

Three-tiered Multiple-Choice Assessment Tool in Testing Grade 11 STEM Students' Comprehensive Knowledge in General Chemistry 1

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ABSTRACT

This study examined the utilization of a three-tiered multiple-choice assessment in measuring the comprehensive knowledge of Grade 11 STEM students in General Chemistry 1, focusing on conceptual comprehension, critical thinking, and quantitative skills. A descriptive research design was employed involving 34 Grade 11 STEM students from Buenavista National High School, selected through total enumeration. A validated 25-item three-tiered multiple-choice test aligned with the General Chemistry 1 curriculum served as the primary assessment instrument. Quantitative data were analyzed using the median to determine students' levels of comprehensive knowledge, while qualitative data from students' insights were examined through thematic analysis. Findings revealed that students demonstrated moderate to high levels of comprehensive knowledge across the three domains, reflecting a developing yet consistent understanding of chemistry concepts and their applications. The qualitative findings further showed that students perceived the three-tiered assessment as helpful in encouraging deeper critical thinking, identifying misconceptions, and increasing awareness of their reasoning and confidence in their responses. The study concludes that the three-tiered multiple-choice assessment provides a comprehensive and diagnostic approach to evaluating students' chemistry knowledge. Its integration into classroom assessment practices may help teachers identify learning gaps, address misconceptions, and promote more meaningful learning in chemistry education

INTRODUCTION

Assessment plays an important role in improving the quality of science education because it provides evidence of what students know, understand, and can apply. In Chemistry, assessment is particularly important because the subject requires learners to develop not only knowledge of scientific facts but also conceptual understanding, critical thinking, and quantitative skills. Students are expected to explain chemical phenomena, analyze relationships among concepts, interpret information, and solve numerical problems. Therefore, assessment tools should measure these different dimensions of learning rather than focusing primarily on factual recall.

In the Philippines, the Department of Education (DepEd) emphasizes the use of formative and summative assessments that promote meaningful learning and higher-order thinking skills (DepEd, 2015). However, traditional multiple-choice questions (MCQs) remain widely used because they are practical, objective, and easy to administer and score. Despite these advantages, conventional MCQs may provide limited information about students' actual understanding. A student may select the correct answer through guessing, memorization, or incomplete reasoning. As a result, traditional MCQs may not adequately reveal misconceptions or determine the reasoning behind students' responses, particularly in science subjects (Treagust & Chandrasegaran, 2020; Gurel, Eryilmaz, & McDermott, 2021).

This limitation is particularly significant in Chemistry, where students may correctly answer questions involving formulas, definitions, or calculations without fully understanding the underlying concepts. Three-tiered multiple-choice questions provide an alternative assessment approach by incorporating three components: an answer, a reasoning or justification, and a confidence level. This structure allows teachers to determine not only whether students provide correct answers but also whether their reasoning supports their responses and how confident they are in their understanding. Thus, three-tiered assessments can provide a more diagnostic picture of student learning and help identify misconceptions that may not be evident through conventional tests.

Despite their potential, three-tiered MCQs remain less commonly used in Philippine secondary Chemistry classrooms, particularly because of limited localized assessment materials and teachers' exposure to this assessment format. In Buenavista National High School and similar public secondary schools in the Schools Division of Marinduque, General Chemistry 1 assessments largely utilize conventional multiple-choice formats. Although these assessments are useful for measuring student performance, they may not fully capture students' reasoning, misconceptions, and confidence, which are important components of comprehensive knowledge.

Furthermore, while tiered assessments have been examined in science education, there remains a need for localized studies exploring their application among Grade 11 STEM learners in actual Chemistry classroom settings. This highlights the need for an assessment tool that integrates answer selection, reasoning, and confidence to provide teachers with a more comprehensive understanding of student learning.

In response to this gap, the present study developed and utilized a Tiered MCQs Compendium of Assessment in Chemistry following the ADDIE instructional design model. Specifically, the study aimed to develop a three-tiered multiple-choice assessment aligned with the General Chemistry 1 curriculum and measure students' comprehensive knowledge in terms of conceptual understanding, critical thinking, and quantitative understanding. It further sought to assess these three dimensions using the developed three-tiered MCQ structure to obtain a more comprehensive representation of students' knowledge and reasoning.

In addition, the study aimed to elicit students' insights regarding the use of three-tiered MCQs as an assessment tool. Understanding students' perceptions is important because their experiences can provide information about how the assessment influences their reasoning, recognition of misconceptions, confidence, and awareness of their own learning processes. These insights complement quantitative assessment results and provide a learner-centered perspective on the usefulness of the assessment format.

Overall, the study sought not only to measure whether students could arrive at correct answers but also to understand how they reason and how confident they are in their responses. Through the development and utilization of a contextualized three-tiered assessment, the study hopes to contribute to more meaningful and diagnostic assessment practices in General Chemistry 1. Its findings may assist Chemistry teachers in identifying learning gaps and misconceptions, improving instructional interventions, and promoting deeper conceptual, critical, and quantitative understanding among Grade 11 STEM learners.

THEORETICAL REVIEW

This study is anchored in Costa's Levels of Inquiry and the Revised Bloom's Taxonomy, which provide a theoretical basis for assessing students' cognitive processes from basic understanding to higher-order thinking. These frameworks support the use of three-tiered MCQs in assessing comprehensive knowledge in General Chemistry 1.

Costa's Levels of Inquiry

Costa's Levels of Questioning, devised by educational researcher Art Costa, comprised three tiers of questioning intended to foster higher-order thinking and inquiry. Analogous to Bloom's taxonomy, the lower levels of Costa's framework require students to use more fundamental faculties; as learners ascend through the levels, the questions compel the application of increasingly complex cognitive skills.

In the context of this study, Costa's Levels of Inquiry is relevant as it explains why correlation of questions such as TMCQs can be an effective method in assessing comprehensive knowledge in General Chemistry.

Revised Bloom's Taxonomy

This study is also anchored in the Revised Bloom's Taxonomy which organizes cognitive processes from remembering and understanding to applying, analyzing, evaluating, and creating. The framework is relevant because

comprehensive knowledge in General Chemistry 1 requires cognitive skills beyond factual recall. Specifically, conceptual understanding reflects comprehension of chemical principles, quantitative understanding involves the application of concepts in problem-solving, and critical thinking requires analysis and evaluation of information and reasoning. Accordingly, the three-tiered multiple-choice assessment—incorporating answer selection, reasoning, and confidence—provides a structured means of assessing these cognitive dimensions and offers a more comprehensive representation of students' chemistry understanding

Conceptual Framework

The study adopts a researcher-developed Three-Tier Comprehensive Knowledge Assessment Framework, which conceptualizes students' comprehensive knowledge in General Chemistry 1 through three dimensions: conceptual understanding, critical thinking, and quantitative understanding. These dimensions are assessed through a three-tiered structure consisting of answer selection, reasoning or justification, and confidence level. The interaction of these tiers provides a more comprehensive profile of students' knowledge by identifying their level of understanding, reasoning patterns, misconceptions, and confidence. Students' insights further provide a learner-centered perspective on the use of the assessment, thereby informing its implications for Chemistry assessment practices.

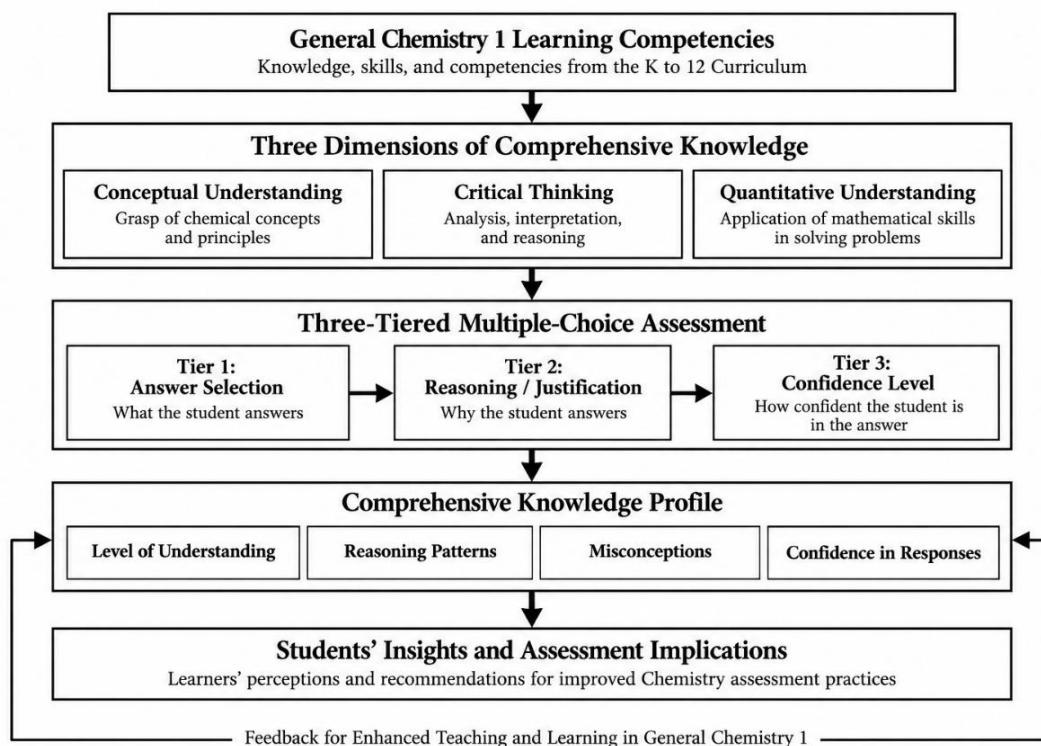


Figure 1. *Conceptual Framework of the Study*

METHODOLOGY

The study employed a descriptive mixed-methods research design to assess Grade 11 STEM students' comprehensive knowledge in General Chemistry 1 in terms of conceptual understanding, critical thinking, and quantitative understanding. A 25-item traditional multiple-choice test and a three-tiered multiple-choice assessment consisting of answer, reasoning, and confidence tiers were developed, validated by experts, and subjected to reliability testing. The traditional MCQ was administered first, followed by the three-tiered assessment after a one-week interval. Students' insights regarding the three-tiered assessment were also gathered through open-ended questions and written reflections.

The study involved 34 Grade 11 STEM students enrolled in General Chemistry 1 at Buenavista National High School during the first semester of SY 2025–2026. Total enumeration was employed; hence, all students in the identified population who participated in the study were included as respondents.

Quantitative data were analyzed using the median to determine students' levels of comprehensive knowledge across the three domains. Mean ratings were used to establish the validity of the assessment instruments, while Cronbach's alpha was used to determine their internal consistency reliability. Students' qualitative responses were analyzed through thematic analysis, involving coding, grouping related responses, and identifying recurring themes regarding the effectiveness, difficulty, and usefulness of the three-tiered assessment.

RESEARCH RESULTS

To establish students' baseline level of comprehensive knowledge in General Chemistry 1, the researcher initially administered a traditional multiple-choice question (MCQ) test. The assessment measured students' performance across three domains: conceptual understanding, critical thinking, and quantitative understanding. Results from the conventional MCQ served as an initial representation of students' chemistry knowledge based on answer accuracy. These findings were subsequently examined alongside the results of the three-tiered multiple-choice questions (TTMCQs), which incorporated answer selection, reasoning, and confidence to provide a more comprehensive and diagnostic assessment of students' understanding.

Table 1 shows that students demonstrated an overall moderate level of conceptual understanding (Mdn = 35), indicating adequate foundational knowledge but incomplete mastery of chemistry concepts. Higher understanding was observed in selected domains, particularly *Limiting Reagents*, *Ideal Gas Law and Gas Mixtures*, and *Biomolecules and Organic Synthesis*, while most domains remained at the moderate level. This pattern suggests continuing difficulty in integrating abstract, symbolic, and molecular-level concepts, consistent with studies reporting challenges in learning chemistry topics that require multiple representations and conceptual connections (George et al., 2021; Pinto et al., 2023). From the perspectives of Bloom's Taxonomy and Costa's Levels of Inquiry, the findings suggest that students generally demonstrate basic conceptual comprehension but require further development toward higher-order analysis

and independent reasoning. This supports the view that meaningful chemistry learning depends on progressively connecting foundational concepts into coherent knowledge structures (Guidang, 2016; Liu et al., 2024). Overall, the findings indicate developing conceptual understanding and highlight the need to strengthen conceptual integration and higher-order reasoning to achieve more comprehensive knowledge.

Table 1. Students' Level of Comprehensive Knowledge in terms of Conceptual Understanding

Test	Content Domain	Median	Interpretation
1	Properties of Matter and Consumer Chemistry	35	High Understanding
2	Atomic Structure and Chemical Formulas	35	Moderate Understanding
3	Chemical Reactions and Stoichiometry	30	Moderate Understanding
4	Limiting Reagents	37.50	High Understanding
5	Mass Relationships in Reactions	32.50	Moderate Understanding
6	Gas Laws	35	Moderate Understanding
7	Ideal Gas Law and Gas Mixtures	40	High Understanding
8	Gas Stoichiometry and Effusion	35	Moderate Understanding
9	Quantum Mechanical Model of the Atom	35	Moderate Understanding
10	Ionic and Covalent Bond Formation	35	Moderate Understanding
11	Molecular Structure and Geometry	30	Moderate Understanding
12	Molecular Polarity and Organic Functional Groups	32.50	Moderate Understanding
13	Organic Reactions and Polymers	32.50	Moderate Understanding
14	Biomolecules and Organic Synthesis	37.50	High Understanding
Median		35	Moderate Understanding

**Highest Possible Score=60 points*

Legend: 0-11 - Very Low Understanding, 12-23 - Low Understanding, 24-35 - Moderate Understanding, 36-47 - High Understanding, 48-60 - Complete Understanding

Table 2 shows that students demonstrated an overall high level of critical thinking (Mdn = 31.25), indicating strong abilities to analyze, interpret, and apply chemical concepts. Complete understanding was observed in seven domains,

particularly *Ideal Gas Law*, *Gas Mixtures*, and *Ionic and Covalent Bond Formation*, suggesting stronger performance in topics involving structured relationships and logical patterns. This finding supports studies showing that organized and interconnected chemistry concepts facilitate analytical reasoning and problem-solving (Pal & Chattaraj, 2023; Putz, 2021). In contrast, domains involving more complex, multi-step reasoning showed comparatively lower performance, with Biomolecules and Organic Synthesis having the lowest median (Mdn = 25). Such difficulty is consistent with the greater cognitive demands associated with molecular interactions, organic transformations, and predictive reasoning (Dai, 2021; Pal & Chattaraj, 2023). Overall, students demonstrated well-developed critical thinking, although they need further support with chemistry concepts that require complex, abstract, multi-step reasoning.

Table 2. Students' Level of Comprehensive Knowledge in Terms of Critical Thinking

Test	Content Domain	Median	Interpretation
1	Properties of Matter and Consumer Chemistry	32.50	Complete Understanding
2	Atomic Structure and Chemical Formulas	34.50	Complete Understanding
3	Chemical Reactions and Stoichiometry	30	High Understanding
4	Limiting Reagents	27.50	High Understanding
5	Mass Relationships in Reactions	30	High Understanding
6	Gas Laws	32.50	Complete Understanding
7	Ideal Gas Law and Gas Mixtures	35	Complete Understanding
8	Gas Stoichiometry and Effusion	33.50	Complete Understanding
9	Quantum Mechanical Model of the Atom	30	High Understanding
10	Ionic and Covalent Bond Formation	35	Complete Understanding
11	Molecular Structure and Geometry	32.50	Complete Understanding
12	Molecular Polarity and Organic Functional Groups	30	High Understanding
13	Organic Reactions and Polymers	30	High Understanding
14	Biomolecules and Organic Synthesis	25	High Understanding
Median		31.25	High Understanding

*Highest Possible Score=40 points

*Legend: 0–7 – Very Low Understanding, 8–15 – Low Understanding, 16–23 – Moderate Understanding, 24–31 – High Understanding, 32–40 – Complete Understanding

Table 3 shows that students demonstrated an overall high level of quantitative understanding (Mdn = 18.5), indicating strong ability to interpret numerical relationships, apply formulas, and solve chemistry problems. Complete understanding was observed in *Mass Relationships in Reactions*, *Ionic and Covalent Bond Formation*, and *Molecular Polarity and Organic Functional Groups* (Mdn = 20), suggesting stronger performance in tasks involving structured procedures and direct quantitative relationships. In contrast, the remaining domains showed high understanding, with comparatively lower performance in *Atomic Structure and Chemical Formulas* and *Gas Laws* (Mdn = 15). These results suggest greater difficulty when problems require multiple variables, conceptual interpretation, and integration of abstract chemical principles. This pattern supports findings that quantitative chemistry becomes more challenging when students must simultaneously integrate mathematical, symbolic, and conceptual representations (Liu, 2023; Merone et al., 2021). Overall, students showed strong quantitative understanding but may need further support applying numerical skills to complex, conceptually demanding problems.

Table 3. Students' Level of Comprehensive Knowledge in Terms of Quantitative Understanding

Test	Content Domain	Median	Interpretation
1	Properties of Matter and Consumer Chemistry	17.5	High Understanding
2	Atomic Structure and Chemical Formulas	15	High Understanding
3	Chemical Reactions and Stoichiometry	19	High Understanding
4	Limiting Reagents	17	High Understanding
5	Mass Relationships in Reactions	20	Complete Understanding
6	Gas Laws	15	High Understanding
7	Ideal Gas Law and Gas Mixtures	19	High Understanding
8	Gas Stoichiometry and Effusion	18	High Understanding
9	Quantum Mechanical Model of the Atom	18	High Understanding
10	Ionic and Covalent Bond Formation	20	Complete Understanding
11	Molecular Structure and Geometry	19	High Understanding
12	Molecular Polarity and Organic Functional Groups	20	Complete Understanding
13	Organic Reactions and Polymers	16	High Understanding
14	Biomolecules and Organic Synthesis	19	High Understanding
Average Mean		18.5	High Understanding

*Highest Possible Score=25 points

*Legend: 0-4 - Very Low Understanding, 5-9 - Low Understanding, 10-14 - Moderate Understanding, 15-19 - High Understanding, 20-25 - Complete Understanding

Instrument

The study utilized a Three-Tiered Multiple-Choice Questions (TTMCQ) Test designed to provide a more comprehensive and diagnostic assessment of students' knowledge in General Chemistry 1. Each item consisted of three interconnected tiers that assessed not only the correctness of students' responses but also their reasoning and confidence.

Tier 1 - Content/Answer Tier. This tier presented a multiple-choice chemistry question that required students to select the correct answer from the given options. It primarily measured students' knowledge and ability to understand, apply, or analyze chemistry concepts and solve quantitative problems.

Tier 2 - Reasoning/Justification Tier. This tier required students to select the scientific explanation or reasoning that best supported their Tier 1 response. It was intended to determine whether a correct answer was supported by appropriate conceptual reasoning and to help identify incomplete understanding or misconceptions.

Tier 3 - Confidence Tier. This tier measured students' confidence in their answer and reasoning using a five-point scale, ranging from 1 (Still exploring) to 5 (Very confident). The confidence rating provided information about students' certainty regarding their knowledge and supported the identification of responses characterized by confidence, uncertainty, or possible misconceptions.

Taken together, the three tiers provided a more comprehensive assessment by examining what students know, why they selected their answers, and how confident they are in their understanding.

Table 4. Sample Questions from the Tiered MCQ

Tier 1	Tier 2	Tier 3
A reaction produces 12 g actual yield from 15 g theoretical yield. What is the percent yield?	Why is this calculation correct? A. Percent yield compares actual yield to theoretical yield using a ratio B. Percent yield is calculated using $(\text{theoretical} \div \text{actual}) \times 100$ C. Percent yield ignores theoretical values in calculations D. D. Percent yield depends only on product mass	How confident are you in your answer and explanation? • 5 – Very confident • 4 – Confident • 3– Somewhat confident • 2 – Learning more • 1 – Still exploring
If the theoretical yield is 40 g and percent yield is 125%, what is the actual yield?	Why is this possible in calculations?	How confident are you in your answer and explanation?

A. 45 g	A. Percent yield greater than 100% indicates experimental error or impurities	☐ 5 – Very confident
B. 50 g	B. Percent yield greater than 100% is always correct in ideal reactions	☐ 4 – Confident
C. 55 g	C. Percent yield depends only on reactant mass	☐ 3 – Somewhat confident
D. 60 g	D. Percent yield ignores theoretical yield limits	☐ 2 – Learning more
		☐ 1 – Still exploring

Scoring Guide

The Three-Tiered Multiple-Choice Questions (TTMCQ) Scoring Guide was developed to classify students' level of understanding based on the combined results of the three assessment tiers: answer accuracy, reasoning accuracy, and confidence level. Rather than assigning scores solely on the correctness of the answer, the scoring scheme considers whether students can provide appropriate scientific reasoning and demonstrate confidence in their knowledge. Scores range from 1 to 5, representing levels from No Understanding to Complete Understanding. This approach enables the assessment to distinguish complete understanding, partial understanding with or without misconceptions, alternative conceptions, and lack of understanding, thereby providing a more diagnostic representation of students' comprehensive knowledge in chemistry.

Table 5. Scoring Guide

Tier 1- Answer	Tier 2- Reasoning	Tier 3- Confidence	Level	Notes/ Explanation of Student Level
Correct	Correct	5	5 – Complete Understanding	Student fully understands the concept, gives correct reasoning, and is very confident. Shows mastery and clear metacognition.
Correct	Correct	3-4	4 – Partial Understanding (No Misconception)	Student understands the concept and reasoning is correct, but confidence is moderate. Knowledge is

				accurate but not fully assured.
Correct	Correct	1-2	4 – Partial Understanding (No Misconception)	Student knows the answer and reasoning but lacks confidence. Understanding is correct but metacognitive awareness is low.
Correct	Incorrect	3-5	3 – Partial Understanding (With Misconception)	Student knows the answer, but reasoning is flawed or incomplete. Shows some misconceptions, though confidence is moderate to high.
Correct	Incorrect	1-2	3 – Partial Understanding (With Misconception)	Student answers correctly but cannot explain why, and lacks confidence. Understanding is superficial or inconsistent.
Incorrect	Correct	3-5	3 – Partial Understanding (With Misconception)	Student answers incorrectly but reasoning is partially correct. Shows mixed understanding; may be transitioning from misconceptions.
Incorrect	Correct	1-2	3 – Partial Understanding (With Misconception)	Student chooses wrong answer, but reasoning is partially correct, lacks confidence. Mixed understanding with low metacognition.
Incorrect	Incorrect	3-5	2 – Alternative Conception	Student has incorrect answer and reasoning but is confident. Holds misconceptions;

				confident in a wrong mental model.
				Student guesses or is confused. Minimal understanding and low confidence; shows lack of conceptual knowledge.
Incorrect	Incorrect	1-2	1 - No Understanding	

Table 6 shows that students demonstrated an overall moderate level of conceptual understanding (Mdn = 27) across all content domains using the three-tiered multiple-choice assessment. This suggests that students possess essential conceptual foundations but have not yet achieved consistent mastery. Unlike conventional MCQs, the three-tiered format evaluates answer accuracy, scientific reasoning, and confidence, thereby distinguishing genuine understanding from guessing or fragmented knowledge. The moderate performance indicates that students may recognize chemistry concepts but struggle to justify and confidently explain their responses, reflecting developing rather than complete conceptual understanding. This supports the diagnostic value of three-tiered assessments in distinguishing correct knowledge from misconceptions or partial understanding. Consistent with Bloom's Taxonomy, the findings further suggest a need to strengthen students' progression from recognition and understanding toward deeper analysis and evaluation. Overall, the three-tiered assessment provided a more diagnostic representation of students' conceptual understanding by examining not only what students know but also the reasoning and confidence underlying their responses.

Table 6. Students' Level of Comprehensive Knowledge as Measured by Three-Tiered MCQs in Terms of Conceptual Understanding

Test	Content Domain	Median	Interpretation
1	Properties of Matter and Consumer Chemistry	23.5	Moderate Understanding
2	Atomic Structure and Chemical Formulas	24	Moderate Understanding
3	Chemical Reactions and Stoichiometry	25	Moderate Understanding
4	Limiting Reagents	27	Moderate Understanding
5	Mass Relationships in Reactions	27.5	Moderate Understanding
6	Gas Laws	25	Moderate Understanding
7	Ideal Gas Law and Gas Mixtures	26.5	Moderate Understanding

8	Gas Stoichiometry and Effusion	28.5	Moderate Understanding
9	Quantum Mechanical Model of the Atom	25	Moderate Understanding
10	Ionic and Covalent Bond Formation	27.5	Moderate Understanding
11	Molecular Structure and Geometry	31.5	Moderate Understanding
12	Molecular Polarity and Organic Functional Groups	28	Moderate Understanding
13	Organic Reactions and Polymers	27	Moderate Understanding
14	Biomolecules and Organic Synthesis	27	Moderate Understanding
Median		27	Moderate Understanding

*Highest Possible Score=60 points

*Legend: 0–11 – Very Low Understanding, 12–23 – Low Understanding, 24–35 – Moderate Understanding, 36–47 – High Understanding, 48–60 – Complete Understanding

Table 7 shows that students demonstrated an overall moderate level of critical thinking (Mdn = 22) using the three-tiered multiple-choice assessment. Most content domains remained at the moderate level, while *Limiting Reagents*, *Ideal Gas Law and Gas Mixtures*, and *Molecular Polarity and Organic Functional Groups* reached high understanding, suggesting stronger performance in areas involving structured and familiar problem-solving processes. The moderate overall performance indicates that students can analyze and apply chemistry concepts but still struggle to evaluate, justify, and defend their reasoning. The three-tiered format makes these limitations more evident by considering not only answer correctness but also the quality of reasoning and confidence in the response. This supports the view that critical thinking involves reasoned judgment and self-regulation rather than merely obtaining correct answers (Nandagopal & Zohar, 2020; de los Santos, 2025). Overall, the findings indicate that students' critical thinking remains developing and highlight the diagnostic value of three-tiered assessment in revealing the reasoning and certainty underlying their responses

Table 7. Students' Level of Comprehensive Knowledge as Measured by Three-Tiered MCQs in Terms of Critical Thinking

Test	Content Domain	Median	Interpretation
1	Properties of Matter and Consumer Chemistry	22.5	Moderate Understanding
2	Atomic Structure and Chemical Formulas	21	Moderate Understanding
3	Chemical Reactions and Stoichiometry	22	Moderate Understanding
4	Limiting Reagents	23.5	High Understanding
5	Mass Relationships in Reactions	21	Moderate Understanding
6	Gas Laws	23	Moderate Understanding
7	Ideal Gas Law and Gas Mixtures	24	High Understanding
8	Gas Stoichiometry and Effusion	21.5	Moderate Understanding
9	Quantum Mechanical Model of the Atom	23	Moderate Understanding
10	Ionic and Covalent Bond Formation	22	Moderate Understanding
11	Molecular Structure and Geometry	21	Moderate Understanding
12	Molecular Polarity and Organic Functional Groups	24	High Understanding
13	Organic Reactions and Polymers	21	Moderate Understanding
14	Biomolecules and Organic Synthesis	23	Moderate Understanding
Median		22	Moderate Understanding

**Highest Possible Score=40 points*

**Legend: 0–7 – Very Low Understanding, 8–15 – Low Understanding, 16–23 – Moderate Understanding, 24–31 – High Understanding, 32–40 – Complete Understanding*

Table 8 shows that students demonstrated an overall moderate level of quantitative understanding (Mdn = 13) using the three-tiered multiple-choice assessment, with all content domains similarly classified as moderate. This suggests that students have basic computational skills but struggle to explain and justify the quantitative reasoning behind their solutions. The three-tiered format revealed that correct computations do not necessarily reflect complete understanding, as students must align their answers with appropriate reasoning and confidence. This supports the view that quantitative reasoning extends beyond mathematical operations to include interpretation and logical analysis of numerical relationships (Peretz et al., 2023). From the perspective of Bloom's

Taxonomy, students appear more proficient at the application level but require further development in analysis and evaluation. Overall, the findings indicate that students' quantitative understanding remains largely procedural and developing, while demonstrating the diagnostic value of three-tiered assessment in identifying gaps among computation, reasoning, and confidence.

Table 8. Students' Level of Comprehensive Knowledge as Measured by Three-Tiered MCQs in Terms of Quantitative Understanding

Test	Content Domain	Median	Interpretation
1	Properties of Matter and Consumer Chemistry	12.50	Moderate Understanding
2	Atomic Structure and Chemical Formulas	14	Moderate Understanding
3	Chemical Reactions and Stoichiometry	14	Moderate Understanding
4	Limiting Reagents	13.50	Moderate Understanding
5	Mass Relationships in Reactions	12.5	Moderate Understanding
6	Gas Laws	13	Moderate Understanding
7	Ideal Gas Law and Gas Mixtures	12	Moderate Understanding
8	Gas Stoichiometry and Effusion	13	Moderate Understanding
9	Quantum Mechanical Model of the Atom	14	Moderate Understanding
10	Ionic and Covalent Bond Formation	13	Moderate Understanding
11	Molecular Structure and Geometry	12	Moderate Understanding
12	Molecular Polarity and Organic Functional Groups	13	Moderate Understanding
13	Organic Reactions and Polymers	13	Moderate Understanding
14	Biomolecules and Organic Synthesis	14	Moderate Understanding
Median		13	Moderate Understanding

*Highest Possible Score=25 points

*Legend: 0-4 – Very Low Understanding, 5-9 – Low Understanding, 10-14 – Moderate Understanding, 15-19 – High Understanding, 20-25 – Complete Understanding

To complement the quantitative findings, a qualitative analysis explored students' insights and experiences with the use of the Three-Tiered Multiple-Choice Questions (TTMCQs) as an assessment tool. Responses from the 34 students were analyzed thematically to identify recurring patterns related to their thinking, reasoning, and learning experiences.

Table 9. Emerging Themes on Students' Insights Regarding the Use of the Three-Tiered Multiple-Choice Questions Test as an Assessment

Code	Frequency	Percentage
Higher-Order Thinking Requirement	29	85.29
Reduction of Guessing and Increased Answer Accountability	26	76.74
Revealing True Conceptual Understanding	24	70.59
Identification of Misconceptions	22	64.71
Challenging but Valid Assessment Experience	27	79.41
Development of Metacognitive Awareness	23	67.65
Diagnostic Learning Function	21	61.76
Increased Cognitive Load and Time Demand	18	52.94
Preference for Meaningful Assessment	20	58.82
Assessment as a Learning Tool	25	73.53

The results from the 34 student respondents reveal generally positive and reflective insights regarding the use of TTMCQs as an assessment tool. Their responses highlight how the assessment format influenced their thinking processes, awareness of understanding, and evaluation of their own learning in chemistry. Three (3) major themes emerged: (1) higher-order thinking and reasoning demands, (2) reduction of guessing and exposure of the true understanding, and (3) development of metacognitive awareness and learning reflection.

A dominant insight among the 34 learners is that TTMCQs require deeper cognitive engagement compared to traditional multiple-choice tests. Students emphasized that they could not rely on memorization or surface-level recall because they were required to justify their answers and evaluate their confidence. One student stated,

"Hindi siya basta pili lang ng sagot, kailangan mo talagang ipaliwanag kung bakit tama." (It is not just choosing an answer; you really need to explain why it is correct.)

This indicates that students recognized the shift from recall-based assessment to reasoning-based evaluation. It aligns with Bloom, Benjamin S.'s taxonomy, where higher-order thinking involves analysis and evaluation rather than simple remembering and understanding. Another learner added,

"Mas mahirap siya pero mas naiintindihan ko yung lesson habang sumasagot." ("It is harder, but I understand the lesson more while answering.")

This suggests that the assessment also functioned as a learning process, not just an evaluative tool.

Another strong theme is the reduction of guessing behavior as well as increased accountability. Students repeatedly expressed that guessing was no

longer an effective strategy because answers required justification and confidence. A student remarked,

"Hindi ka makakahula kasi kailangan mo ipaliwanag yung sagot mo." ("You cannot just guess because you need to explain your answer.")

This shows that the TTMCQ structure discouraged random selection and promoted responsibility for responses. Another student stated,

"Dito malalaman kung alam mo talaga o hula lang." ("Here, you will know if you really know it or you are just guessing.")

These responses reflect that the assessment increased the authenticity of student performance by minimizing chance-based success. According to Türkoguz (2020), multi-tier diagnostic instruments are designed to uncover students' understanding by requiring justification, making guessing less influential in determining performance.

The third major insight involves true understanding and exposure to misconceptions. Many students reported that they initially believed they understood the lesson, but the reasoning tier revealed gaps in their knowledge. One learner shared,

"Akala ko tama ako, pero nung pinapaliwanag na, doon ko nalaman na mali pala." ("I thought I was correct, but when I had to explain it, I realized I was wrong.")

This indicates that TTMCQs effectively uncover conceptual misunderstandings that are often hidden in traditional MCQs. Another student noted,

"May mga sagot ako na confident ako, pero mali pala yung reasoning ko." ("I had answers I was confident about, but my reasoning was actually wrong.")

This demonstrates that confidence alone does not guarantee conceptual accuracy, reinforcing the diagnostic value of the assessment. This also supports Türkoguz (2020), who emphasized that multi-tier assessments provide more authentic measures of student understanding by distinguishing between correct answers and correct reasoning.

In addition, students highlighted self-reflection and the development of metacognitive awareness through the confidence tier. Several learners mentioned that the test made them evaluate how certain they were about their answers. A student stated,

"Napaisip ako kung sigurado ba talaga ako sa sagot ko." ("It made me think if I am really sure about my answer.")

This reflects the role of TTMCQs in promoting metacognition, as students must assess not only what they know but also how certain they are about their knowledge. This aligns with the idea that effective assessment should develop self-regulated learning and awareness of one's own thinking process.

Moreover, the responses of the learners indicate that TTMCQs are perceived as a more meaningful and reflective assessment tool compared to traditional MCQs. Although students described the test as more challenging, they consistently recognized its value in revealing real understanding, reducing guessing, and improving learning. The integration of answer selection, reasoning, and confidence judgment allowed students to engage in deeper thinking and self-assessment. As one learner summarized,

"Mas maganda ito kaysa normal na exam kasi dito talaga makikita kung alam mo o hindi." ("This is better than a normal exam because it really shows whether you understand or not.")

These findings confirm that TTMCQs not only function as an assessment tool but also as learning experience that promotes deeper understanding, reflection, and conceptual awareness among students in chemistry.

DISCUSSION

From the interpretations and analyses of the data obtained, the following findings are hereby shown:

1. Comprehensive knowledge students generally demonstrate a moderate to high level of understanding across conceptual, critical thinking, and quantitative domains. Critical thinking emerged as the strongest area, while conceptual understanding and quantitative understanding were relatively weaker. This indicates that students perform better in recall-based and structured analytical tasks but still struggle with deeper conceptual integration and complex quantitative reasoning. The results also suggest that traditional assessments tend to capture surface level to moderately developed understanding rather than fully integrated conceptual mastery.
2. The development and validation of the TTMCQs revealed that the instrument is psychometrically sound, valid, and reliable, with moderately difficult items, excellent discrimination indices, highly functional distractors, and excellent internal consistency ($\alpha = 0.93$). These results confirm that TTMCQ is an effective assessment tool that differentiates student ability levels while minimizing guessing. The test structure ensures responses reflect not only correctness but also reasoning and confidence, making it a more diagnostic form of assessment than traditional MCQs.
3. Comprehensive knowledge using TTMCQs (consistently yielded a moderate level of performance across all domains, with noticeably lower results compared to students' results in the first exam. This indicates that while students may answer correctly in conventional tests, their understanding becomes less stable when required to justify answers and evaluate confidence. The TTMCQ results reveal gaps in conceptual integration, inconsistent reasoning in critical thinking tasks, and procedural dependence in quantitative problem-solving.
4. Students' insights on using the TTMCQs reveal generally positive and reflective perceptions. Learners emphasized that the assessment required higher-order thinking, reduced guessing, exposed misconceptions, and promoted metacognitive awareness. Although described as more difficult, students perceived the test as fairer and more meaningful because it revealed their true understanding rather than relying on memorization or guessing.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings, the researcher concludes that:

1. Students demonstrate a moderate to high comprehensive knowledge level in chemistry across conceptual understanding, critical thinking, and quantitative understanding. Students are more proficient in recall and structured analysis but still need further development in deeper conceptual integration and quantitative reasoning.
2. The TTMCQs were found to be valid, reliable, and psychometrically sound, with appropriate difficulty levels, strong discrimination indices, highly functional distractors, and excellent internal consistency confirming that the instrument is effective in measuring student understanding through correctness, reasoning, and confidence.
3. Students' performance using TTMCQs shows a consistent moderate level across conceptual, critical thinking, and quantitative domains, indicating that learners are still developing deeper understanding and highlighting difficulties in fully integrating concepts, consistently applying reasoning, and supporting quantitative solutions with clear justification.
4. Students expressed positive and reflective views on the use of TTMCQs, noting that it encourages higher-order thinking, reduces guessing, reveals misconceptions, and promotes self-awareness in learning, despite being more challenging.

Based on the findings, the following recommendations are hereby recommended:

1. TTMCQs may be used as tool for assessing students' conceptual understanding, critical thinking, and quantitative reasoning in a more diagnostic manner. Teachers may consider integrating them with other assessment forms to obtain a more comprehensive picture of student learning.
2. TTMCQs may be utilized to evaluate deeper understanding, reasoning, and confidence in responses, while Traditional MCQs may still be used for assessing basic recall and foundational knowledge.
3. Instructional strategies may be strengthened to further develop students' conceptual understanding, critical thinking, quantitative reasoning, and retention, particularly through structured and spaced learning activities that reinforce key concepts.
4. Classroom instruction should emphasize justification and explanation of answers, along with regular practice in problem-solving and retrieval exercises, to support deeper understanding and long-term retention of concepts.
5. Teachers are encouraged to use TTMCQs not only for summative assessment but also for formative purposes, as these can help identify misconceptions, monitor student confidence, and provide meaningful feedback for learning improvement.
6. Future assessment practices should be aligned with higher-order thinking skills, ensuring that test design discourages guessing and encourages students to demonstrate clear reasoning and understanding of concepts.

FURTHER STUDY

Future research is recommended to further explore the effectiveness of Three-Tier MCQs across different subjects, grade levels, and educational settings, as well as their impact on long-term retention and academic achievement, preferably with larger sample sizes for broader generalization.

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