American Journal of Educational Research, 2026, Vol. 14, No. 5, 125-133
Available online at http://pubs.sciepub.com/education/14/5/1
Published by Science and Education Publishing
DOI:10.12691/education-14-5-1

Student Experiences with AI-Assisted Chemistry Learning in Public Secondary Schools

Katherine Joy G. Reyes[1,*], Maria Teresa M. Fajardo[2]

[1]Natural Sciences Department, Bukidnon State University, Malaybalay City, 8700, Philippines
[2]Department of Science Education, University of Science and Technology of Southern Philippines, Cagayan de Oro City, 9000, Philippines
*Corresponding author: katherinejoyreyes@buksu.edu.ph

Received April 13, 2026; Revised May 15, 2026; Accepted May 22, 2026

Abstract This qualitative descriptive study explored secondary students' experiences of chemistry learning and AI-assisted academic support in selected public schools in Malaybalay City, Bukidnon, Philippines. Data consisted of 78 coded student excerpts drawn from a student qualitative response matrix organized across 14 semi-structured prompts; these excerpts were analyzed thematically following Braun and Clarke and interpreted through constructivist learning theory. Findings are organized around four analytic areas. First, students' cognitive and representational difficulties intensified when lessons shifted from recall to application, particularly in equations, problem-solving, balancing reactions, formula substitution, and use of the periodic table. Second, teacher explanation remained the primary trusted scaffold because it offered step-by-step clarification, local language mediation, examples, feedback, and verification. Third, AI and digital tools such as ChatGPT, Gemini, Bing, Copilot, PhET simulations, and selected productivity tools were used unevenly as supplementary aids for explanations, examples, reports, and clarification. Fourth, students valued AI when it made complex topics faster, clearer, or more relatable, but questioned it when responses were inaccurate, lengthy, not step-by-step, English-heavy, or constrained by weak internet and limited device access. The findings suggest that AI can support chemistry learning when it is guided, localized, verified, and integrated with teacher-mediated instruction rather than treated as a replacement for classroom explanation.

Keywords: *artificial intelligence, AI literacy, AI-assisted learning, qualitative descriptive study, student learning difficulties, teacher mediation, thematic analysis*

Cite This Article: Katherine Joy G. Reyes, and Maria Teresa M. Fajardo, "Student Experiences with AI-Assisted Chemistry Learning in Public Secondary Schools." *American Journal of Educational Research*, vol. 14, no. 5 (2026): 125-133. doi: 10.12691/education-14-5-1.

1. Introduction

Chemistry is the branch of science that studies matter, its composition, structure, properties, changes, and the energy involved in those changes. As a school subject, it involves understanding substances, atoms, elements, compounds, reactions, formulas, equations, laboratory processes, and quantitative problem-solving. Chemistry remains a demanding school subject because learners must coordinate multiple forms of knowledge simultaneously, including observable phenomena, particle-level explanations, symbolic notations, and quantitative reasoning. In high school classrooms, these representational demands can make chemistry appear fragmented, especially when students can identify terms but cannot translate them into equations, solve unfamiliar problems, or connect formulas with chemical meaning. Classic and contemporary chemistry education researchers explain this difficulty through the need to coordinate macroscopic, submicroscopic, and symbolic representations [1,2]. More recent work on representational competence further shows that students need explicit support in translating among equations, diagrams, symbols, and verbal explanations because these representations do not automatically become meaningful to novice learners [3]. Students' difficulty in chemistry is therefore not limited to lack of effort; rather, it reflects the significant cognitive, symbolic, and procedural demands involved in building coherent mental models from symbols, diagrams, formulas, and explanations.

Artificial intelligence (AI) tools are changing the instructional landscape as potential supports for personalized explanation, adaptive feedback, visualization, problem generation, and independent study. Educational AI and intelligent tutoring systems can provide responsive feedback and additional opportunities for practice [4,5], while generative AI tools are increasingly discussed as supports for science and chemistry instruction when used with careful prompting and teacher oversight [6,7,8,9]. However, AI use also raises concerns about accuracy, overreliance, privacy, bias, academic integrity, hallucinated content, and the need for teacher mediation

[10,11,12]. In chemistry, students must understand the reasoning behind AI-generated answers because plausible but incorrect outputs can reinforce misconceptions when they are accepted without verification. Teacher guidance is therefore necessary to ensure that AI supports meaningful learning rather than superficial answer retrieval.

The current paper examines students' learning difficulties and experiences with AI-assisted learning in high school chemistry. Grounded in constructivist perspectives on learning, the study focuses on how students make sense of chemistry concepts, how they use AI-assisted tools to support their learning, and what forms of instructional support help or hinder their understanding. The study is deliberately qualitative in orientation, privileging students' explanations, experiences, and meaning-making, rather than statistical prediction.

The local context is central to the study because the participating schools were located in urban, peri-urban, and rural areas of Malaybalay City, Bukidnon. This variation reflects broader digital divide and educational equity concerns: students' ability to benefit from AI depends not only on the availability of tools but also on device access, internet stability, language accessibility, confidence in using digital resources, teacher readiness, and school-level support [13,14,15]. By examining resource-varied public school contexts, the study positions AI-assisted chemistry learning as an issue of both instructional innovation and equitable access.

The study was guided by the following research questions:

RQ1. How do students describe their difficulties learning chemistry, particularly in relation to prior knowledge, problem-solving, representation tools, and instructional support?

RQ2. How do students use, evaluate, and verify AI-generated or digitally mediated support in chemistry learning?

2. Review of Related Literature

2.1. Chemistry Learning Difficulties and Representational Competence

Chemistry learning difficulties are commonly explained through the complex interaction of conceptual understanding, symbolic representation, quantitative reasoning, prior knowledge, and language demands. The chemistry triplet emphasizes that learners must connect observable events, particle-level explanations, and symbolic forms such as formulas and equations [1,2]. Representational competence is therefore central to chemistry learning because students must not only recognize symbols and equations but also translate among different forms of chemical information [3]. Literature on science learning further suggests that when foundational concepts are weak or disconnected from application, students may memorize terms without developing transferable understanding [16,17].

The additional literature also emphasizes the value of relevance, contextualization, and structured learning support. Studies in bioscience and health science education show that students understand difficult science content more effectively when instructors explicitly connect abstract ideas to real-world or discipline-based applications [18,19]. Although these studies are not all chemistry-specific, they strengthen the present study's assumption that chemistry difficulty should be interpreted as a problem of transfer and application, not simply content exposure. For secondary chemistry, this means that problem-solving, balancing equations, using the periodic table, and interpreting formulas require guided bridges between prior knowledge and new chemical reasoning.

2.2. Affective and Inclusive Dimensions of Chemistry Learning

Learning difficulty in chemistry is also affective and social. Students who experience confusion, low confidence, or fear of asking questions may disengage from the classroom interactions that could support understanding. Literature on science learning interventions suggests that study-skills support, self-efficacy building, pacing adjustments, and structured feedback can reduce early learning barriers [16,17]. Inclusive pedagogy is likewise important because accessibility, language support, and anti-exclusionary instructional practices shape who can participate meaningfully in science learning. These insights are relevant to public secondary classrooms where students' confidence, language comfort, and access to learning resources vary.

2.3. AI-Assisted Learning and Generative AI in Science and Chemistry Education

AI-assisted learning has expanded from adaptive tutoring and automated feedback toward generative tools capable of producing explanations, examples, lesson materials, laboratory activities, visuals, and practice tasks [4,5,7,8] [14,20,21]. Systematic reviews of AI in science education report promising instructional affordances, including personalization, feedback, and support for inquiry, but they also emphasize the need for teacher guidance and critical evaluation [4,10,11,12,25,30,32]. In chemistry education, recent work has examined the use of ChatGPT and generative AI for chemistry laboratory teaching, prompt-based activity generation, chemistry visuals, and implications for teaching and learning [8,9,20,21]. These studies suggest that generative AI can support chemistry learning, but only when disciplinary accuracy, safety, and pedagogical alignment are checked by knowledgeable teachers.

At the same time, generative AI introduces discipline-specific risks. Chemistry content may involve incorrect equations, unsafe laboratory suggestions, inaccurate visualizations, incomplete mechanisms, or plausible explanations that hide faulty reasoning. Research on ChatGPT-generated science lesson plans and AI-supported teaching materials warns that outputs may be useful starting points but require expert review before classroom use [8,22]. For students, this means that AI should not be treated as a final authority. It should be used as a scaffold for explanation, practice, and comparison under teacher guidance.

2.4. Teacher Mediation, Trust, and Verification

Teacher mediation remains central in AI-assisted learning because teachers contextualize information, align tasks with curriculum, interpret student misconceptions, and validate the accuracy of AI-generated outputs. Literature on AI and education increasingly frames productive classroom use as a teacher-AI-student interaction in which the teacher remains the pedagogical and ethical guide while AI supports routine explanation, practice generation, and resource creation [23,24]. Teacher preparation studies further argue that educators need AI-related pedagogical content knowledge, prompt design skills, and critical AI literacy to use generative AI responsibly [25,31].

Trust is therefore not a simple matter of accepting or rejecting AI. In AI-assisted chemistry learning, trust should be calibrated: students need enough confidence to use AI as a support for explanation and practice, but enough caution to question its answers, compare sources, and inspect the chemistry reasoning. Recent work on AI-powered educational technology shows that student trust influences perceived usefulness and readiness to adopt AI tools, while studies of students' verification practices show that frequent AI use may coexist with limited verification and uncertainty about accuracy [33,36]. For chemistry, this distinction is crucial because fluent AI responses can appear authoritative even when equation, coefficients, units, or mechanisms are wrong.

In the present study, students' trust was relational, contextual, and evidence-based. Students trusted teachers not merely because teachers were familiar, but because teachers could explain step-by-step, shift into local language, adjust pacing, diagnose errors, provide examples, and check work. By contrast, students' trust in AI was conditional on whether the response was clear, accurate, step-by-step, language-accessible, and consistent with teacher explanations, class notes, worked examples, and chemical logic. Teacher mediation therefore functions as a trust-calibration process: teachers help students decide when AI output is useful, when it is incomplete, and when it must be rejected or revised.

Trust also has ethical and equity dimensions. UNESCO's guidance on generative AI emphasizes human-centered, age-appropriate, ethical, safe, equitable, and pedagogically validated use of AI in education [34]. Similarly, the OECD argues that generative AI can support learning when guided by clear teaching principles, but may produce performance without learning when students outsource thinking to general-purpose tools [35]. These perspectives reinforce the need to build trustworthy classroom routines rather than simply introduce AI access. In chemistry, trustworthy AI use means checking whether a balanced equation conserves atoms, whether units and formulas match the problem, whether explanations connect macroscopic, submicroscopic, and symbolic levels, and whether suggested laboratory procedures are safe and teacher-approved.

Verification is especially important in chemistry because students may lack the expertise to detect subtle symbolic, quantitative, or conceptual errors. Responsible AI integration therefore requires routines for comparing AI outputs with teacher explanations, notes, worked examples, textbooks, reputable sources, and chemical logic [7,13,22]. Such verification practices can strengthen self-regulated learning because students are asked to inspect assumptions, steps, units, symbols, and reasoning before accepting an answer. In this sense, trust in AI should be calibrated rather than automatic: students can value AI as a tool while still recognizing that teacher guidance and disciplinary evidence remain necessary.

2.5. Digital Divide, Language Accessibility, and Equity in AI Integration

AI-assisted learning is also an equity issue. The benefits of AI depend on reliable devices, stable internet, sufficient laboratory access, teacher readiness, and students' digital confidence. Literature on AI integration identifies access gaps, uneven teacher readiness, and infrastructure limitations as barriers that may widen existing educational inequities if not addressed [13,14,15]. For multilingual learners, language accessibility is equally important because English-heavy or overly technical AI responses can limit comprehension. Thus, AI-enhanced chemistry learning should be designed as guided, localized, inclusive, and access-sensitive rather than assumed to be universally beneficial.

3. Materials and Methods

3.1. Research Design

This study employed a qualitative descriptive research design using thematic analysis to explore students' experiences, challenges, supports, and concerns in learning chemistry and using AI tools. This design was appropriate because the paper sought to describe students' accounts in accessible, practice-oriented terms while still producing analytic themes about chemistry learning and AI-assisted support. The analysis focused on what students reported about classroom experiences, AI tool use, language barriers, internet access, verification practices, and the forms of support that helped or hindered understanding. The qualitative descriptive orientation was also suitable because the study aimed to preserve students' meanings while linking their accounts to practice-based implications for chemistry instruction and AI integration.

The study was anchored on constructivist learning theory, which views learning as an active process of knowledge construction shaped by prior knowledge, social interaction, support, and the use of representational tools [26,27]. Constructivism guided the coding and interpretation by directing attention to how students connected prior mathematical and scientific knowledge with chemistry concepts, how teacher explanations functioned as social mediation, and how symbols, diagrams, equations, simulations, and AI outputs served either as scaffolds or sources of cognitive difficulty. This framing is consistent with recent literature emphasizing that AI-supported learning becomes educationally valuable when learners are guided to compare, explain, question, and verify outputs rather than passively receive answers [7,23,24].

Data were derived from a student qualitative response matrix based on semi-structure prompts about chemistry learning and AI-assisted study. The prompts allowed students to describe difficult topics, confusing symbols or equations, experiences of feeling lost, teacher explanations, use of digital or AI tools, access challenges, AI-related benefits and limitations, and strategies for checking AI-generated answers. Because the available dataset was organized as coded response excerpts rather than full individual transcripts, the coded excerpts was treated as the unit of analysis. Reporting identifiers such as P3-E4 were assigned to excerpts for readability and do not represent complete participant profiles.

3.2. Research Setting and Participants

The study took place in 12 public secondary schools in Malaybalay City, Bukidnon, Philippines, representing urban, peri-urban, and rural settings. The schools were selected through a purposive maximum-variation logic to capture differences in ICT facilities, internet stability, and instructional resource contexts. This variation was important because AI-assisted learning is shaped by infrastructure, device availability, school readiness, and teacher support [13,14,15]. The student qualitative dataset consisted of 78 coded response excerpts organized from 14 prompts and represented Grade 7 to Grade 12 students' accounts of chemistry learning and AI-assisted study. Because individual demographic profiles were not supplied in the article dataset, the study does not make claims about individual-level characteristics; instead, it analyzes recurring meanings across the excerpt-level dataset.

Ethical procedures included institutional and school permission, consent and assent processes, voluntary participation, anonymization through alphanumeric / excerpt-based coding, removal of identifying information, and secure storage of digital and physical records. These procedures were retained as the ethical basis for reporting the qualitative findings from students' responses.

3.3. Data Source and Instrument

The primary source was the student qualitative data matrix containing interview prompts, research question alignment, variable or construct labels, constructivist framework links, response excerpts, interpretations, syntheses, and evidence counts. Sample prompts included: Which chemistry topics were hardest for you, and why? What chemistry lesson content usually confuses you? How have symbols, equations, or diagrams influenced your learning? How does your teacher usually explain chemistry lessons? Have you used AI tools, simulations, or virtual laboratories for chemistry? What problems do you face when using AI for chemistry? How do you check whether an AI answer is correct? These prompts improved transparency by showing how the themes were connected to the data source.

3.4. Data Analysis

The analysis followed Braun and Clarke's six-phase approach: familiarization with the excerpts, initial coding, theme development, theme review, theme definition and naming, and analytic writing [28]. The existing codes in the matrix were reviewed, compared with the original excerpts, and were reorganized into higher-order themes aligned with the two research questions. Coding decisions were checked against prompt-level syntheses, construct labels, and evidence counts. Where meanings overlapped, the themes were refined to avoid duplication and to preserve distinctions among representational difficulty, affective difficulty, instructional support, AI access, and verification practices.

Trustworthiness was addressed through credibility, dependability, confirmability, and transferability strategies rather than through statistical reliability. Credibility was strengthened by retaining representative quotations and maintaining close alignment among excerpts, interpretations, and themes. Dependability was supported through an audit trail of prompt-level codes, syntheses, and evidence counts. Confirmability was supported by grounding interpretations in direct student statement rather than researcher assumptions. Transferability was supported through thick description of the Malaybalay City public school context, including urban, peri-urban, and rural differences in ICT access.

4. Results

Six interrelated themes were generated from the student qualitative data: (1) chemistry difficulty as a shift from recall to application, (2) representational breakdown in equations and symbolic tools, (3) affective barriers that intensify chemistry learning difficulties, (4) teacher explanation as the primary trusted support, (5) AI as supplementary but unevenly accessible instructional support, and (6) verification as teacher-anchored self-regulation. Table 1 summarizes the themes, key evidence, analytic interpretations, evidence counts, and implications for AI-enhanced chemistry instruction.

Table 1. Summary of qualitative themes from student interview data

Theme	Key student evidence and analytic interpretation	Evidence count	Instructional implication
1. Difficulty shifts from recall to application.	Hardest topics included equations, problem-solving, atoms, elements, reactions, and balancing chemical reactions. Students could name concepts but struggled when required to apply them in multi-step or quantitative tasks.	5 excerpts	Use structured problem sequences that connect concepts, formulas, and procedures.
2. Symbolic tools do not automatically support understanding.	Students could read the periodic table but struggled to substitute values, use symbols, or place coefficients in equations. Representational tools became useful only when students mapped symbols to quantities and processes across macroscopic,	13 excerpts	Teach explicit translation among periodic-table information, chemical symbols, diagrams, and equations.

	submicroscopic, and symbolic levels.		
3. Affective barriers intensify chemistry learning difficulties.	Students described confusion, nervousness, low confidence, and hesitation to ask questions. Cognitive difficulty was intensified by anxiety and reluctance to seek help.	4 excerpts	Normalize questioning, provide low-stakes practice, and create supportive feedback routines.
4. Teacher explanation remains the primary trusted support	Students valued step-by-step explanation, examples, board drawings, local language shifts, and teacher checking of work. Students treated teacher guidance as more reliable and accessible than unguided AI output.	5 excerpts	Position AI as a teacher-guided supplement, not a replacement for classroom explanation.
5. AI is useful but unevenly accessible	Students reported using ChatGPT, Gemini, Bing, Copilot, alongside digital tools and simulations such as Canva, and PhET; access was limited by devices, slow internet, and short computer laboratory time. AI engagement depended on infrastructure, familiarity, language accessibility, and understandable explanations.	30 excerpts	Provide offline-ready examples, structured prompts, simulation activities, and equitable access plans.
6. Verification is teacher-anchored self-regulation	Students checked AI answers through teachers, notes, comparison with other sources, and logic checking. Learners recognized AI errors and used familiar academic authorities to validate output.	8 excerpts	Teach AI verification routines focused on reasoning, source checking, and chemistry accuracy.

4.1. Chemistry Difficulty as Shift from Recall to Application

Students consistently described chemistry as difficult when learning shifted beyond naming or memorizing concepts toward using equations, solving problems, and balancing reactions. One excerpt identified ‘problem-solving’ and ‘atoms’ as difficult because ‘it is more difficult to understand the equation’ (P1-E1). Another student noted that chemistry could be enjoyable but became challenging ‘if I don’t know about the equations’ (P1-E2), while another pointed specifically to ‘chemical reactions. . . especially during balancing of chemical reactions’ (P1-E3). These examples show that difficulty emerged most strongly when students were required to apply concepts in procedural or quantitative tasks.

This theme suggests that students' learning difficulty was not a general avoidance of chemistry content but a specific challenge in moving from recognition to application. Students could often identify chemistry topics but struggled when they had to determine formulas, substitute values, balance equations, or interpret reaction processes. This pattern supports the need for instruction that links conceptual explanation with guided problem-solving sequences rather than treating computation as a separate skill [16,17,29].

4.2. Representational Breakdown in Equations and Symbolic Tools

The second theme centered on the students’ difficulty in translating symbols, diagrams, and visual aids into procedures they could use for problem-solving. Students reported that they could recognize elements or read the periodic table, yet struggled to use this information in equations. One student explained, ‘I don’t know where to put the numbers’ when balancing equations (P3-E4), while another stated, ‘I can read the periodic table. . . [but] I don’t understand how to use the information in solving problems’ (P3-E5). These excerpts show that representational tools became helpful only when students understood how symbols mapped onto chemical quantities, particle behavior, and solution steps.

These responses connect directly to the chemistry triplet: macroscopic observations, submicroscopic particle-level explanations, and symbolic representations. Periodic tables, symbols, diagrams, and equations do not automatically reduce cognitive load; they become meaningful only when students can translate among observable phenomena, particle models, and symbolic procedures [1,3]. AI-supported chemistry instruction should therefore prompt students to explain what a symbol represents, what particle-level process is implied, and how the equation connects to the problem context. Recent work on generative AI visuals in chemistry also suggests that AI-generated representations may support learning only when students are guided to critique their accuracy and meaning [20,21].

4.3. Affective Barriers and Help-Seeking Hesitation

Students described chemistry difficulty affective terms, including confusion, nervousness, low confidence, and hesitation to ask questions. One student stated that difficult lessons led to feeling ‘confused’ (P4-E1). Another said ‘I really feel nervous. . . I am not confident with my skills in chemistry’ (P4-E2), while a third explained, ‘I am shy to ask questions’ when symbols and numbers were unclear (P4-E3). These responses show that affective barriers interacted with conceptual and representational difficulty.

This demonstrates that chemistry difficulty is not only cognitive but also emotional and social. When students anticipate failure or feel embarrassed to ask for clarification, they may disengage from the very interactions that could support understanding. Literature on science learning support emphasizes the value of study-skills instruction, confidence-building, inclusive classroom climates, and structured feedback in reducing barriers to participation [16,17,18]. This suggests that AI may function as a low-pressure support space, but only when outputs are accurate, accessible, developmentally appropriate, and connected to teacher-guided clarification rather than used in isolation.

4.4. Teacher Explanation as the Primary Trusted Support

Teacher explanation emerged as the most trusted learning support. Students valued teachers who explained step-by-step, shifted language to help comprehension, provided multiple examples, drew on the board, used PowerPoint slides, and checked students' work. In the data matrix, teacher explanation was described as 'step by step' with 'multiple examples' and sometime supported through PowerPoint or chalkboard drawings (P6-E1). Another excerpt emphasized that the teacher checked work 'one-by-one' after students practiced applying the lesson (P6-E4). Trust was therefore grounded in contextualized explanation, local language mediation, feedback, and verification.

Although students valued digital tools, they did not position AI as a replacement for teacher explanation. Rather, teacher guidance served as the primary interpretative authority against which AI outputs were judged. This finding strengthens the 'trust' of the students in their teachers not simply because teachers were familiar, but because teachers could adapt explanations to local language, classroom pace, students' errors, and chemistry-specific reasoning. This aligns with literature describing teacher-mediated AI use as a human-guided interaction in which teachers preserve pedagogical judgment, ethical oversight, and disciplinary accuracy [23,24,25].

4.5. AI as Supplementary but Unevenly Accessible Learning Support

Students reported varied experiences with AI and digital learning tools. AI tools like ChatGPT, Gemini, and Bing Copilot were used mainly for explanations, examples, clarification, and help with assignments. Other tools such as Canva and Microsoft applications, functioned more as productivity or presentation tools unless AI-assisted features were specifically used, while PhET was better understood as a simulation platform for visualizing concepts. This distinction matters because students' learning experiences involved a broader digital ecology rather than AI tools alone.

However, several barriers limited the extent to which students could benefit from these tools. Students reported slow internet, insufficient devices, limited computer laboratory time, English-heavy explanations, lengthy responses, and concerns about inaccurate computations or chemical equation errors. These access issues elevate the equity dimension of AI integration: usefulness cannot be evaluated apart from device availability, internet stability, language accessibility, and teacher support.

This theme supports a balanced interpretation of AI in chemistry education. AI can expand access to explanations and examples, but its usefulness depends on several factors, including the quality of the prompt, clarity of the response, alignment with students' language needs, availability of digital infrastructure, and the presence of teacher guidance. AI tools are not reliable by default; they become educationally valuable when embedded in guided, verified, and equitable learning routines [8,9,13,14,22].

4.6. Verification as Teacher-Anchored Self-Regulation

When checking answers generated by AI, students did not treat AI as automatically authoritative. Instead, they described four verification routines: teacher verification, notes-based verification, source comparison, and logic checking. Students asked teachers for confirmation, returned to notes to see whether AI answers matched classroom explanations, compared AI-generated solutions with teacher-provided solutions, and checked other source when uncertain. One student summarized the process as asking the teacher, reviewing notes, and checking other sources to be sure (P14-E1). Another primarily compared the AI answer with the teacher's solution to determine whether it was correct (P14-E2).

This finding shows emerging self-regulation and critical AI awareness. Students recognized that AI could make errors and that verification was necessary. At the same time, verification remained teacher anchored, meaning that students still needed expert guidance to evaluate chemical reasoning. A practical contribution of this study is therefore a verification framework for chemistry AI use: (1) ask whether the answer matches the teacher's explanation, (2) compare it with notes or worked examples, (3) check another credible source, and (4) inspect the chemical logic, units, symbols, and steps before accepting the answer. This aligns with literature calling for explicit verification training, critical AI literacy, and teacher-guided evaluation of AI outputs [7,13,22,30].

5. Discussion

The qualitative findings indicate that students' chemistry difficulties are not merely motivational; they are conceptual, symbolic, mathematical, and affective. Students struggled most when they had to choose formulas, substitute values, balance equations, interpret symbols, and connect periodic table information with problem-solving. These findings reinforce the argument that chemistry learning requires explicit support for representational translation and not only additional practice [1,2,3,29]. The results also echo broader science education literature showing that students need structured support, contextual relevance, and confidence-building opportunities when foundational scientific ideas are difficult to transfer into application [16,17,19]. In this sense, AI-supported instruction should not simply provide faster answers; it should help students connect concepts, representations, and procedures.

This study contributes to AI-in-education literature by showing that students in resource-varied public school contexts treat AI not as an authority, but as a supplementary explanation tool whose usefulness depends on teacher mediation and verification. Before and after using AI, students continued to rely on teachers, classmates, notes, and self-study. AI became an added layer in this learning ecology, useful for examples and clarification but risky when it supplied final answers without reasoning. This supports a complementary model of AI integration in which AI extends practice opportunities while teachers preserve conceptual accuracy and instructional coherence [9,12,21,23,24].

The data also explain why teacher mediation remains indispensable. Students trusted teachers because teachers could contextualize explanations, shift language, draw diagrams, provide examples, check work, and correct misunderstandings. AI tools, by contrast, were useful but unevenly reliable and unevenly accessible. Students identified inaccurate computations, chemical equation errors, excessive information, English-only explanations, weak internet connections, limited device access, and insufficient computer laboratory time. Responsible AI integration is therefore both a pedagogical issue and an infrastructure issue: the presence of an AI tool does not guarantee equitable or meaningful learning [8,13,14,15,22].

From a constructivist perspective, students need supports that connect prior mathematical knowledge with chemistry's symbolic and representational systems. Their basic computation skills did not automatically transfer to chemistry because chemical equations require conceptual interpretation, not only numerical manipulation. Teacher-guided AI use can support constructivist learning when students are asked to explain steps, identify assumptions, compare representations, generate practice items, and verify chemical reasoning rather than copy final answers. Process-oriented prompting is therefore recommended: students should ask AI to show steps, explain why each step is valid, identify likely misconceptions, and provide similar practice problems with feedback. This recommendation is consistent with chemistry-specific AI literature emphasizing prompt engineering, expert validation, and critical evaluation of AI-generated chemistry materials [8,9,31,32].

For professional development, the findings suggest four priorities.

1. Representation-focused teaching: teachers need strategies for translating chemistry concepts across words, diagrams, equations, periodic-table information, and particle-level explanations [1,3].

2. Verification-centered AI literacy: students should be taught to verify AI outputs through teacher confirmation, notes-based checking, source comparison, and logic checking [13,22,2530].

3. Equitable AI integration: schools should consider offline-ready materials, shared-device routines, local-language frameworks, teacher readiness, and realistic access plans [13,14,15].

4. Teacher - mediated prompting: professional development should train teachers to design prompts that require reasoning, assumptions, step-by-step explanations, chemistry accuracy checks, and practice generation rather than final-answer retrieval [8,9,31,25].

6. Recommendations for Practice

Based on the findings, AI tools should be integrated as guided classroom supports that strengthen explanation, practice, representation, and verification rather than as substitutes for teacher instruction. The following recommendations translate the students' experiences into tangible strategies for chemistry and other science classrooms.

1. Use AI to support step-by-step explanation rather than final-answer retrieval. Teachers can demonstrate prompts that ask AI to explain a concept or problem one step at a time, define each symbol, show substitutions, and justify why each step is valid. For example, students may ask an AI tool to explain how to balance a chemical equation, but they should be required to copy the steps, label the reactions and products, identify the coefficients, and explain the conversation of atoms before accepting the answer [7,8,9,29].

2. Pair AI output with teacher-led verification. Each AI-assisted activity should include a verification routine: compare the AI response with the teacher's explanation, check class notes or textbook examples, consult another credible source when needed, and inspect the chemistry logic, units, symbols, and steps. This routine directly addresses students' concern that AI may provide inaccurate computations, unclear reasoning, or incorrect chemical equations [7,13,22,23,25].

3. Use AI for representation translation in chemistry. Teachers can ask students to use AI to restate a chemistry idea in multiple forms: a short verbal explanation, a balanced equation, a particle-level description, a diagram description, and a real-life example. The teacher should then guide students in checking whether these representations match one another. This is especially useful for topics such as atoms, elements, compounds, periodic-table information, chemical reactions, and balancing equations [1,3,20,21].

4. Created supported practice sets with feedback. Teachers may use AI to generate graduated practice items that move from simple recall to guided application and independent problem-solving. For instance, a teacher can request five balancing-equation exercises arranged from easy to difficult, with hints and answer keys separated from the student worksheet. The teacher should review all items before use to ensure that the equations, quantities, and explanations are chemically accurate [4,5,8,29].

5. Localize language, examples, and difficulty level. Because students reported difficulty with English-heavy or overly lengthy explanations, teachers can prompt AI tools to simplify responses, use age-appropriate language, provide local or familiar examples, and translate key explanations into classroom-appropriate language when necessary. Localized AI output should still be checked by the teacher to ensure that scientific terms remain accurate [13,14,15,25,32].

6. Integrate AI with simulations, visuals, and hands-on science activities. AI tools can be paired with PhET simulations, teacher-made diagrams, laboratory demonstrations, or simple household-based science examples. Before a simulation, AI may help generate guiding questions; during the activity, students can

record observations; after the activity, AI can help students compare their observations with scientific explanations. This approach keeps AI connected to inquiry and observation rather than isolated answer generation [4,8,20,21].

7. Establish equitable access routines. Since students identified slow internet, limited devices, and short computer-laboratory time as barriers, teachers and schools should prepare low-bandwidth and offline alternatives. These may include printed AI-generated practice sheets reviewed by the teacher, group-based device sharing, rotating AI stations, pre-downloaded simulation tasks, and classroom discussion of selected AI responses projected by the teacher. AI integration should not penalize students who have limited device or internet access [13,14,15].

8. Teach responsible AI use as part of science learning. Teachers should set clear classroom rules for AI-assisted work: students must disclose when AI was used, avoid copying AI responses as final answers, verify all scientific claims, and never follow AI-generated laboratory procedures without teacher approval. This recommendation is important in chemistry and other science subjects where inaccurate or unsafe procedures may create misconceptions or safety risks [10,11,12,22].

9. Use AI to support teacher planning, not to replace teacher judgement. Teachers can use AI to draft lesson hooks, analogies, differentiated worksheets, quiz items, remediation exercises, and reflection questions. However, all AI-generated materials should be reviewed for curriculum alignment, accuracy, safety, language suitability, and fairness before classroom use. Teacher expertise remains necessary because students continue to rely on teachers for clarification, feedback, local language mediation, and trust-building [8,22,23,24,31].

10. Provide school-level support for guided AI integration. School leaders and curriculum planners should support teachers through professional development on prompting, verification, AI ethics, science safety, and inclusive digital pedagogy. Schools should also plan access to devices, internet scheduling, privacy safeguards, and shared repositories of teacher-reviewed AI prompts and activities. These supports can help ensure that AI benefits students across urban, peri-urban, and rural learning contexts rather than widening existing access gaps [13,14,15] [25,31,32].

Overall, the recommended model is teacher-guided, verification-centered, localized, and equity-sensitive. AI should help students ask better questions, compare explanations, practice problem-solving, and connect representations, while teachers remain responsible for disciplinary accuracy, classroom context, student confidence, and ethical use.

7. Limitations

This study is limited by its use of coded excerpts rather than full individual participant profiles; therefore, the unit of analysis was the response excerpt, not the individual student. The study was also limited to selected public secondary schools in Malaybalay City, Bukidnon, and findings may not fully represent schools with different infrastructure, language contexts, or curricular conditions. Finally, the study did not use quantitative measure learning outcomes, so it cannot determine the direct effect of AI use on achievement. Its contribution is interpretative and practice-orient, focusing on students' reported experiences of chemistry learning and AI-assisted support.

8. Conclusions

This study examined students' experiences of chemistry learning and AI-assisted academic support in selected public secondary schools. The findings show that chemistry difficulty was both representational and affective: students struggled when they had to move from recall to application, translate symbols into equations, connect periodic-table information with problem-solving, and manage anxiety or hesitation is asking questions.

AI was useful when it provided faster, clearer, or more relatable explanations, but its benefits were uneven because of device limitations, slow internet, language barriers, response quality, and the risk of inaccurate or unsupported answers. Students did not treat AI as a replacement for teachers. Instead, teacher explanation remained the primary trusted scaffold, and teacher-guided verification emerged as necessary for responsible AI use in chemistry. The study concludes that AI-enhanced chemistry instruction should be guided, localized, equity-sensitive, representation-focused, and verification-centered.

ACKNOWLEDGEMENTS

The authors acknowledge the participating schools and students of the Malaybalay City Schools Division, Bukidnon whose interview responses formed the qualitative data for this manuscript.

Statement of Competing Interests

The authors declare no competing interests.

List of Abbreviations

AI: Artificial Intelligence; ICT: Information and Communications Technology; PhET: Physics Education Technology.

References

[1] Johnstone, A.H. “Why is science difficult to learn? Things are seldom what they seem”, *Journal of Computer Assisted Learning*, 7(2). 75-83. Jun.1991.

[2] Taber, K.S. Chemical misconceptions: Prevention, diagnosis, and cure, Volume 1: Theoretical background. Royal Society of Chemistry, London. 2002.

[3] Gkitzia, V., Salta, K. & Tzougraki, C. “Students’ competence in translating between different types of chemical representations,” *Chemistry Education Research and Practice*, 21(1). 307-330. Jan.2020.

[4] Chen, L., Chen, P. & Lin, Z. “Artificial intelligence in education: A review,” *IEEE Access*, 8, 75264-75278. Apr. 2020.

[5] Aleven, V., McLaughlin, E.A., Glenn, R.A. & Koedinger, K.R. “Instruction based on adaptive learning technologies,” in *Handbook of Research on Learning and Instruction*, 2nd ed., Routledge, New York, 522-560. 2017.

[6] Chan, C.K.Y. & Hu, W. “Students’ voices on generative AI: Perceptions, benefits, and challenges in higher education,” *International Journal of Educational Technology in Higher Education*, 20(1), 43. Jul. 2023.

[7] Guo, Y. and Lee, D. “Leveraging ChatGPT for enhancing critical thinking skills,” *Journal of Chemical Education*, 100(12). 4876-4883, Nov. 2023.

[8] Araújo, J. L., & Saúde, I. “Can ChatGPT enhance chemistry laboratory teaching? Using prompt engineering to enable AI in generating laboratory activities.” *Journal of Chemical Education*, 101(5), 1858-1864, Apr. 2024.

[9] Berber, S., Brückner, M., Maurer, N., & Huwer, J. “Artificial intelligence in chemistry research: Implications for teaching and learning,” *Journal of Chemical Education*, 102(4), 1445-1456, Mar. 2025.

[10] Akgun, S. & Greenhow, C. “Artificial intelligence in education: Addressing ethical challenges in K-12 settings,” *AI and Ethics*, 2, 431-440, 2022.

[11] Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S.B., Santos, O.C., Rodrigo, M.T., Cukurova, M., Bittencourt, I.I., & Koedinger, K.R. “Ethics of AI in education: Towards a community-wide framework,” *International Journal of Artificial Intelligence in Education*, 32, 504-526, Sep. 2022.

[12] Zhang, P., & Tur, G. “A systematic review of ChatGPT use in K-12 education,” *European Journal of Education*, 59(2). 2023.

[13] Pratiwi, H., Riwanda, A., Hasruddin, Sujarwo, & Syamsudin, A. “Transforming learning or creating dependency: Teachers' perspectives and barriers to AI integration in education,” *Journal of Pedagogical Research*. 9(2), 127-142, Mar. 2025.

[14] Rashid, S. F., Duong-Trung, N., & Pinkwart, N. *Generative AI in education: Technical foundations, applications, and challenges,* IntechOpen. 2024.

[15] Levy-Nadav, L., Shamir-Inbal, T., & Blau, I., “Digital competencies for effective GenAI use in secondary schools: A longitudinal exploration of teachers' perspectives and classroom practices,” *Journal of Computer Assisted Learning*, 41(5). 2025.

[16] Buchwitz, B. J., Beyer, C. H., Peterson, J. E., Pitre, E., Lalic, N., Sampson, P. D., & Wakimoto, B. T., “Facilitating long-term changes in student approaches to learning science,” *CBE-Life Sciences Education*, 11(3), 273-282, 2012.

[17] Owens, A., “Filling in some gaps: A pre-nursing bioscience and study skills intervention,” *Collegian*, 27(1), 141-146. 2020.

[18] Gresty, K., & Cotton, D., “Supporting biosciences in the nursing curriculum: development and evaluation of an online resource,” *Journal of Advanced Nursing*, 44(4), 339-349, 2003.

[19] Rafferty, B., Mthimunye, K., & Bimerew, M., “Theory-practice gap: Nursing students' self-reported depth of understanding of bioscience and its relevance to clinical practice,” *PLOS ONE*, 18(11), e0294319, 2023.

[20] Akaygün, S., & Kılıç, İ., “Generative artificial intelligence (GenAI) as the artist of chemistry visuals: Chemistry preservice teachers' reflections on visuals created by GenAI,” *Journal of Chemical Education*, 102(7), 2549-2564. 2025.

[21] Aydın, S., Şirin, G. T., Ilkyaz, O. C., & Mutlu, Y., “Exploring the artificial intelligence interaction profiles of participants with different levels of teaching experience for lesson planning in the context of acids and bases,” *Chemistry Education Research and Practice*, 26(4), 977-995, 2025.

[22] Powell, W. A., & Courchesne, S., “Opportunities and risks involved in using ChatGPT to create first grade science lesson plans,” *PLOS ONE*, 19(6), e0305337, 2024.

[23] Grassini, S., “Shaping the future of education: Exploring the potential and consequences of AI and ChatGPT in educational settings,” *Education Sciences*, 13(7), 692, 2023.

[24] Wang, L., Xu, Y., Zhang, M., Bai, R., & Xie, T., “Teaching innovation in a pharmacy course: integration of Questioning-Training of Comprehensive Knowledge Application and a Teacher-AI-Student Interaction Model,” *BMC Medical Education*, 25(1), 2025.

[25] Kohnke, L., & Zou, D., “Artificial intelligence integration in TESOL teacher education: Promoting a critical lens guided by TPACK and SAMR,” *TESOL Quarterly*, 59(S3), 2025.

[26] Piaget, J., *To Understand is to Invent: The Future of Education,* Grossman Publishers, New York, 1973.

[27] Vygotsky, L.S., *Mind in Society: The Development of Higher Psychological Processes.* Harvard University Press, Cambridge, MA, 1978.

[28] Braun, V. and Clarke, V., *Thematic Analysis: A Practical Guide*. London, SAGE Publications, London, 2021.

[29] Bodner, G.M. & Herron, J.D., “Problem-solving in chemistry,” in *Chemical Education: Towards Research-based Practice,* Kluwer Academic Publishers, Dordrecht, pp.235-266, 2002.

[30] Henriksen, D., Creely, E., Gruber, N., & Leahy, S., “Social-emotional learning and generative AI: A critical literature review and framework for teacher education,”. *Journal of Teacher Education*, 76(3), 312-328, 2025.

[31] Blonder, R., Feldman-Maggor, Y., & Rap, S., “Are they ready to teach? Generative AI as a means to uncover pre-service science teachers' PCK and enhance their preparation program,” *Journal of Science Education and Technology*, 34(6), 1301-1310, 2024.

[32] Tang, K., “Informing research on generative artificial intelligence from a language and literacy perspective: A meta-synthesis of studies in science education,” *Science Education*, 108(5), 1329-1355, 2024.

[33] Nazaretsky, T., Mejia-Domenzain, P., Swanny, V., Frej, J., & Käser, T., “The critical role of trust in adopting AI-powered educational technology for learning: An instrument for measuring student perceptions,” Computers and Education: Artificial Intelligence, 8, 100368, 2025. [Online], Available: https://doi.org/10.1016/j.caeai.2025.100368.

[34] Miao, F., & Holmes, W., Guidance for generative AI in education and research. UNESCO, Paris, 2023. [Online], Available: https://unesdoc.unesco.org/ark:/48223/pf0000386693.

[35] OECD, OECD Digital Education Outlook 2026: Exploring Effective Uses of Generative AI in Education, OECD Publishing, Paris, 2026. [Online], Available: https://doi.org/10.1787/062a7394-en.

[36] Martin-Moncunill, D., & Alonso Martinez, D., “Students’ Trust in AI and Their Verification Strategies: A Case Study at Camilo José Cela University,” Education Sciences, 15(10), 1307, 2025, [Online], Available: https://doi.org/10.3390/educsci15101307.