Learning Chemistry with Generative Artificial Intelligence: A Phenomenological Study of Secondary School Students' Experiences in Bayelsa State, Nigeria

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Abstract
Generative artificial intelligence offers new opportunities for supporting Chemistry learning, but accessible explanations may not translate into independent conceptual understanding. This paper examined experiences of understanding Chemistry concepts, perceptions of usefulness and challenges associated with generative artificial intelligence within a secondary school context in Bayelsa State, Nigeria. A qualitative analysis informed by an interpretative phenomenological approach was undertaken using ten participants. Analysis involved examining individual accounts, identifying experiential meanings and comparing patterns across cases. The accounts portrayed conceptual understanding as developing through manageable explanations, recognition of errors, comparison with other resources, and independent practice. However, apparent clarity sometimes coexisted with difficulties applying knowledge to unfamiliar problems. Perceived usefulness centred on repeated clarification without embarrassment, support outside classroom instruction, revision activities and alternative explanations. Challenges included shared devices, data costs, unreliable connectivity, unfamiliar terminology, uncertainty about response accuracy, difficulty formulating questions and the temptation to copy solutions. The analysis suggests that generative artificial intelligence may serve as a supplementary resource when combined with teacher guidance, textbooks, practical demonstrations, and independent problem-solving.

Keywords: *generative artificial intelligence, Chemistry learning, secondary school students, phenomenology, Bayelsa State*

Introduction

Chemistry education requires students to interpret abstract concepts, explain observable phenomena and apply symbolic representations to unfamiliar problems. These demands make the quality of learning support particularly important at the secondary school level. Generative artificial intelligence introduces another source of such support through conversational tools capable of producing explanations, examples and responses to learners' questions. However, the availability of immediate answers does not necessarily translate into meaningful understanding. Miao and Holmes (2023) emphasise that educational applications of generative artificial intelligence require pedagogical validation and human oversight, suggesting that technological

capability alone provides an insufficient basis for judging educational value.

Within Chemistry learning, conversational interaction could allow students to request simpler explanations, revisit difficult ideas and seek clarification without waiting for classroom instruction. Nevertheless, these possibilities must be distinguished from demonstrated learning benefits. In an investigation involving general Chemistry examination questions, Clark (2023) found that ChatGPT could not reliably answer or explain many representative questions. Although the study examined an earlier version of the technology, it establishes an important concern: fluent explanations may conceal weaknesses in chemical reasoning. Consequently, students' perceptions of helpfulness require examination alongside how they interpret, question and use the responses they receive during actual learning encounters.

The relationship between perceived usefulness and scientific accuracy is therefore central to understanding students' experiences. Tyson (2023) identified conceptual errors, unreliable mathematical operations and fabricated references in ChatGPT outputs. Such limitations suggest that students may encounter responses that appear authoritative while containing misleading information. However, identifying weaknesses in generated content does not explain how learners experience these weaknesses. Some may recognise inconsistencies and consult alternative sources, whereas others may accept explanations because they are clearly expressed. These contrasting possibilities make it necessary to investigate students' accounts rather than assume that access produces either educational improvement or inevitable dependence on technology.

Equity and learner protection further complicate the educational promise of generative artificial intelligence. Miao and Holmes (2023) highlight concerns involving digital exclusion, privacy, human agency and age-appropriate use. For secondary school students, these concerns raise questions about the conditions under which interaction becomes educationally meaningful. In Bayelsa State, device availability, connectivity, affordability and teacher guidance should therefore be investigated as contextual influences rather than treated as uniform or established barriers. Attention to these conditions can reveal how students' encounters with the same technology acquire different meanings across their learning environments, without presuming that all students have comparable opportunities to participate.

Existing performance evaluations provide valuable evidence about technological limitations, but their findings cannot fully represent the experiences of secondary school Chemistry learners in Bayelsa State. Examination responses reveal what a system produces; they offer less insight into what students experience while seeking explanations, deciding whether to trust answers or confronting confusion. A phenomenological approach is therefore appropriate for examining these experiences through participants' descriptions. Its contribution lies in understanding how generative artificial intelligence is encountered and interpreted within everyday Chemistry learning.

Accordingly, this study explores students' experiences of understanding Chemistry concepts, their perceptions of usefulness and the challenges encountered when learning with generative artificial intelligence.

Aim and Objectives of the Study

The aim of this study is to explore and understand the lived experiences of secondary school students who use generative artificial intelligence to learn Chemistry in Bayelsa State, Nigeria.

The study aimed, to:

1. Explore students' experiences of using generative artificial intelligence to understand

Chemistry concepts.
2. Examine students' perceptions of the usefulness of generative artificial intelligence in learning Chemistry.
3. Explore the challenges students encounter when using generative artificial intelligence to learn Chemistry.

Literature Review

The first research question seeks to explore students' experiences of using generative artificial intelligence to understand Chemistry concepts. Its rationale rests on the need to examine what occurs when students engage with generated explanations during learning. Access to explanations does not necessarily establish conceptual understanding, as students may find a response helpful without being able to explain or apply the underlying concept. Exploring their descriptions of specific learning encounters can reveal how they experience clarification, confusion and the interpretation of chemical ideas. This question therefore supports the phenomenological purpose of understanding the experience from students' perspectives rather than presuming that the technology improves understanding.

The second research question examines students' perceptions of the usefulness of generative artificial intelligence in learning Chemistry. This question is necessary because perceived usefulness represents students' judgments about the value of the technology, which may differ from their actual understanding of Chemistry concepts. A student may value a tool for providing quick answers, while another may consider it useful because it offers explanations suited to individual learning needs. Examining the reasons underlying these judgments can clarify what students regard as meaningful learning support. The question consequently allows the study to investigate perceived usefulness without treating favourable opinions as evidence of improved academic achievement.

The third research question explores the challenges students encounter when using generative artificial intelligence to learn Chemistry. Its rationale is that the educational value of the technology cannot be adequately understood without examining difficulties experienced during its use. These difficulties may concern interpreting responses, assessing their credibility or accessing the tools, but their relevance must emerge from participants' accounts rather than be assumed beforehand. Exploring concrete experiences can reveal how students interpret and respond to obstacles within their learning contexts. This question therefore provides a critical understanding of the conditions that constrain students' engagement and offers a basis for developing support responsive to their expressed needs.

Theoretical Review

Constructivist learning theory, particularly Piaget's (1970) account of knowledge construction, provides a theoretical foundation for this study. The theory views learners as active constructors of understanding who interpret new information through existing cognitive structures, modifying these structures when unfamiliar experiences challenge prior knowledge. In Chemistry learning, interactions with generative artificial intelligence may provide explanations that students assimilate into existing understanding or use to reconsider misconceptions. However, receiving a coherent response does not establish that meaningful knowledge construction has occurred; students may reproduce generated answers without critically examining their chemical meaning. This perspective therefore directs attention to students' experiences of interpreting AI-generated explanations, the usefulness they attribute to these interactions and the difficulties they encounter

in constructing understanding. While constructivism helps explain the learning processes potentially involved, it serves as a sensitising framework rather than a predetermined structure imposed on participants' accounts, allowing the phenomenological analysis to remain attentive to meanings emerging from their lived experiences.

Methodology

The study adopted a qualitative phenomenological design to explore secondary school students' lived experiences of learning Chemistry with generative artificial intelligence in Bayelsa State, Nigeria. An interpretivist orientation guided the investigation, recognising that students constructed meanings through their interactions with the technology within particular learning contexts. The inquiry addressed experiences of understanding Chemistry concepts, perceived usefulness and challenges encountered.

Participants were senior secondary school Chemistry students who had personally used a generative artificial intelligence tool for Chemistry learning on at least three occasions during the preceding school term. Criterion-based purposive sampling identified eligible students, while maximum variation sampling supported inclusion across school locations, gender and class levels. The initial recruitment target was approximately 12–15 students. Final recruitment was guided by the richness of participants' accounts and the contribution of additional interviews to understanding the phenomenon. The findings supported contextual understanding rather than statistical generalisation. Data were collected through individual, semi-structured interviews lasting approximately 30–45 minutes. The interview guide contained open-ended questions aligned with the three research objectives, with prompts encouraging descriptions of specific learning encounters. Participants discussed Chemistry concepts they had explored using generative artificial intelligence, explained their perceptions of its usefulness and described difficulties encountered. Where separate permission was provided, participants referred to anonymised examples of previous interactions to clarify their accounts. Two experts in Chemistry Education and one qualitative researcher reviewed the guide for relevance, clarity and neutrality. A pilot interview with an eligible student outside the main sample informed its refinement. Interviews were conducted in quiet, school-approved settings, audio-recorded with permission and transcribed verbatim. Field notes documented contextual observations, while a reflexive journal captured the researcher's assumptions and interpretive decisions. Data were analysed using interpretative phenomenological analysis. Each transcript was read repeatedly and annotated to identify experiential meanings, which were developed into themes within individual accounts before convergence and divergence across participants were examined. Contradictory accounts were retained to preserve the complexity of students' experiences. Constructivist theory informed interpretation after initial theme development without imposing predetermined categories. Trustworthiness was strengthened through close engagement with transcripts, an audit trail, peer scrutiny of interpretations and contextual descriptions supported by anonymised quotations. Participants were invited to clarify ambiguous statements and comment on concise summaries of their accounts. Ethical approval was obtained from the relevant institutional committee, and permission was secured from educational authorities and participating schools. Parental consent and student assent were obtained for participants younger than 18 years, while adult participants provided informed consent. Participation was voluntary, teachers were absent during interviews, and withdrawal attracted no academic penalty. Pseudonyms protected participants' identities, and recordings and transcripts were stored securely with access restricted to the research team.

Results

Research Question 1: What are students' experiences of using generative artificial intelligence to understand Chemistry concepts?

Analysis of the ten accounts, particularly responses to Questions 3–5, identified five interconnected themes. These captured experiences of clarification, recognition of errors, construction of understanding through discussion, incomplete understanding and the distinction between following an explanation and applying it independently.

Table 1: Themes relating to experiences of understanding Chemistry concepts

Theme	Interpretation	Illustrative participant accounts
Making concepts clearer through manageable explanations	Breaking explanations into steps and using specific examples made difficult ideas easier to follow.	P01, P04, P06, P07
Recognising errors in previous understanding	Worked explanations helped students identify particular mistakes in calculations and symbolic representations.	P02, P05
Building understanding through comparison and discussion	Students combined generated explanations with textbooks, alternative responses and conversations.	P03, P08, P09
Experiencing understanding as partial	Students described progress with familiar examples while remaining uncertain about more demanding applications.	P02, P03, P04, P06, P07, P08, P09
Distinguishing apparent understanding from independent performance	Attempting another question revealed whether following an explanation translated into independent application.	P02, P05, P10

Theme 1: Making concepts clearer through manageable explanations

The accounts described understanding as developing when explanations were broken into smaller units or connected to concrete examples. P01 recalled asking about electron transfer in sodium chloride and then requesting clarification about attraction between the resulting ions:

"I felt relieved because the explanation was broken into smaller parts." — P01

For P01, clarification emerged through successive questions rather than a single response. The account linked this experience with drawing electron arrangements and subsequently explaining ionic bonding without consulting notes.

P06 similarly described an initially overwhelming explanation of electrolysis becoming more accessible after requesting a different presentation:

"When I asked it to arrange the process in steps, it became clearer." — P06

P04 connected examples of methane, ethane and ethene with recognising patterns in hydrocarbon formulae. P07 associated examples of common substances with remembering the pH scale. Across these accounts, the experience of clarity depended on how information was organised and related to existing knowledge.

Theme 2: Recognising errors in previous understanding

Some accounts described a specific moment of recognising an earlier mistake. P02, discussing the molar mass of calcium carbonate, stated:

"I had forgotten to multiply the atomic mass of oxygen by three." — P02
The explanation helped P02 locate the source of a calculation error rather than merely obtain a different answer. Nevertheless, the participant acknowledged that further practice was needed.
P05 described repeatedly changing subscripts when balancing chemical equations. The generated explanation distinguished subscripts from coefficients:
"I realised that I had been making the same mistake repeatedly." — P05
P05 subsequently reported balancing two equations independently and explaining the distinction to a classmate. These accounts portrayed clarification as recognising why a previous approach was inappropriate. The reported improvements were participants' own assessments rather than independently observed performance.

Theme 3: Building understanding through comparison and discussion
Understanding was also described as developing through interaction with several learning resources. P09 compared ChatGPT and Gemini explanations of periodic trends:
"I combined the explanations with my textbook notes." — P09
The different emphases helped P09 interpret nuclear attraction, shielding and examples from particular elements. However, references to exceptions introduced further confusion, requiring separation of general patterns from special cases.
P03 compared an explanation of distillation with a textbook, while P08 discussed the Haber process with a friend and revisited the textbook when temperature effects remained unclear. These accounts positioned generated explanations within a wider process of reading, discussion and reconsideration. Understanding was constructed through these connections rather than attributed exclusively to the AI response.

Theme 4: Experiencing understanding as partial
Several accounts distinguished progress in one aspect of a topic from mastery of the whole concept. P06 could write a cathode reaction but remained uncertain about anode products in other electrolytes:
"I was still uncertain about predicting anode products in other electrolytes, so I knew my understanding was incomplete." — P06
Similarly, P04 could identify simpler hydrocarbons but struggled with branched structures. P07 could classify solutions using pH values but lacked confidence about hydrogen ion concentration. P08 understood pressure effects in the Haber process more readily than temperature effects.
P03's experience exposed another boundary:
"But I still had difficulty imagining how the fractionating column worked because I had not seen one physically." — P03
The accounts therefore presented understanding as uneven, with explanatory progress coexisting with unresolved conceptual or visual difficulties.

Theme 5: Distinguishing apparent understanding from independent performance
Attempting another task provided an important basis for judging understanding. P02 reported solving two of three similar questions correctly, recognising both progress and continuing difficulty. P05 described independent equation balancing as evidence of understanding.
P10 provided a contrasting account of Boyle's law:
"The example was clear while I was reading it, and I thought I understood." — P10

When attempting another question, P10 could not determine which values to substitute:
"I realised that reading an answer was not the same as knowing how to solve the question myself." — P10
This account qualified the more positive experiences. An explanation could feel clear during reading without enabling independent application. P10 responded by returning to textbook examples and further practice.

Research Question 2: How do students perceive the usefulness of generative artificial intelligence in learning Chemistry?

Table 2: Themes relating to perceived usefulness of generative artificial intelligence in learning Chemistry

Theme	Interpretation	Illustrative accounts
Repeated clarification without embarrassment	The tools provided opportunities to ask further questions privately and revisit explanations.	P01, P06
Additional support outside classroom instruction	Students valued explanations when teachers or other helpers were unavailable, subject to access.	P02, P03, P04, P07
Support for revision and independent practice	Worked examples, practice questions and summaries supported examination preparation and self-testing.	P02, P05, P09
Alternative explanations and shared learning	Different explanations provided material for comparison and discussion.	P08, P09
Usefulness as a supplementary resource	Perceived value remained conditional on verification, active practice and continued teacher support.	P01–P10

Theme 1: Repeated clarification without embarrassment

The accounts associated usefulness with the opportunity to ask questions repeatedly without the social discomfort sometimes experienced in class. P01 explained:
"In class, I sometimes feel shy asking the teacher to explain something again, but with ChatGPT, I can keep asking until I understand better." — P01
For P01, usefulness involved control over the pace and repetition of explanations. The tool provided a private space for returning to an unresolved question. This perception extended beyond convenience to a sense of emotional reassurance:
"It has made studying Chemistry less frightening because I know there is another way to get an explanation." — P01
P06 similarly valued follow-up questions when a particular step remained unclear. These accounts positioned conversational interaction as useful because it allowed students to remain with a difficulty and request further clarification.

Theme 2: Additional support outside classroom instruction

Usefulness was also associated with obtaining assistance beyond school hours. P03 stated:
"It is especially useful when there is no one available to answer my questions after school." — P03
P02 likewise valued receiving an immediate worked example when nobody was available to explain a calculation. P04 described Gemini as providing another opportunity to study outside

class and appreciated learning at an individual pace.
However, this perceived availability was qualified by students' circumstances. P07 explained:
"Gemini is helpful when I need simple explanations. I like that it gives examples. It is not something I can use every day because I do not have my own phone." — P07
Thus, the accounts distinguished valuing the support from being able to access it consistently. Perceived usefulness did not imply uninterrupted availability.

Theme 3: Support for revision and independent practice
Several accounts located usefulness in revision activities rather than explanation alone. P05 valued the opportunity to obtain further exercises:
"I like that I can ask for more questions when I finish the first set." — P05
P05 described copying practice questions into a notebook, attempting them and subsequently checking answers. The perceived benefit involved extending opportunities to practise material already introduced in class.
P02 emphasised calculations and past examination questions, while P09 described using generated questions to identify areas requiring further revision. P09 also valued summaries but recognised their limitations:
"It also helps me revise faster when I want a summary, but I know a summary may leave out some details." — P09
These accounts presented usefulness as support for organising and extending revision. They did not provide independent evidence of improved examination performance.

Theme 4: Alternative explanations and shared learning
Some accounts valued the tools for offering another way of approaching familiar content. P09 stated:
"It has been useful because it gives me different explanations of the same concept." — P09
This account associated usefulness with comparing explanations rather than relying on one presentation. P08 described a related experience within group study:
"It provides explanations that give us something to think about, but we still have to check whether we have understood correctly." — P08
For P08, generated explanations contributed to discussion with friends. Their usefulness lay partly in supplying material for collective consideration. The account retained an active role for learners, who needed to discuss and evaluate what the explanation meant.

Theme 5: Usefulness as a supplementary resource
Across the accounts, teachers, textbooks and class notes retained an important place. P01 explained:
"My Chemistry textbook and teacher are still my main sources." — P01
P06 particularly valued teacher and textbook support for syllabus coverage and laboratory work. P03 and P07 similarly described practical demonstrations or classroom illustrations as more helpful for particular aspects of Chemistry.
P10 provided a qualification to favourable perceptions:
"It has been useful in some ways, especially when I need an explanation quickly. But I sometimes become too dependent on it because it is easier to request an answer than to struggle with a question." — P10

Discussion of Findings

Regarding the first objective, the supplied accounts portrayed understanding Chemistry concepts as a gradual process involving clarification, error recognition and independent practice. Explanations organised into manageable steps helped students reconsider difficulties involving bonding, mole calculations and chemical equations. However, understanding remained uneven: some accounts described successful application to familiar questions alongside uncertainty about more complex examples. P10's inability to solve a related gas-law problem after following a worked solution particularly illustrated the distinction between an explanation appearing clear and the learner being able to apply it independently. This pattern is consistent with Valeri et al. (2025), who reported students' use of ChatGPT for conceptual clarification in STEM learning, and Ardyansyah et al. (2024), who documented contrasting approaches to engaging with generated answers. From a constructivist perspective, the accounts suggest that explanations became meaningful through questioning, comparison and practice. They do not establish that generative artificial intelligence independently improved conceptual understanding.

Concerning the second objective, perceived usefulness centred on repeated clarification, revision support and access to alternative explanations outside classroom instruction. The opportunity to ask questions without embarrassment appeared particularly meaningful in P01's account, while other accounts valued practice questions, summaries and material for group discussion. These perceptions correspond with Ardyansyah et al. (2024), whose participants appreciated accessible and detailed responses, and Valeri et al. (2025), who identified responsive conceptual support as a valued feature. Nevertheless, usefulness was conditional: students continued to prioritise teachers, textbooks and practical demonstrations, and P10 associated convenient answers with the temptation to avoid independent effort. Clark et al. (2024) similarly demonstrated the value students attached to critically comparing generated material with their own work. Accordingly, usefulness should be understood as students' judgments about particular forms of assistance rather than evidence of improved achievement or comprehensive mastery.

For the third objective, the accounts indicated that challenges arose through the interaction of access conditions, response quality and students' learning practices. Shared devices, data costs, connectivity interruptions and charging difficulties constrained opportunities to use the tools, while unfamiliar terminology, omitted conditions and conflicting explanations complicated interpretation. These concerns resonate with Miao and Holmes's (2023) emphasis on equitable access, human agency and pedagogical oversight. Uncertainty about scientific accuracy also corresponds with the limitations identified by Clark (2023) and Tyson (2023), although the data showed that discrepancies sometimes arose from inaccurate inputs or alternative explanations rather than AI error. Copying, distraction and difficulty managing study time further qualified the perceived benefits.

Conclusion

The analysis suggests that generative artificial intelligence can support Chemistry learning through accessible explanations, repeated clarification and opportunities for revision, while its educational value depends on students' active engagement and independent practice. Perceived clarity did not consistently translate into the ability to solve unfamiliar problems, and usefulness remained conditional on response accuracy, appropriate language and access to devices and connectivity. Teacher guidance, textbooks and practical demonstrations therefore remained important for checking information and developing understanding. Generative artificial intelligence is consequently best positioned as a supplementary learning resource, supported by

digital literacy and equitable access.

Recommendations

1. Chemistry teachers should integrate AI-assisted explanations with independent problem-solving and practical demonstrations to help students translate apparent understanding into meaningful application.
2. Students should use generative artificial intelligence for clarification, revision and self-testing alongside teacher guidance, textbooks and class notes.
3. Schools and education authorities should provide supervised access to suitable devices and reliable connectivity, together with training in question formulation, response verification and responsible study practices.

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