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Learning Gaps in the Mole Concept: A Conceptual Understanding-Based Analysis

Christine Joy C. Llaneras[1] Edna B. Nabua[2,] Cheira M. Tarayao[3], Cathniel L. Verallo[4]

[1234]Mindanao State University-Iligan Institute of Technology, Philippines

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ABSTRACT

This study examined the least learned competencies in the mole concept among 50 Senior High School STEM students at Sta. Filomena–Iligan City East National High School using a teacher-developed, content-validated 30-item diagnostic test aligned with the Department of Education Senior High School Science Curriculum Guide. Descriptive quantitative analyses—including mean scores, standard deviations, Mean Percentage Scores (MPS), frequency distributions, and mastery-level interpretations— were used to measure student performance. Results showed that 72% of the students were classified under Did Not Meet Expectation, with a mean score of 14.63 (SD = 5.84), indicating an overall MPS below the 75% mastery benchmark. The least learned competencies were calculating the molar mass of elements and compounds (MPS = 27, Not Mastered) and applying molar volume of gases at STP (MPS = 39, Not Mastered). Other weak areas included converting mass–mole–particle quantities, applying mole ratios, solving real-life and multi-step mole problems, and relating mole to mass using molar mass (MPS = 56– 58, Least Mastered). Students showed better performance in using Avogadro's number (MPS = 61) and explaining the mole as a unit of measurement (MPS = 77.33, Nearly Mastered). The results suggest that many students struggle because the difficult competencies require multiple calculation steps, stronger math skills, and connecting symbols, numbers, and ideas, which increases mental effort. In contrast, students find basic concepts and definitions easier to recall. This study serves as a performance diagnostic investigation that helps identify learning gaps and supports improvement in teaching approaches. Future studies may test specific instructional strategies designed to strengthen students' quantitative skills and understanding of the mole concept.

Keywords: Diagnostic Assessment, Chemistry Education, Least Learned Competencies, Mole Concept, Senior High School

INTRODUCTION

Chemistry is a core subject in the Senior High School STEM curriculum under the Department of Education's K–12 Program, and the mole concept plays a central role in learning stoichiometry, gas laws, and solution chemistry. However, Philippine studies continue to report that chemistry remains difficult for many learners because of its abstract nature and quantitative demands, leading students to rely on memorization rather than conceptual understanding (Dela Cruz & Javier, 2021; Santos & Reyes, 2022). These challenges are most evident in mole problem solving, where learners struggle to relate conceptual ideas to mathematical procedures.

Despite its function as a link between microscopic particles and measurable quantities, students commonly display misconceptions about the mole and Avogadro's number, resulting in errors in mole– mass–particle conversions and stoichiometric calculations (Reyes, Cruz, & Malabanan, 2021; Dizon & Balagtas, 2020). Difficulties persist even after instruction, particularly when teaching remains procedural rather than conceptual (Ramos & Dela Peña, 2023), reflecting broader national trends in scientific proficiency such as those observed in PISA 2018.

In response, recent literature emphasizes diagnosing least learned competencies and understanding why students struggle with multi-step mole tasks, including issues of mathematical readiness, representation, and cognitive load. Guided by this perspective, the present study employs a curriculumaligned diagnostic test to identify least learned mole competencies among Senior High School learners and to generate instructional insights grounded in documented learning difficulties.

METHODOLOGY

This study utilized a quantitative descriptive design to determine the least learned competencies in the mole concept. The research was conducted at Iligan City East National High School – Sta. Felomina and involved 50 Grade 11 STEM students selected through purposive sampling.

Data were gathered using a 30-item teacher-developed diagnostic test aligned with the DepEd Most Essential Learning Competencies (MELCs). The instrument demonstrated acceptable internal consistency, with reliability values of Cronbach's alpha = 0.7492, KR-20 = 0.7510, and KR-21 = 0.7331.

Data analysis employed frequency, mean, and Mean Percentage Score (MPS) to determine students' mastery levels, which were interpreted using the DepEd Mastery Level Scale to identify competencies with the lowest performance.

Development of the Assessment Instrument

The researcher provided a letter of permission to conduct the research, which was approved by the

Schools Division Superintendent (SDS) of DepEd Iligan and the School Principal of Sta. Felomina–Iligan City East National High School. The process began with the development of a teacher-made test questionnaire constructed using a Table of Specifications (TOS) and aligned with the DepEd Curriculum Guide. The initial questionnaire consisted of fifty (50) items and was validated by the research adviser and two (2) expert validators in Chemistry. After validation, the questionnaire was revised based on the validators' comments, resulting in the second version of the instrument.

The second version of the test questionnaire was then administered to Senior High School students for pilot testing. The results were analyzed through item analysis to determine which items should be revised, retained, or discarded using the difficulty and discrimination indices. The final version of the questionnaire consisted of thirty (30) multiple-choice items and was administered to Grade 11 STEM students, with the selection of respondents depending on their availability during the implementation. A total of 50 students

participated in the testing. The results of the final administration were analyzed and served as the basis for achieving the objectives of the study, particularly in identifying the least learned competencies in the mole concept.

Data Analysis

The data was collected, tabulated, analyzed and interpreted. The tables below were used to have an accurate interpretation of the data. It will serve as the basis for determining the description of the intervals to which they belong.

Table 1. Interpretation on Students' Performance on Diagnostic Test

Index	Description	PERCENTAGE	REMARKS
27-30	Outstanding	90 – 100	Passed
26	Very Satisfactory	80 – 89	Passed
24-25	Satisfactory	80 – 84	Passed
23	Fairly Satisfactory	75 – 79	Passed
0-22	Did Not Meet Expectation	Below 75	Failed

This table provides a summary interpretation of learners' overall performance based on the DepEd's performance index.

Reference: DepEd Order No. 8 s, 2015

Table 2. Mastery levels and percentage equivalent

MASTERY LEVEL	**PERCENTAGE EQUIVALENT**
Mastered	80-100
Nearly Mastered	75-79
Least Mastered	51-54

Not Mastered	50 and below

Reference: DepEd PPST – Module 11

This table serves as the reference scale for interpreting the learners' Mean Percentage Scores

(MPS). Scores of 80–100% indicate Mastered, 75–79% Nearly Mastered, 51–54% Least Mastered, and 50% and below Not Mastered, reflecting the degree of learner proficiency and the extent of learning gaps across competencies.

RESULTS AND DISCUSSION

Table 3. Summary of Assessment Results

Index	**Frequency**	**Percentage**	**Interpretation**	**Remark**
27-30	0	0%	Outstanding	Passed
26	0	0%	Very Satisfactory	Passed
24-25	9	18%	Satisfactory	Passed
23	5	10%	Fairly Satisfactory	Passed
0-22	36	72%	Did Not Meet Expectation	Failed
Total	50	100%		
Mean 14.63	**Standard Deviation** 5.84		**Interpretation** Did not meet the expectation	Failed

Table 3 presents the distribution of students' scores on the 30-item diagnostic test. The computed mean score of 14.63 falls within the score range of 0–22, which is interpreted as Did Not Meet Expectations. This result indicates that, on average, students were unable to attain the expected level of performance on the assessment. The standard deviation of 5.84 reflects a wide dispersion of scores around the mean, suggesting substantial variability in learners' performance. Despite this variability, the majority of scores remained clustered within the lower performance range.

Further analysis revealed that 36 out of 50 students (72%) did not meet the expected performance level, whereas only 14 students (28%) obtained passing scores. Notably, none of the respondents achieved performance levels classified as Very Satisfactory or Outstanding. Collectively, these findings indicate low mastery of the assessed mole concept competencies among the learners. The results underscore the presence of significant learning gaps and highlight the need for targeted instructional interventions and remediation strategies to enhance students' conceptual understanding and overall performance in chemistry.

Table 4: Overall Mastery of Competencies

Rank	**Topic**	**MPS**	**Descriptive Equivalent**
1	Calculate molar mass of elements and compounds	27	Not Mastered
2	Apply molar volume of gases at STP	39	Not Mastered
3	Convert mass, mole, and number of particles	56	Least Mastered
4	Apply mole ratios in chemical reactions	56	Least Mastered
5	Apply mole concept in real-life situations and problem solving	56.67	Least Mastered
6	Relate mole to mass using molar mass	58	Least Mastered
7	Use Avogadro's number in counting particles	61	Least Mastered
8	Explain the mole as a unit for measuring amount of substance	77.33	Nearly Mastered

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

Table 4 shows that most competencies related to the mole concept fall within the Least Mastered or Not Mastered categories based on their MPS values. The lowest performance occurred in calculating molar mass and applying molar volume at STP, both classified as Not Mastered, while competencies involving conversions, mole ratios, real-life application, and the use of Avogadro's number were Least Mastered. Only explaining the mole as a unit of measurement reached a Nearly Mastered level, indicating stronger recall of definitions than competence in computation-based tasks.

The results reveal a diagnostic pattern in which students understand the mole at a descriptive level but encounter difficulty when tasks require mathematical integration, symbolic representation, and multi- step reasoning. These weaknesses are consistent with challenges in mathematical readiness, representational competence, and cognitive load, and with misconception patterns such as confusing mass with quantity or relying on rote procedures.

CONCLUSION

The results of this diagnostic investigation reveal substantial gaps in Senior High School learners' mastery of key mole-concept competencies. With 72% of students classified under Did Not Meet Expectation and a mean score of 14.63 (SD = 5.84), the overall performance indicates that most learners have not yet developed the quantitative and representational skills required for proficiency in mole-related problem solving. Competency-level analysis shows that the least mastered areas involve calculating molar mass (MPS = 27) and applying molar volume at STP (MPS = 39), followed by tasks that require sequential numerical conversions, interpretation of symbolic relationships, and application to real-life problem contexts (MPS = 56–58). In contrast, relatively stronger performance in Avogadro-number use and basic definitional understanding suggests that learners are more comfortable with recall-based knowledge than with multi-step analytical reasoning.

These findings indicate that students' difficulties are not limited to content familiarity but are strongly linked to mathematical readiness, representational competence, and cognitive load demands associated with multi-step quantitative operations. Strengthening scaffolded problem-solving routines, explicit connections between symbols and quantities, and guided practice in multi-representation tasks may help reduce the cognitive barriers observed in the least learned competencies.

RECOMMENDATION

Based on the findings, the following recommendations are proposed to address the identified learning gaps in the mole concept:

1. Chemistry teachers should provide targeted remediation on the least mastered competencies, particularly calculating molar mass and applying molar volume at STP, using guided, step-bystep computation activities.
2. Instruction should integrate visual and representational supports, such as particle diagrams, mole–mass–volume conversion maps, and worked-example solutions, to help students connect symbols, quantities, and concepts in multi-step problems.
3. Regular formative assessments and diagnostic checks should be implemented to monitor misconception patterns and provide immediate feedback, allowing teachers to adjust instruction based on specific learning difficulties.
4. Future studies are encouraged to pilot and evaluate instructional innovations—such as contextualized problem-based tasks or structured quantitative skill-building activities—to determine their effectiveness in improving students' mastery of the mole concept.

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