January 2026; Published: 14 January 2026

ABSTRACT

This study investigated the mastery levels of Grade 11 STEM learners across the Third- Quarter competencies of General Chemistry 2 to identify areas requiring targeted instructional support. Using a descriptive quantitative research design, data were collected from fifty (50) Grade 11 STEM students enrolled in General Chemistry 2 at a private secondary school in the Philippines. A researcher- developed, MELC-aligned achievement test consisting of fifty multiple-choice items was employed to assess learners' conceptual and procedural understanding. The instrument underwent expert validation, pilot testing, and reliability analysis, yielding a Kuder–Richardson Formula 20 (KR-20) coefficient of 0.844. The results revealed varying levels of mastery across the fifteen assessed competencies. Most competencies were classified as Mastered or Nearly Mastered, particularly those related to phase changes, solution chemistry, thermochemistry, and chemical kinetics, indicating stronger performance in conceptually oriented and qualitative topics. In contrast, the lowest mastery levels were observed in competencies requiring the integration of conceptual understanding and mathematical application, notably the quantitative treatment of colligative properties and the application of Hess's Law in determining heat changes. These competencies posed challenges due to their reliance on multi-step problem solving, numerical computation, and abstract reasoning. The findings underscore the uneven nature of chemistry mastery across competencies and highlight the need for strand-responsive instructional strategies that emphasize guided problem-solving, visual representations, and contextualized learning experiences. The study provides empirical baseline data that can inform the development of targeted instructional interventions, such as Strategic Intervention Materials, to enhance learners' mastery of quantitatively demanding chemistry concepts and improve overall achievement in General Chemistry 2.

Keywords: Least Mastered Competency, Mastery Level, MELCs

INTRODUCTION

Chemistry is widely regarded as the central science because of its integrative role in linking disciplines such as biology, geology, medicine, and engineering. It provides foundational explanations for the composition of matter, chemical reactions, and molecular interactions that govern both natural and technological processes. In an era marked by increasing demand for scientific literacy, chemistry education plays a critical role in enabling learners to understand phenomena that influence health, industrial development, and environmental sustainability (Nguyen et al., 2021).

Despite its centrality, chemistry remains a challenging subject for many learners. Empirical studies consistently report difficulties in understanding abstract concepts, symbolic representations, and mathematically intensive relationships that require higher-order cognitive processing (Sibomana et al., 2021). These challenges often result in fragmented conceptual understanding and uneven mastery across chemistry competencies. In particular, students frequently struggle to integrate macroscopic observations, submicroscopic explanations, and symbolic representations—an essential requirement for meaningful learning in General Chemistry 2.

The third quarter of General Chemistry 2 in the Department of Education context encompasses cognitively demanding topics, including intermolecular forces, colligative properties, acids and bases, chemical kinetics, and

chemical equilibrium. These areas are widely documented as persistent sources of misconceptions and low achievement. A recent systematic review highlighted that misconceptions in chemical equilibrium and acid–base chemistry remain prevalent and continue to hinder accurate scientific understanding (Suparman et al., 2024). Insufficient mastery of these foundational concepts may limit learners' capacity to engage with more advanced chemical principles.

Instructional disruptions during and after the COVID-19 pandemic have further complicated the acquisition of chemistry competencies. Reduced access to hands-on laboratory experiences and the widespread adoption of modular and remote learning modalities have constrained opportunities for experiential learning and conceptual reinforcement (Lucena Rodríguez et al., 2021). These conditions may have contributed to inconsistent mastery of chemistry competencies across curricular domains.

Within the Philippine K–12 curriculum, the Most Essential Learning Competencies (MELCs) emphasize the attainment of minimum expected learning outcomes. Identifying competencies that are least mastered is therefore essential for guiding instructional planning and remediation efforts. Monitoring mastery levels enables educators to address learning gaps systematically and to design interventions that respond to learners' specific needs (Sibomana et al., 2021).

Guided by these considerations, the present study aims to identify the least mastered competency in General Chemistry 2 among Grade 11 STEM learners, based on mastery levels derived from a researcher- developed assessment aligned with the MELCs. By determining the competency with the lowest achievement rate, the study provides baseline empirical evidence to inform instructional decision-making and targeted academic support in senior high school chemistry.

METHODOLOGY

Research Design. This study employed a descriptive quantitative research design to determine the mastery levels of Grade 11 STEM learners in selected General Chemistry 2 competencies. The design was appropriate for identifying patterns of achievement and ranking competencies based on students' performance without manipulating instructional variables.

Participants. The participants consisted of fifty (50) Grade 11 STEM learners enrolled in General Chemistry 2 at La Salle Academy, Iligan City, during the School Year 2025–2026. Purposive sampling was used, as the respondents were officially taking General Chemistry 2 during the third quarter and were therefore suitable for assessing mastery of the prescribed competencies. The participants constituted a single intact group exposed to uniform curriculum standards and instructional conditions, ensuring alignment with the Most Essential Learning Competencies (MELCs). Ethical protocols were observed, and approval was secured from school authorities prior to data collection.

Instrument. A researcher-made achievement test was developed to assess learners' mastery of General Chemistry 2 competencies for the third quarter. The instrument was aligned with the MELCs issued by the Department of Education and was guided by a Table of Specifications to ensure balanced representation of content areas and cognitive levels. The initial version of the test consisted of fifty (50) multiple-choice items, each with four options and one correct answer.

The test covered key third-quarter topics, including intermolecular forces, properties of liquids and solids, solutions and concentration units, colligative properties, thermochemistry, and chemical kinetics. Each item was explicitly linked to a specific learning competency to support accurate determination of mastery levels. Content validity was established through expert validation by specialists in chemistry education, who evaluated the items for relevance, clarity, cognitive appropriateness, and alignment with the MELCs. Revisions were made based on their feedback.

The revised instrument was pilot-tested among one hundred fifty (150) Grade 12 STEM learners from the same institution who had previously completed General Chemistry 2. Item analysis was conducted to determine difficulty and discrimination indices. Items with negative discrimination indices were discarded, while those

with low but positive indices were revised for clarity and effectiveness. Reliability analysis using the Kuder–Richardson Formula 20 (KR-20) yielded a coefficient of 0.844, indicating good internal consistency. The finalized instrument was subsequently administered to the target respondents.

Data Analysis. Data were analyzed using descriptive statistical techniques, including frequency counts, Mean Percentage Scores (MPS), and ranking of competencies based on mastery levels. Tabulated results served as the basis for interpreting mastery classifications and identifying the least mastered competency in General Chemistry 2 (Third Quarter).

Table 1. Mastery Level and its Description

Mean Percentage Score (MPS)	Mastery Level
80% - 100%	Mastered
75% - 79%	Nearly Mastered
51% - 54%	Least Mastered
50% and below	Not Mastered

Reference: DepEd PPST - Module 11

RESULTS AND DISCUSSION

Table 2. Mastery Level of Grade 11 Learners on General Chemistry 2 Competencies

No.	Competency	# items	Total Possible Score	Total Correct	Mastery Level (%)	Interpretation
1	Use the kinetic molecular model to explain properties of liquids and solids.	2	100	87	87.00	Mastered
2	Describe and differentiate types of intermolecular forces and predict the IMF present in molecules.	2	100	75	75.00	Nearly Mastered
3	Explain the effect of IMF on properties (surface tension, viscosity,vapor pressure, boiling point, molar heat of vaporization).	2	100	77	77.00	Nearly Mastered
4	Interpret phase changes and diagrams of water and CO_2.	1	50	47	94.00	Mastered
5	Describe the different types of solutions and express concentration in various units.	3	150	122	81.33	Mastered
6	Explain the effects of temperature and pressure on solubility.	3	150	129	86.00	Mastered
	Describe and calculate colligative properties; differentiate between	5	250	206	82.40	Mastered

7	electrolyte and nonelectrolyte solutions.					
8	Relate solution concentration to its colligative behavior (boiling point, freezing point).	1	50	35	70.00	Least Mastered
9	Explain energy changes in chemical reactions; distinguish exothermic vs. endothermic.	3	150	131	87.33	Mastered
10	Explain the first law of thermodynamics and enthalpy of a reaction.	2	100	75	75.00	Nearly Mastered
11	Apply Hess's Law and thermochemical equations to determine heat change.	1	50	36	72.00	Least Mastered
12	Relate bond formation/ breaking toenthalpy and reaction heat.	2	100	82	82.00	Mastered
13	Describe how various factors influence the rate of a reaction.	5	250	212	84.80	Mastered
14	Differentiate reaction order and write rate laws.	3	150	128	85.33	Mastered
15	Explain the effects of temperature, activation energy, and catalysts using collision theory.	4	200	167	83.50	Mastered

Legend: Not mastered (50 % below); Least mastered (51 – 74%); Nearly Mastered (75 – 79%); Mastered (80 – 100%)

This study investigated the mastery levels of Grade 11 STEM learners across the Third-Quarter competencies of General Chemistry 2 to identify areas requiring targeted instructional support. Using a descriptive quantitative research design, data were collected from fifty (50) Grade 11 STEM students enrolled in General Chemistry 2 at a private secondary school in the Philippines. A researcher-developed, MELC-aligned achievement test consisting of fifty multiple-choice items was employed to assess learners' conceptual and procedural understanding. The instrument underwent expert validation, pilot testing, and reliability analysis, yielding a Kuder–Richardson Formula 20 (KR-20) coefficient of 0.844. The results revealed varying levels of mastery across the fifteen assessed competencies. Most competencies were classified as Mastered or Nearly Mastered, particularly those related to phase changes, solution chemistry, thermochemistry, and chemical kinetics, indicating stronger performance in conceptually oriented and qualitative topics. In contrast, the lowest mastery levels were observed in competencies requiring the integration of conceptual understanding and mathematical application, notably the quantitative treatment of colligative properties and the application of Hess's Law in determining heat changes. These competencies posed challenges due to their reliance on multi-step problem solving, numerical computation, and abstract reasoning. The findings underscore the uneven nature of chemistry mastery across competencies and highlight the need for strand-responsive instructional strategies that emphasize guided problem-solving, visual representations, and contextualized learning experiences. The study provides empirical baseline data that can inform the development of targeted instructional interventions, such as Strategic Intervention Materials, to enhance learners' mastery of quantitatively demanding chemistry concepts and improve overall achievement in General Chemistry 2.

Results indicate that Grade 11 learners demonstrated varying levels of mastery across the Third- Quarter competencies of General Chemistry 2. The majority of the competencies were classified as Mastered or Nearly Mastered, indicating that learners have generally acquired the essential knowledge and skills required to understand the core chemical principles addressed during the quarter. Higher mastery levels were particularly evident in competencies related to phase changes, solution chemistry, thermochemistry, and chemical kinetics. This trend suggests that learners tend to perform more effectively in topics that emphasize conceptual understanding and qualitative reasoning.

Conversely, several competencies were identified as Least Mastered, particularly those involving the quantitative application of solution concentration to colligative properties and the use of Hess's Law to determine heat changes. These findings suggest that learners encounter greater difficulty with competencies that require multi-step problem solving, mathematical manipulation, and the integration of quantitative reasoning with abstract chemical concepts.

Overall, the results demonstrate that while learners show satisfactory performance across most third- quarter competencies, mastery remains uneven across content areas. This pattern aligns with prior research indicating that achievement in chemistry varies across competencies, especially in areas that demand higher- order cognitive processing and advanced problem-solving skills (Andres & Gonzales, 2022; Dela Cruz, 2020).

CONCLUSION AND RECOMMENDATION

The findings of this study indicate that Grade 11 STEM learners demonstrated varying levels of mastery across the fifteen third-quarter competencies in General Chemistry 2. The majority of the competencies were classified as Mastered or Nearly Mastered, particularly those related to phase changes, solution chemistry, thermochemistry, and chemical kinetics. These results suggest that learners are generally more proficient in competencies that emphasize descriptive explanations and conceptual understanding. Nevertheless, mastery was not uniform across all competencies, as several areas reflected partial understanding that warrants further instructional reinforcement.

The lowest mastery levels were observed in competencies that required the integration of conceptual knowledge with mathematical application. Notably, the competency involving the relationship between solution concentration and colligative behavior obtained the lowest Mean Percentage Score, followed by the application of Hess's Law in determining heat changes. These outcomes indicate that learners encounter greater difficulty when chemistry learning demands multi-step problem solving, numerical computation, and abstract reasoning. Although learners demonstrated a foundational grasp of basic principles, limitations in quantitative reasoning and the application of thermochemical relationships constrained their ability to achieve full mastery of these competencies.

Taken together, these findings underscore the need for targeted instructional support addressing the identified least mastered competencies. Teachers handling General Chemistry 2 are encouraged to implement additional guided problem-solving activities, structured practice exercises, and remediation tasks that emphasize systematic analysis of colligative property calculations and thermochemical equations. Instructional strategies that incorporate visual representations, worked examples, and contextualized problem scenarios may help learners bridge the gap between conceptual understanding and mathematical application.

Furthermore, the development of Strategic Intervention Materials (SIMs) or supplementary instructional modules is recommended to address learning gaps in colligative properties and Hess's Law. These materials should include engaging learning activities, problem-solving drills, and formative assessments designed to strengthen learners' confidence and proficiency in quantitative chemistry concepts. School administrators and curriculum planners may also consider reviewing instructional time allocation and content sequencing to ensure adequate emphasis on these cognitively demanding topics. Future research may extend this work by examining factors that contribute to low mastery or by designing and evaluating targeted intervention programs aimed at improving achievement in the identified competencies. Through these initiatives, more effective instructional support may be provided to enhance learners' mastery and overall performance in General Chemistry 2.

ACKNOWLEDGMENT

The author extends heartfelt gratitude, first and foremost, to God for the guidance, strength, and wisdom that made this study possible. Sincere appreciation is also extended to the school administrators and General Chemistry teachers of La Salle Academy, Iligan City, for granting permission and support in the conduct of this study, as well as to the Grade 11 STEM learners for their cooperation and active participation. The author likewise acknowledges the College of Education of Mindanao State University–Iligan Institute of Technology for its continued academic guidance and support.

REFERENCES

1. Abao, T. G., Pañares, J. D., & Gonzales, R. (2023). Effects of virtual laboratory instruction on students' chemistry performance. International Journal of Science and Management Studies, 6(6), 14–20.
2. Almahdawi, M. (2025). Factors influencing high school students' understanding of organic qualitative analysis. Eurasia Journal of Mathematics, Science and Technology Education.
3. Andres, R. M., & Gonzales, A. L. (2022). Identifying least mastered competencies as basis for instructional intervention in science. Science Education International, 33(2), 159–168. https://doi.org/10.33828/sei.v33.i2.7
4. Ausubel, D. P. (1968). Educational psychology: A cognitive view. Holt, Rinehart & Winston.
5. Benedicto, S. (2024). Addressing least mastered competencies in Earth and Life Science through problem- based laboratory activities. Journal of Innovation in Psychology, Education and Didactics, 28(2), 75–88.
6. Beruin, L. C. (2022). STEM students' conceptions and experiences of online learning during the COVID-19 pandemic. Journal of Pedagogical Research, 6(4), 143–167. https://doi.org/10.33902/JPR.202217716
7. Biggs, J., & Tang, C. (2011). Teaching for quality learning at university (4th ed.). Open University Press.
8. Broad, H., McGrath, C., & Thomson, A. (2023). Impact of blended learning on chemistry students' conceptual understanding during the pandemic. Journal of Chemical Education, 100(3), 1123–1134.
9. Dela Cruz, J. P. (2020). Mastery level of STEM-related competencies among Grade 11 learners. Asia Pacific Journal of Multidisciplinary Research, 8(3), 45–52.
10. Gilbert, J. K., & Treagust, D. F. (2009). Multiple representations in chemical education. Springer. https://doi.org/10.1007/978-1-4020-8872-8
11. Johnstone, A. H. (1991). Why is science difficult to learn? Things are seldom what they seem. Journal of Computer Assisted Learning, 7(2), 75–83. https://doi.org/10.1111/j.1365-2729.1991.tb00230.x
12. Jusniar. (2020). Students' misconceptions about rates of reaction and equilibrium relationships. European Journal of Educational Research, 9(1), 371–383.
13. Kumar, S. (2025). Assessing secondary students' misconceptions in acid–base chemistry: A diagnostic approach. International Journal of Scientific Research in Education, 2(2), 137–150.
14. Llego, M. A. (2022). Most Essential Learning Competencies (MELCs) for School Year 2022–2023. TeacherPH. https://www.teacherph.com/melcs/
15. Lopez, E. C. R., Ramirez, C. A., & Flores, A. M. (2025). Predictors of academic performance in chemical engineering courses. International Journal of Engineering Education.
16. Lucena Rodríguez, C., Mula-Falcón, J., Domingo Segovia, J., & Cruz-González, C. (2021). The effects of COVID-19 on science education: A thematic review of international research. Journal of Turkish Science Education, 18(Special Issue), 26–45. https://doi.org/10.36681/tused.2021.70
17. Mai, Y., Qian, Y., Lan, H., & Li, L. (2021). Upper-secondary students' concept organization related to chemical equilibrium. Journal of Baltic Science Education, 20(3), 443–455. https://doi.org/10.33225/jbse/21.20.443
18. Mamintal, A. (2024). Development and validation of a chemistry-based e-module using least mastered competencies. American Journal of Multidisciplinary Research and Innovation, 3(6), 49–61.
19. Melitante, K. J. A., Nabua, E. B., Salic-Hairulla, M., Fernandez, M. J., & Rosales, V. (2025). Profiling least mastered competencies among Grade 11 non-STEM learners: Basis for targeted instructional intervention. International Journal of Research and Innovation in Social Science, 9(4), 6541–6549.
20. Munawwarah, M. (2025). Unveiling misconceptions in core chemistry topics: A systematic study. Journal of Science and Geoscience Pedagogy, 4(1), 1–15.

21. Murni, A. T., Syaful, H., & Pratiwi, R. (2022). The impact of inquiry-based modules on students' understanding of reaction rates. International Journal of Instruction, 15(4), 245–260.
22. Navalta, E. R., Nabua, E. B., Micutuan, R. P. G., Abdurahman, M. M., & Poblete, T. C. (2025). Learning competencies of Grade 11 STEM learners in organic chemistry. International Journal of Research and Innovation in Social Science, 9(1), 3363–3373.
23. Nguyen, T. L., Johar, N. A., & Ismail, R. (2021). Enhancing chemistry education through contextual learning: A review of recent studies. Journal of Chemical Education Research, 5(1), 12–22.
24. Nurwidodo, N., Susanti, R., & Widodo, W. (2023). Science learning in the COVID-19 era: A systematic literature review. Eurasia Journal of Mathematics, Science and Technology Education, 19(4), 1–12.
25. Ocanay, L. C., Santos, M., & Villar, E. (2022). Performance trends of senior high school learners in General Chemistry 2. Philippine Journal of Science Education, 11(1), 55–67.
26. Oladejo, A. I., Ademola, I. A., Ayanwale, M. A., & Tobih, D. (2023). Concept difficulty in secondary school chemistry: Influence of gender and school characteristics. Journal of Technology and Science Education, 13(1), 255–275.
27. Organisation for Economic Co-operation and Development. (2019). OECD learning compass 2030: A series of concept notes. OECD Publishing.
28. Ortiz, F. J. A., Dalayap, J. M. R., & Vergara, D. A. (2025). Chemistry learning challenges and coping strategies among STEM and non-STEM pre-service teachers. ASEAN Journal for Science Education, 4(2), 109–120.
29. Paraguas, S. W. (2025). Self-efficacy and general chemistry problem-solving proficiency among first-year college students. Canadian Journal of Educational and Social Studies, 5(2), 44–60.
30. Poblete, T. C., Nabua, E. B., Abdurahman, M. M., Navalta, E. R., Jr., & Micutuan, R. P. G. (2025). Grade 11 STEM learners' learning competencies and motivation in General Chemistry. International Journal of Research and Innovation in Social Science, 9(1), 3763–3774.
31. Pratomo, H., Fitriyana, N., & Wiyarsi, A. (2025). Mapping chemistry learning difficulties across grade levels: A cross-sectional study. Journal of Education and Learning, 19(2), 909–920.
32. Rahayu, I., Fitria, N., & Rahman, A. (2024). Analysis of misconceptions in factors affecting reaction rate among high school students. KnE Social Sciences, 9(1), 276–287.
33. Rahmawati, Y., Fitria, R., & Utami, S. (2022). Enhancing conceptual understanding of chemical equilibrium using PhET simulations. Journal of Technology and Science Education, 12(2), 334–347.
34. Ramirez, H. J., & Paderna, E. E. (2024). Students' perceived mastery and relevance of chemistry competencies toward sustainable development. Chemistry Teacher International, 6(2).
35. Redhana, I. W. (2021). Green chemistry laboratory activities and their effects on students' understanding of equilibrium. Journal of Turkish Science Education, 18(3), 395–410.
36. Santos, J. T. D., Lim, R. R., & Rogayan, D. V., Jr. (2021). Least mastered competencies in biology: Basis for instructional planning. Jurnal Pendidikan Biologi Indonesia, 7(3), 283–298.
37. Sayre, E. D., Nabua, E. B., Salic-Hairulla, M., Alcopra, A., & Fernandez, M. J. (2025). Assessing General Chemistry learning gaps: A needs assessment of competency mastery among Grade 11 learners. International Journal of Research and Innovation in Social Science.
38. Sibomana, A., Karegeya, C., & Sentongo, J. (2021). Factors affecting secondary school students' academic achievements in chemistry. International Journal of Learning, Teaching and Educational Research, 20(12), 114–126. https://doi.org/10.26803/ijlter.20.12.7
39. Solas, E. P. C. (2025). Factors affecting university students' performance in first-year physical chemistry. Caribbean Educational and Social Studies Review.
40. Suparman, A. R., Rohaeti, E., & Wening, S. (2024). Student misconception in chemistry: A systematic literature review. Pegem Journal of Education and Instruction, 14(2), 238–252. https://doi.org/10.47750/pegegog.14.02.28
41. Taber, K. S. (2002). Chemical misconceptions: Prevention, diagnosis and cure (Vol. 1). Royal Society of Chemistry.
42. Taglorin, H. L. L., Nabua, E. B., Latonio, B. C., & Bolocon, A., Jr. (2025). Least mastered competencies in Grade 10 chemistry and associated motivation levels. International Journal of Research and Innovation in Social Science, 9(2), 1008–1021.
43. Talanquer, V. (2011). Macro, submicro, and symbolic: The many faces of the chemistry "triplet." International Journal of Science Education, 33(2), 179–195.

https://doi.org/10.1080/09500690903386435

44. Walag, A. M. P., Nabua, E. B., Micutuan, R. P. G., & Abdurahman, M. M. (2025). Learning competencies of Grade 11 STEM learners in organic chemistry: Basis for strategic intervention. International Journal of Research and Innovation in Social Science, 9(1), 3363–3373.