Becoming a Chemistry Teacher in the Age of AI: Pedagogical Encounters From School-Based Teaching Practice

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Abstract

The integration of artificial intelligence (AI) in pre-service teacher education is increasingly relevant in response to the growing complexity of technology-based learning environments. Understanding student perceptions is crucial for determining how AI can be meaningfully adopted in school learning practices, particularly regarding its usefulness, ease of use, and level of trust in the technology. However, empirical studies examining pre-service teachers' experiences with AI during school-based teaching practice remain limited. This study investigated the experiences of pre-service chemistry teacher students in using AI as part of their learning preparation in the school settings. A mixed-methods design was employed, involving final-semester students from the Chemistry Education Study Program at the University of Lambung Mangkurat, Indonesia (N = 50), who were participating in a teaching practice program at school. Quantitative data were collected through a Technology Acceptance Model (TAM)-based questionnaire supplemented by in-depth interviews. The results indicated that students view AI as a helpful tool for accessing learning resources, developing teaching materials, and generating creative ideas for learning. At the same time, some students remained cautious about trusting the accuracy and scientific reliability of AI-generated information, leading them to rely on verification processes and pedagogical guidance. Furthermore, the majority of students strongly recommended the need for structured training or workshops to support more optimal use of AI in learning. These findings indicated a tension between independent use of AI and the need for pedagogical and institutional support, underscoring the importance of targeted, ethical, and pedagogically grounded integration of AI into the curriculum.

Keywords: artificial intelligence, pre-service chemistry teachers, higher education, teachers' identities

Introduction

AI in higher education has the potential to provide personalized and tailored learning experiences tailored to student needs, providing real-time feedback, and increasing student engagement (Abbasi et al., 2025; González Campos et al., 2024; Kuka et al., 2022; Orr et al., 2025; Singh & Hiran, 2022). Intelligent tutoring systems and adaptive learning platforms are representative examples of AI that adapt to students' educational content, learning style, and pace (Mupaikwa, 2025; Ratul et al., 2025). In the context of teaching efficiency, teachers can use AI-based assessments to automate various tasks, administration, especially the student assignment grading process, so that lecturers can focus more on supporting students' academic development (González Campos et al., 2024; Gurumayum et al., 2024; Ratul et al., 2025; Téllez et al., 2024). Furthermore, research processes can be conducted more efficiently, such as data collection, analysis, and presentation, as well as writing, editing, and summarizing literature (Dockens & Shelton, 2025; Orr et al., 2025). Therefore, AI development must be based on ethical principles as a form of protection and security to prepare a generation that is sensitive to the digital world (including AI) (Andocilla-Oleas et al., 2025; Wang, 2021).

In chemistry education, AI is significantly transforming the teaching and learning experience. Studies have shown that AI-based adaptive learning systems can help students understand complex chemical concepts more reflectively, including feedback and tailored content (Pullanikkattil et al., 2025; Tanveer et al., 2024). In a virtual context, AI integration can provide a safe and accessible environment for students to conduct experiments and explore chemical reactions without the risks of a physical lab (Pullanikkattil et al., 2025; Tanveer et al., 2024). It is essential, given that the laboratory aspect serves as a hands-on learning experience, allowing students to interact with various levels of representation, such as macroscopic, submicroscopic, and symbolic (Barke et al., 2012; Schwedler & Kaldewey, 2020; Tanveer et al., 2024).

Several studies have also described a variety of innovations that can improve students' skills in AI applications, such as workshops on retrosynthesis and protein structure prediction (Berber et al., 2025), intelligent tutors (Pullanikkattil et al., 2025), Gemini/BERT in assessment processes (Yamtinah et al., 2025), and detectors in exams (Sorenson & Hanson, 2024), as well as helping to design more effective and engaging chemistry lessons (Kadioğlu & Oskay, 2024; Leitea, 2023; Tanveer et al., 2024). Previous studies have identified several limitations regarding students' perceptions of AI in education. Many studies have not adequately examined the long-term impacts of AI use in education, including technical barriers and issues with the quality of the resulting content (Esfijani et al., 2025). This point emphasizes the need for in-depth studies regarding the alignment of AI integration with educational goals and its practical use (Christou, 2024; Esfijani et al., 2025), including ethical considerations of AI integration in education (Dobrovská et al., 2024; Isop, 2024; Lamanauskas & Makarskaitė-Petkevičienė, 2025; Nunez Lemoz et al., 2025).

While numerous studies have explored the potential and impact of AI in education, prior research has focused on students in general in higher education settings. Unlike previous studies, this study involves prospective science teacher students undergoing teaching practice in schools. In addition to the authentic teaching practice context, this study also emphasizes the local educational context in Banjarmasin City, South Kalimantan. This situation provides a more genuine perspective for understanding how AI is perceived in real-life teaching, particularly the alignment of local values, learning culture, and ways of thinking that characterize prospective teachers in this region. Through the field experience program in schools, students use AI technology not only as a learning tool but also to design lessons, manage student interactions, and assess the effectiveness of AI use in pedagogical and ethical contexts. Therefore, this study offers a unique perspective on how prospective chemistry teachers' AI literacy, pedagogical readiness, and moral awareness are formed through authentic field experiences grounded in local values and culture.

Theoretical Framework

In this study, the Technology Acceptance Model (TAM) served as the primary theoretical foundation for exploring students' perceptions of the use of artificial intelligence (AI) in education. TAM contains two essential factors: "perceived usefulness (PU)" and "perceived ease of use (PEU)" (Davis & Granić, 2024). PU describes the extent to which students believe that the use of AI can improve the effectiveness and efficiency of learning. PEU reflects how easily students feel they can use AI technology without encountering significant obstacles. Research by Musa et al. (2024) found that using the TAM model helps in understanding market responses to digital products. The application of TAM was also used by Phuong Dung et al. (2023) to determine a person's acceptance of the digital world, which influences their intention to start something. PU and PEU are the main elements of TAM and have been consistently shown to influence students' attitudes and behavioral intentions towards technology (Bantoto et al., 2024; Chen et al., 2025; Karan & Chakma, 2025; Runge et al., 2025; Selevičienė & Koloda, 2025; Supriyanto et al., 2024; Zhao et al., 2024).

In a higher education setting, Fan (2023) used TAM to determine how students use social media in their learning. TAM effectively explained student acceptance of AI tools, such as ChatGPT and humanoid robots. Factors such as self-efficacy and perceived enjoyment further strengthened the model's predictive power (Chen et al., 2025; Karan & Chakma, 2025; Selevičienė & Koloda, 2025; Supriyanto et al., 2024; Ursavaş et al., 2025). Studies have found that TAM can guide the integration of AI into the curriculum, ensuring that tools are user-friendly and aligned with student needs and expectations (Bantoto et al., 2024; Selevičienė & Koloda, 2025; Supriyanto et al., 2024). The TAM, which encompasses individual characteristics (novelty-seeking and self-efficacy), provides deeper insights into student acceptance of AI, particularly in terms of perceived usefulness and ease of use (Chen et al., 2025; Ursavaş et al., 2025). Combinations of other models also strengthen and enrich the understanding of AI acceptance by adding factors such as discomfort, insecurity, and perceived behavioral control, including the Technology Readiness Index (TRI) and the Theory of Planned Behavior (TPB) (Zhao et al., 2024).

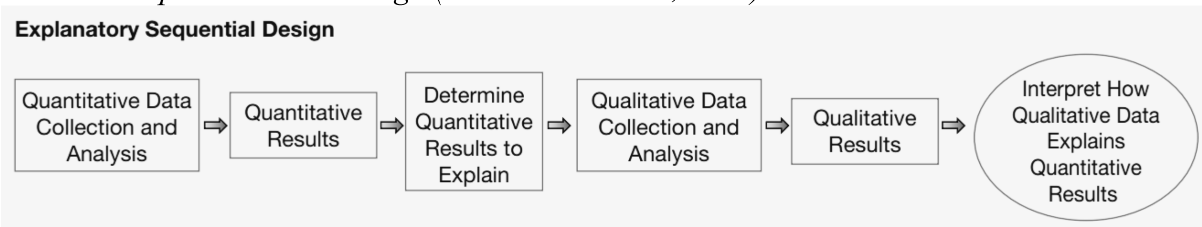
The TAM helps explore how individuals, including students, perceive and value technology, and how these perceptions and values affect students' attitudes, particularly regarding AI in learning. The diversity of perceptions and acceptance of technology can serve as a strong foundation for teaching, such as integrating AI into assessments, assignments, and references in learning design. By using the TAM, educators and policymakers can design and implement AI tools that meet students' needs and improve academic performance, given that technological literacy is a crucial element for today's generation.

Methodology

Design

This study employed a mixed-methods design to gain a comprehensive understanding of students' perceptions of AI (Creswell & Clark, 2018). Participants were final-semester students in the Department of Chemistry Education at the University of Lambung Mangkurat, Indonesia, who were undergoing a teaching practicum program at a school. Purposive sampling was used to ensure respondents had direct experience with chemistry content and technology-based courses.

Figure 1
Research Implementation Design (Creswell & Clark, 2018)



Instruments

Data were collected using a questionnaire and semi-structured interviews. The questionnaire consisted of 15 items structured based on the Technology Acceptance Model (TAM) framework, with two main factors: Perceived Usefulness (PU) and Perceived Ease of Use (PEU) (Davis & Granić 2024). In addition, a review of previous research on integration in education was conducted to strengthen the development of relevant indicators, such as alignment of AI with curriculum objectives, teacher readiness, assessment strategies, access challenges, adaptability, ethical challenges, and various concerns in using AI (Abidine et al., 2025; Almasri 2024; Guha et al., 2025; Kasat et al., 2025; Kohnke & Green-Eneix, 2025; Ramesh, 2025). The results of this review were then elaborated into several additional operational indicators that support the adopted definition of the TAM concept, particularly the perception component. PU was described as understanding complex chemical concepts with the help of AI, supporting learning motivation, and encouraging creativity in the design of learning experiences. At the same time, PEU included readiness to use AI, trust in the accuracy of sources, and the need for additional training.

The elaboration was then formulated as questionnaire items using a Likert scale. The questionnaire was then consulted and discussed with experts in educational psychology, chemistry education, and educational research and evaluation. The expert input was used to refine the instrument before use in data collection. The questionnaire underwent content validation by experts in chemistry education, educational research and evaluation, and Indonesian language and literature education to ensure clarity, relevance, and alignment with the study's objectives. Content validation included format, language, content, and sustainability values. Interviews were conducted using open-ended questions to explore students' opinions and experiences in greater depth, thereby strengthening the data obtained.

Data Collection and Analysis Procedures

Several stages were carried out in the study: (1) formulating the study objectives, (2) developing a Likert-based questionnaire, (3) developing an interview guide, (4) validating the questionnaire, and (5) distributing the instrument and collecting data. Quantitative data were analyzed using descriptive statistics, expressed as percentages, to provide an overview of student perceptions. Qualitative data from interviews were analyzed using thematic analysis to identify key themes related to the benefits, challenges, and recommendations for using AI.

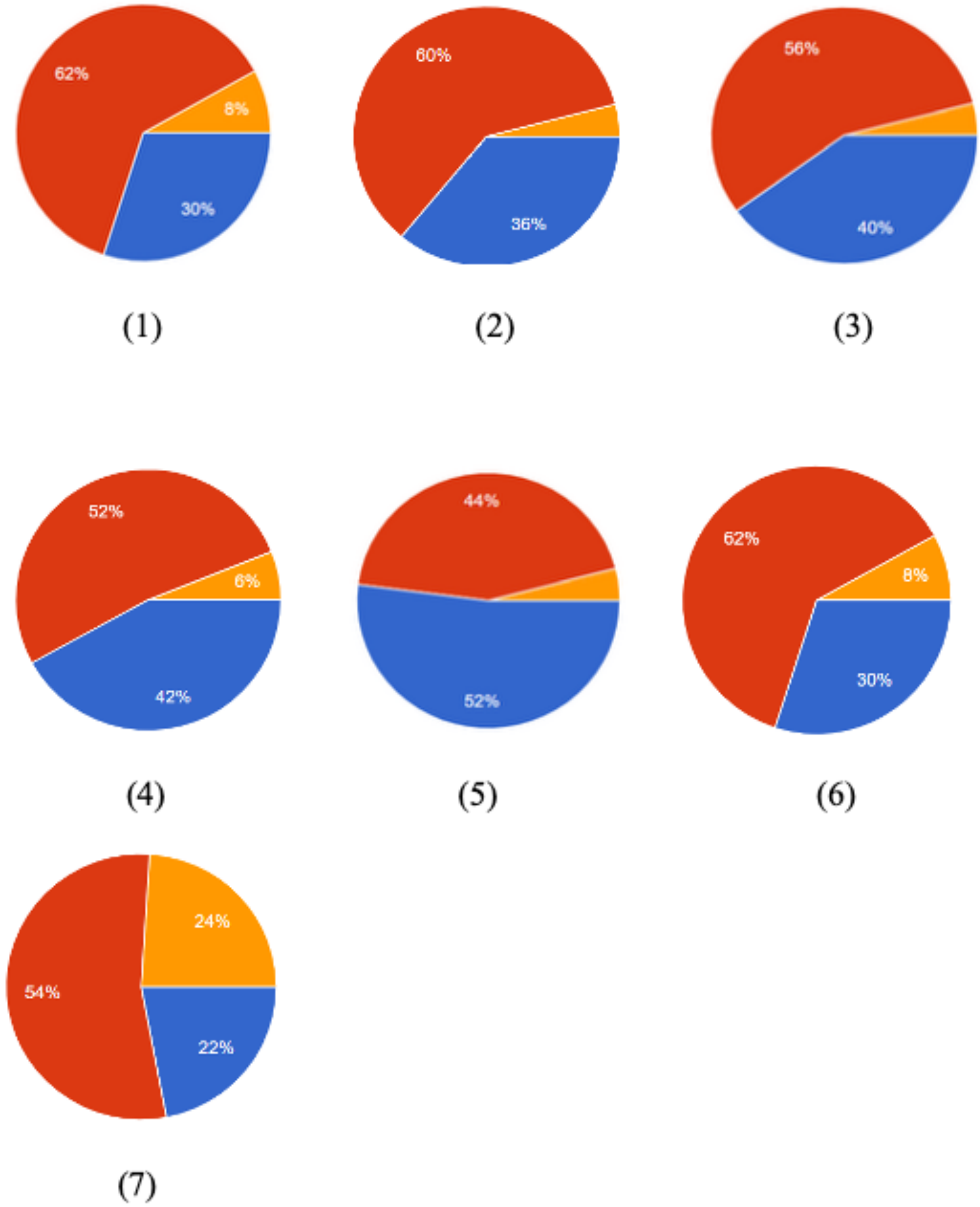
Triangulation between quantitative and qualitative data was conducted to strengthen the validity of the study's findings.

Research validity was assessed using the Content Validity Index (CVI) (Yusoff, 2019). Lynn (1986) recommended a minimum of three experts, with a neutral 4-point ordinal scale. In the assessment, scores 3 and 4 are coded as “1,” while scores 1–2 are coded as “0” (Ozair et al., 2017). Items are considered valid if all validity indices are > 0.80, especially I-CVI (item-level content validity index = agreed item/number of experts), S-CVI/Ave (scale-level content validity index based on the average method), and S-CVI/UA (scale-level content validity index based on the universal agreement method) (Lau et al., 2018; Ozair et al., 2017; Yusoff, 2019).

Results

Before interpreting the study's findings, the instrument's quality must be confirmed for accuracy or validity. The content validity of the Technology Acceptance Model (TAM)-based instrument was determined through expert judgment with a Content Validity Index (CVI) involving experts. The results showed that most items had an I-CVI ≥ 0.75, with an S–CVI/Ave of 0.98 and an S-CVI/UA of 0.95. These data indicate a very high level of expert agreement on the relevance and clarity of the instrument items. This finding confirms that the instrument has adequately represented the construct being measured. Furthermore, the reliability test used Cronbach's Alpha, yielding a value of 0.874, indicating high internal consistency. Thus, the instrument is declared valid and reliable, making it suitable as a basis for interpreting students' perceptions of Perceived Usefulness and Perceived Ease of Use within the TAM framework.

Figure 2
Analysis Results for the "Perceived Usefulness (PU)" Factor for Items 1 – 6. Color Information: Blue (Strongly Agree), Red (Agree), Orange (Less Agree), and Green (Disagree)*

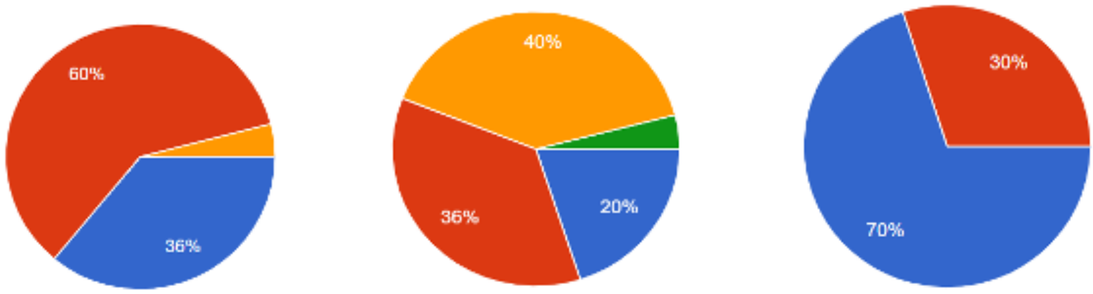


The items:

1. The use of AI technology helps me understand complex chemical concepts
2. I feel helped in preparing chemistry learning activities using AI technology
3. Using AI technology is part of a learning strategy to obtain interesting learning presentation references
4. AI technology can increase my motivation to study chemistry material as a prospective teacher

5. AI technology helps me design more creative learning experiences for students in the future
6. I feel that AI technology helps me develop problem-solving skills and digital literacy needed in the 21st century
7. I can learn chemistry independently and exploratively by using only AI technology

Figure 3
Analysis Results for the "Perceived Ease of Use (PEU)" Factor, for Items 8 – 10. Color Information: Blue (Strongly Agree), Red (Agree), Orange (Less Agree), and Green (Disagree).*



(8) (9) (10)

The items:

8. I am very ready as a prospective teacher to use AI technology in chemistry learning
9. I believe that the information provided by AI technology is accurate, scientific, and reliable
10. There is a need for more training and workshops on the use of AI technology to optimize its application in learning.

Table 1
Results of Student Interviews Regarding Their Perceptions of the Use of AI

Themes	Respondents' Statements	Participants
Benefits of using AI	AI technology is invaluable in the learning process/designing learning activities.	Participant-8
	AI Technology indeed makes it easier for users to find learning resources	Participant-9
	Utilize AI for creative projects and train teachers to use it in teaching	Participant-10
	AI helps teachers and students understand lessons more easily, for example, by assisting them in finding references.	Participant-12
Accuracy of Information	The AI often used is still inaccurate when searching for references, requiring repeated attempts.	Participant-1
	Not all results generated by AI can be trusted 100%, especially in science teaching.	Participant-5
	AI can be a learning resource, but it needs to be supported by other reliable sources.	Participant-3
	AI technology is invaluable, but its drawbacks are inaccuracy and being subscription-based	Participant-4

Need for development	I recommend AI to provide interactive simulations for virtual experiments	Participant-11
	Seminars or training on using AI in chemistry learning are needed	Participant-13
	AI for 3D visualization or augmented reality helps students better understand abstract concepts.	Participant-14
	The integration of AI into courses and workshops on its use in chemistry learning is essential.	Participant-15
Limitations of AI	Although AI is helpful, its output still needs to be filtered further	Participant-2
	There is one thing AI lacks: the human sense of reasoning, feeling, and empathy.	Participant-6
	It is hoped that AI has restrictions to prevent misuse by students	Participant-7

Discussion

The findings indicate a strong consensus that prospective chemistry teacher students consider AI to be invaluable in the academic process and teaching practice, from understanding complex chemical concepts, designing lessons, enriching references and creativity, and sparking learning motivation (a prominent dimension of Perceived Usefulness (PU). However, on the Perceived Ease of Use (PEU) dimension, trust in the accuracy and scientific nature of AI information remains fragile, so practical use is almost always accompanied by verification and guidance from lecturers. The results also found that although students feel ready and are already actively using AI, they also highly recommend training/workshops related to AI or AI integration. It indicates a gap between attitudinal readiness and pedagogically verifiable competencies, as reflected in the widespread demand for AI training in higher education. Thus, students position AI not simply as a substitute for teachers but as a pedagogical collaborator that requires verification protocols, ethical literacy, and institutional support, so that perceived benefits are directly proportional to the reliability of classroom practice. Beneath this consensus, a subtle gap emerges between the benefits and accuracy of AI output.

Confidence-Competence Gap: I Can Use It, but I Need Structural Instructions

The "can already" but "requires teaching" finding is a fascinating finding from the analysis. Students appear adept at operating AI in practical teaching tasks, yet they simultaneously highly recommend AI-related training/workshops. This phenomenon is not a contradiction but rather a sign of a "confidence-competence gap," namely, the gap between declarative readiness and pedagogically verifiable skills. In the analysis, item 8 shows that approximately 60% of students stated they were ready to use AI in chemistry lesson design, indicating high confidence. However, this result contradicts the interview findings, in which students emphasized the need for seminars or specific training on AI integration (student 13), and around 50% of students stated they truly believed the information provided by AI was accurate, scientific, and reliable (item 9).

From the Technology Acceptance Model (TAM) perspective. High perceived usefulness (PU) (clear benefits) helps students prepare for learning, enhance creativity, and understand complex chemistry concepts through AI. However, perceived ease of use (PEU) is hampered by trust (still doubts) regarding the accuracy of AI information and how to moderate content for pedagogical validity. It indicates that students' skills remain technical-operational, such as the ability to execute basic commands and generate AI output, but have not yet fully addressed the critical, verification, and pedagogical aspects required for teaching.

This picture was reinforced in interviews, where student 8 emphasized that AI was very helpful in designing learning activities, but student 6 reminded them that "AI is not human," and therefore lacks intuition, empathy, or contextual judgment. In other words, even though students can operate it well, they still require expert validation and guidance to ensure its valid use in the context of chemistry learning. In this context, what students are looking for is no longer how to turn on AI, but rather how to use it appropriately. The appropriate use of AI can not only boost student confidence but also strengthen the pedagogical competencies essential for future teachers. This confidence, coupled with competence, is necessary for students to become not only AI users but also educators who can use AI effectively and integrate it into chemistry learning.

Therefore, training is perceived as a "bridge" to transform operational skills into valid scientific-pedagogical skills or validated AI-based teaching competencies. For example, training materials can cover chemistry-domain prompting techniques, scientific verification (data sources, calculations, and conceptual coherence), academic ethics, the type of AI technology used, and formats for designing learning, including assessments. Therefore, students desire standardized, clear, and structured AI practices to produce outputs free of conceptual bias or blind dependence. Standardized AI integration has the potential to provide a safe environment for exploration in learning (Pullanikkattil et al., 2025; Tanveer et al., 2024). Appropriate exploration can yield insights that support the construction of scientific structures and mental models for prospective chemistry teachers, particularly understanding at various levels of representation (Barke et al., 2012; Schwedler & Kaldewey, 2020; Tanveer et al., 2024; van Berkel et al., 2009).

These findings reinforce the results of previous studies that emphasized the development of an "ethical framework" to guide the integration of AI in education (Dobrovská et al., 2024; Isop, 2024; Lamanauskas & Makarskaitė-Petkevičienė, 2025; Nunez Lemoz et al., 2025). Furthermore, other studies have highlighted that limited resources and a lack of teacher training are key barriers that must be addressed immediately for more effective AI utilization (Reyes-Villalba et al., 2024). The absence of a detailed ethical framework can lead students to use AI haphazardly, resulting in a lack of confidence that is not balanced by critical competency. In the context of chemistry education, this situation is crucial, given that even minor errors in concept verification can lead to representational bias at various levels (macroscopic, submicroscopic, and symbolic).

Agency vs Dependency

"Agency" is evident when students position AI as a pedagogical partner that strengthens creativity and independent learning. Approximately 96% of respondents stated that AI can help design more creative learning and stimulate accelerated work in searching for references, completing assignments, and developing learning strategies (item 5). In item 6, AI is considered to support 21st-century problem-solving and digital literacy skills (approximately 92%). Interviews corroborated these findings, with students 8 and 9 emphasizing the role of AI in designing learning scenarios and facilitating the search for learning resources, while students 10 and 15 considered AI relevant in developing various creative projects and recommending training courses. Students 11 and 14 even emphasized the need to develop interactive simulations and 3D visualizations powered by AI to better understand chemistry concepts. It demonstrates that many students are not simply passive users of AI but are using it reflectively and innovatively to strengthen their pedagogical identity.

Conversely, students' tendency to be passive and to rely heavily on AI-generated output without a critical approach gives rise to "dependency." Approximately 54% of respondents (item 7) agreed that they could learn chemistry using AI, indicating a high potential for dependence on AI as a primary learning resource. Furthermore, although only 20% of students (item 9) agreed that AI provides accurate information, interviews revealed that students still rely on AI results despite doubting their reliability. Students 1 and 5 stated that AI-generated information is often inaccurate and requires repeated verification. Students 3 and 4 considered AI a viable primary reference, though not always optimal and usually limited to premium features. Student 6 even acknowledged the lack of human sense, suggesting that AI lacks the elements of reason, feeling, and heart that characterize the human race. Therefore, guidance and direction are still needed to ensure its relevance and ethical use. These findings demonstrate an ambivalent stance among students: AI is invaluable for technical and creative tasks, but its presence creates a sense of dependency because of its limitations in conveying the human dimension.

This dialectic can be further understood within the Technology Acceptance Model (TAM). High perceived usefulness (PU) indicates student agency in using AI for learning, but a less-than-fully achieved perceived ease of use (PEU) suggests a sense of dependency due to concerns about accuracy, ethics, and security. In other words, while AI offers numerous pedagogical benefits, it also poses serious challenges, such as potential job replacement, ethical issues, data privacy, and security concerns (Salgado-Reyes et al., 2024; Shafik, 2024). These findings also support studies that argue that AI should be developed with ethical principles to protect and secure, preparing a generation of teachers who are sensitive to digitalization and equipped with skills that are adaptive to the times and sustainable (Andocilla-Oleas et al., 2025; Wang, 2021).

Thus, agency and dependency go hand in hand in student experiences using AI. Students demonstrate agency by using AI to support their creative learning design and develop problem-solving skills. This situation also reflects the dependence on AI, despite lingering doubts about its accuracy. This dialectic emphasizes that AI is not a substitute for teachers but rather a pedagogical collaborator that requires training, mentoring, guidance, and ethical development for optimal implementation in chemistry education.

Chemical Representation and the Need for Visualization and Simulation

In the Perceived Usefulness (PU) dimension, the majority of students agreed with items 4–6, with each item scoring above 90% (strongly agree and agree combined). These items demonstrate strong support for the need for interactive media to address chemical abstraction during the learning process. Conversely, with item 7, the percentage of students who disagreed was < 25%. This item demonstrates students' limitations when AI lacks adequate simulation- or visualization-based learning tools. Furthermore, item 10 (part of the PEU) showed 100% support for the need for training/workshops. It strongly indicates the urgent need for technical training in AI use across various learning needs, including visualization.

These findings confirm that students themselves proposed the need to integrate AI with various simulation-based features, demonstrating their awareness that using AI is not limited to text or automated answers, but must be grounded in evidence-based pedagogy through virtual experiments. In chemistry education, implementing various representation-based solutions (macroscopic, submicroscopic, and symbolic) is a significant challenge. In fact, representation-based understanding is a key element that students need to internalize to easily build scientific structures and mental models, especially at the submicroscopic level (Barke et al., 2012; Cheng & Gilbert, 2009; Gkitzia et al., 2020; Wisudawati et al., 2022). Therefore, virtual lab simulations, reaction mechanism animations, or 3D or Augmented Reality (AR) visualizations are highly relevant as bridges to understanding.

Although perceived ease of use (PEU) is still limited to trust and accuracy, especially in the context of using AI without visual evidence or lab simulations (low support for item 7 and doubt for item 9), students' perceptions are considered to view AI as highly supportive of various components in designing chemistry learning, including the implementation of multi-representation in chemistry learning (seen from the high perceived usefulness in items 4-6). This finding is in line with previous studies related to innovations that can improve students' skills in using AI applications, such as intelligent tutors (Pullanikkattil et al., 2025), assessment processes (Yamtinah et al., 2025), detectors in exams (Sorenson & Hanson, 2024), and chemistry learning design (Kadioğlu & Oskay, 2024; Leitea, 2023; Tanveer et al., 2024). By integrating AI through visualization or interactive simulations, students can engage in meaningful learning while improving their mental models. Thus, students' learning needs for simulation visualization indicate that AI in chemistry education is most effective when positioned as representational scaffolding, an evidence-based tool that bridges the complexities of chemical abstraction while remaining evidence-based.

Structural Barriers

A relatively high score for perceived usefulness (PU) was obtained for items 4–6, with support > 90%. However, barriers to premium access and the absence of institutional guidelines can weaken the Perceived Ease of Use (PEU) dimension. In other words, the reluctance of some students in item 9 indicates that "trust" in AI's accuracy has not yet been fully achieved. This finding is relevant to previous studies that emphasize the need for regulation and institutional support in the integration of AI in higher education (Dobrovská et al., 2024; Isop, 2024; Lamanauskas & Makarskaitė-Petkevičienė, 2025; Nunez Lemoz et al., 2025). Without institutional intervention, the potential for inequality in AI utilization could arise, namely, for technically sound but ethically vulnerable and unsustainable uses. A standardized institutional framework can prevent over-reliance on AI, which can negatively impact students' cognitive development (Christou, 2024; Del Mundo et al., 2024; Esfijani et al., 2025; Vieriu & Petrea, 2025). This intervention is also highly beneficial for students in preparing for the workforce, given the significant gap between industry and higher education: only 3% of employers rate higher education as capable of preparing graduates for the AI era (AI in the Workplace 2025, 2025).

Student 4 stated that AI can only be optimally utilized through paid subscription AI. Paid AI has more comprehensive features. These factors explain why some students rated the use of AI technology in the "less agree" or "disagree" category (as seen in item 9, where only 4% of students disagreed). The gap in access between the free and premium versions widens the "trust" gap, as many students feel the information generated by premium AI is more accurate, scientific, and reliable than that of free AI. On the other hand, some lecturers allow the use of AI, but only as a "tool" or learning aid without clear boundaries for its use. This tolerance is not accompanied by institutional support in the form of a premium AI platform license and explicit ethical guidelines for use, leaving students in an ambiguous position between permissibility, limited access, and the absence of clear ethical guidelines. Studies indicate that around 71% of students want to be involved in decision-making regarding AI integration, especially in determining what kind of AI should be used in their educational process (The Digital Education Council Global AI Student Survey, 2024).

These barriers are not only technical and economic, but also stem from inadequate policy structures. Students view the importance of institutional support, such as providing campus licenses (premium access to AI tools), AI ethics policies in the classroom (guidelines for AI use in the school, limits on plagiarism, scientific verification, and human oversight as ethical standards), curricular integration of AI (incorporating digital literacy and AI ethics across courses), and regular training/workshops, as essential prerequisites for more accurate, ethical, and sustainable AI practices. This perspective highlights the importance of institutional scaffolding that can offset individual limitations, supporting students not only in AI's operational capabilities but also in a supportive educational ecosystem. This finding aligns with a survey that found that approximately 72% of students expect universities to offer numerous courses on AI literacy, training, and the potential for errors (inherent bias/AI hallucinations) resulting from AI use (The Digital Education Council Global AI Student Survey, 2024).

Limitations

Despite numerous findings in the field, several limitations must be considered. First, the sample was limited to chemistry education students at one university, so these findings cannot be generalized to other contexts, including all study programs at the same institution or other universities. Second, the questionnaire was developed using the TAM framework and validated through expert justification, but the items have not been further tested using factor analysis. Third, the interviews did not cover the entire sample, so the diversity of experiences was not fully explored. Fourth, the context of AI use remains predominantly text-based, while the unique needs of chemistry have not been studied in depth, such as virtual labs and visualizations at various levels of representation. This limitation is compounded by the availability of free and premium AI access, which has led to varying perceptions of the accuracy and reliability of AI-generated information.

Recommendations

Given these limitations, a larger sample from multiple universities and across disciplines is highly recommended to obtain a more comprehensive picture of perceptions. Furthermore, it is necessary to add additional factors to the instrument and to the factor analysis to capture a more comprehensive picture of technology acceptance. From a practical perspective, institutions need to provide premium AI access for students, develop ethical guidelines for AI use in chemistry classes, and integrate AI literacy and ethics into curriculum development or ongoing curricula, particularly practice-based courses. Furthermore, organizing workshops or training sessions is a crucial recommendation, particularly those emphasizing verification skills, pedagogical integration, and the use of AI for multi-representational visualization in chemistry. It can build students' confidence and competence in using AI effectively and ethically.

Although this study used the Technology Acceptance Model (TAM) as the primary theoretical framework to understand students' perceptions through the PU and PEU dimensions, the qualitative analysis revealed additional dynamics beyond the TAM's core variables. Findings such as agency, dependency, trust fragility, the confidence-competence gap, structural barriers, and representational needs in chemistry learning demonstrate that students' experiences with

AI are far more complex than the TAM model predicts. Thus, while the TAM serves as a preliminary structure, these emergent findings enrich understanding and provide new theoretical contributions in explaining how students actually interact with AI in pedagogical contexts.

Conclusion

This study shows that the process of "becoming a chemistry teacher" in the era of artificial intelligence (AI) is characterized by diverse pedagogical encounters among students during their teaching practices in school settings. This process positions AI as a collaborative partner that enriches learning, not a substitute for teachers. Using the technology acceptance model (TAM) framework, students rated AI as having high perceived usefulness (PU) because it helped them understand complex chemistry concepts, stimulated creativity, and increased learning motivation. However, the perceived ease of use (PEU) dimension still faces challenges, including doubts about information accuracy, limited premium access, and the absence of institutional ethical regulations. This situation creates a "confidence-competence gap," where students are confident in operating AI technically but still require expert guidance, training, and institutional support for pedagogically valid use. Thus, students' experiences teaching in schools using AI not only expand their technical skills but also shape their pedagogical readiness to integrate technology into chemistry learning in ways that are critical, ethical, and sustainable.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The author used artificial intelligence (AI)-assisted technology, such as ChatGPT, in the writing process to assist with language editing, sentence context clarity, and grammar correction. The use of AI was limited to writing and did not generate research data. The substantial content, data analysis, results description, and conclusions were entirely handled by the author.

References

Abbasi, B. N., Wu, Y., & Luo, Z. (2025). Exploring the impact of artificial intelligence on curriculum development in global higher education institutions. *Education and Information Technologies*, *30*(1), 547–581. https://doi.org/10.1007/s10639-024-13113-z

Abidine, M. Z. E., Nejjari, A., & Khaldi, M. (2025). Integrating generative Artificial Intelligence (GAI) into the teaching-learning of French as a Foreign Language (FLE). In *Supporting Personalized Learning and Students' Skill Development With AI* (pp. 329–342). https://doi.org/10.4018/979-8-3693-8965-2.ch016

AI in the Workplace 2025. (2025). The Digital Education Council (DEC). https://www.digitaleducationcouncil.com/post/ai-in-the-workplace-2025

Almasri, F. (2024). Exploring the Impact of Artificial Intelligence in Teaching and Learning of Science: A Systematic Review of Empirical Research. *Research in Science Education*, *54*(5), 977–997. https://doi.org/10.1007/s11165-024-10176-3

Andocilla-Oleas, I., Mayorga-Jácome, T., & Perez-Cargua, M. (2025). Analysis of Literacy in Artificial Intelligence in Education: An Approach from Teaching. *Lecture Notes in Networks and Systems*, *859 LNNS*, 145–153. https://doi.org/10.1007/978-3-031-78155-1_14

Bantoto, F. M. O., Rillo, R., Abequibel, B., Mangila, B. B., & Alieto, E. O. (2024). Is AI an Effective "Learning Tool" in Academic Writing? Investigating the Perceptions of Third-Year University Students on the Use of Artificial Intelligence in Classroom Instruction. *Lecture Notes in Networks and Systems*, *1098 LNNS*, 72–81. https://doi.org/10.1007/978-3-031-68650-4_8

Barke, H.-D., Harsch, G., & Schmid, S. (2012). Essentials of Chemical Education. *Angewandte Chemie International Edition, 6*(11), 951–952. Springer.

Berber, S., Brückner, M., Maurer, N., & Huwer, J. (2025). Artificial Intelligence in Chemistry Research─Implications for Teaching and Learning. *Journal of Chemical Education*, *102*(4), 1445–1456. https://doi.org/10.1021/acs.jchemed.4c01033

Chen, X., Jiang, L., Zhou, Z., & Li, D. (2025). Impact of perceived ease of use and perceived usefulness of humanoid robots on students' intention to use. *Acta Psychologica*, *258*. https://doi.org/10.1016/j.actpsy.2025.105217

Cheng, M., & Gilbert, J. K. (2009). Introduction: Macro, Submicro and Symbolic Representations and the Relationship Between Them: Key Models in Chemical Education. In J. K. Gilbert & D. Treagust (Eds.), *Multiple Representations in Chemical Education: Models and Modeling in Science Education* (p. 369). Springer.

Christou, P. A. (2024). Implications of Artificial Intelligence (AI) in Education: A Critical Review, Evaluation, and Conceptualization. *Proceedings - 2024 6th International Workshop on Artificial Intelligence and Education, WAIE 2024*, 56–60. https://doi.org/10.1109/WAIE63876.2024.00017

Creswell, J. W., & Clark, V. L. P. (2018). *Designing and Conducting Mixed Methods Research* (3rd ed.). SAGE Publication, Inc.

Davis, F. D., & Granić, A. (2024). *The Technology Acceptance Model (30 Years of TAM)*. Springer.

Del Mundo, M. A., Reyes, E. F. D., Gervacio, E. M., Manalo, R. B., Book, R. J. A., Chavez, J. V., Espartero, M. M., & Sayadi, D. S. (2024). Discourse analysis on experience-based position of science, mathematics, and Tech-Voc educators on generative AI and academic integrity. *Environment and Social Psychology*, *9*(8). https://doi.org/10.59429/esp.v9i8.3028

The Digital Education Council. (2024). *Global AI student survey*. https://www.digitaleducationcouncil.com/post/developing-ai-literacy-and-skills-how-can-institutions-do-it

Dobrovská, D., Vaněček, D., & Yorulmaz, Y. I. (2024). Students' Attitudes towards AI in Teaching and Learning. *International Journal of Engineering Pedagogy*, *14*(8), 88–106. https://doi.org/10.3991/ijep.v14i8.52731

Dockens, A. L., & Shelton, K. (2025). The AI scholar: AI in higher education research and writing. In *AI Integration Into Andragogical Education* (pp. 109–136). https://doi.org/10.4018/979-8-3373-0502-8.ch005

Esfijani, A., Nili, M. R., & Kazemi, M. S. (2025). Artificial Intelligence in Education Challenges and Solutions Through the Eyes of Students. *2025 12th International and the 18th National Conference on E-Learning and e-Teaching, ICeLeT 2025*. https://doi.org/10.1109/ICeLeT66022.2025.11025304

Fan, C. (2023). English learning motivation with TAM: Undergraduates' behavioral intention to use Chinese indigenous social media platforms for English learning. *Cogent Social Sciences*, *9*(2). https://doi.org/10.1080/23311886.2023.2260566

Gkitzia, V., Salta, K., & Tzougraki, C. (2020). Students' competence in translating between different types of chemical representations. *Chemistry Education Research and Practice*, *21*(1), 307–330. https://doi.org/10.1039/c8rp00301g

González Campos, J. A., López Núñez, J. C., & Araya Pérez, C. E. (2024). Higher education and artificial intelligence: challenges for the 21st century. *Aloma*, *42*(1), 79–90. https://doi.org/10.51698/ALOMA.2024.42.1.79-90

Guha, A., Karumbaiah, S., Baeza, C., Castro, M., White, K., & Roman, D. (2025). Teacher Perceptions on AI Support for Bi/multilingual Learners: Superpowers and Constraints. *Lecture Notes in Computer Science*, *15881 LNAI*, 85–91. https://doi.org/10.1007/978-3-031-98462-4_11

Gurumayum, P., Tiwari, N., Kaushik, M., Jha, C., & Arora, M. (2024). AI-Driven Transformations in Higher Education: A Citation and Co-citation Analysis. *International Journal of Experimental Research and Review*, *45*, 261–273. https://doi.org/10.52756/ijerr.2024.v45spl.021

Isop, W. A. (2024). A conceptual ethical framework to preserve natural human presence in the use of AI systems in education. *Frontiers in Artificial Intelligence*, *7*. https://doi.org/10.3389/frai.2024.1377938

Kadioğlu, N., & Oskay, O. O. (2024). Investigating pre-service chemistry teachers' experiences in designing lesson plans using ChatGPT. In *Teachers' Roles and Perspectives on AI Integration in Schools* (pp. 223–260). https://doi.org/10.4018/979-8-3373-1017-6.ch008

Karan, B., & Chakma, C. (2025). Influence of higher education students' perceived behaviour on their artificial intelligence acceptance: an empirical investigation using technology acceptance model. *Journal of Applied Research in Higher Education*. https://doi.org/10.1108/JARHE-11-2023-0535

Kasat, K., Sinha, U., Juneja, S., Ghatge, A., Thorat, N., & Shaikh, N. (2025). Artificial Intelligence in Education: A Comprehensive Examination of Integration, Impact, and Future Implications. *Communications in Computer and Information Science*, *2205*, 182–198. https://doi.org/10.1007/978-3-031-81458-7_11

Kohnke, L., & Green-Eneix, C. (2025). Preparing Pre-Service and In-Service Teachers for the AI-Driven Classroom. In *Teaching and Learning in the Age of Generative AI: Evidence-Based Approaches to Pedagogy, Ethics, and Beyond* (pp. 235–252). https://doi.org/10.4324/9781032688602-15

Kuka, L., Hörmann, C., & Sabitzer, B. (2022). Teaching and Learning with AI in Higher Education: A Scoping Review. In *Lecture Notes in Networks and Systems* (Vol. 456, pp. 551–571). https://doi.org/10.1007/978-3-031-04286-7_26

Lamanauskas, V., & Makarskaitė-Petkevičienė, R. (2025). Pre-service Preschool and Primary School Teachers' Position on Artificial Intelligence. *EAI/Springer Innovations in Communication and Computing*, 183–197. https://doi.org/10.1007/978-3-031-81261-3_14

Lau, A. S. Y., Yusoff, M. S. B., Lee, Y.-Y., Choi, S.-B., Xiao, J.-Z., & Liong, M.-T. (2018). Development and validation of a Chinese translated questionnaire: A single simultaneous tool for assessing gastrointestinal and upper respiratory tract related illnesses in pre-school children. In *Journal of Taibah University Medical Sciences* (Vol. 13, Issue 2, pp. 135–141). https://doi.org/10.1016/j.jtumed.2017.11.003

Leitea, B. S. (2023). ARTIFICIAL INTELLIGENCE AND CHEMISTRY TEACHING: A PROPAEDEUTIC ANALYSIS OF CHATGPT IN CHEMICAL CONCEPTS DEFINING. *Quimica Nova*, *46*(9), 915–923. https://doi.org/10.21577/0100-4042.20230059

Mupaikwa, E. (2025). Transforming Higher Education Through Technology: The Impact of Artificial Intelligence in Education 5.0. In *Impacts of AI on Students and Teachers in Education 5.0* (pp. 553–579). https://doi.org/10.4018/979-8-3693-8191-5.ch020

Musa, H. G., Fatmawati, I., Nuryakin, N., & Suyanto, M. (2024). Marketing research trends using technology acceptance model (TAM): a comprehensive review of researches (2002–2022). *Cogent Business and Management*, *11*(1). https://doi.org/10.1080/23311975.2024.2329375

Nunez Lemoz, S. M., Gail Rocabado Severich, T., Da Silva Ovando, A. C., & Chong, M. (2025). Artificial Intelligence and Education: An Analysis of its Ethical Use to Improve Academic Performance. *EDUNINE 2025 - 9th IEEE Engineering Education World Conference: Education in the Age of Generative AI: Embracing Digital Transformation - Proceedings*. https://doi.org/10.1109/EDUNINE62377.2025.10981341

Orr, L., Burton, K., Blakely, J., & Harrison, S. (2025). Generative artificial intelligence practices for doctoral student engagement. In *AI Applications and Pedagogical Innovation* (pp. 77–98). https://doi.org/10.4018/979-8-3373-5092-9.ch003

Ozair, M., Baharuddin, K. A., Mohamed, S., Esa, W., & Yusoff, M. S. B. (2017). Development and Validation of the Knowledge and Clinical Reasoning of Acute Asthma Management in Emergency Department (K-CRAMED). *Education in Medicine Journal*, *9*, 1–17. https://doi.org/10.21315/eimj2017.9.2.1

Phuong Dung, P. T., Minh An, H., Huy, P. Q., & Dinh Quy, N. Le. (2023). Understanding the startup's intention of digital marketing's learners: An application of the theory of planned behavior (TPB) and technology acceptance method (TAM). *Cogent Business and Management*, *10*(2). https://doi.org/10.1080/23311975.2023.2219415

Pullanikkattil, S., Yerolla, R., & Besta, C. S. (2025). Artificial Intelligence Based Personalized Learning for Chemical Engineering Education. In *Blockchain and AI in Shaping the Modern Education System* (pp. 232–256). https://www.scopus.com/inward/record.uri?eid=2-s2.0-105003053841&partnerID=40&md5=c29349466f5b570e41d7a3a8ddfa4c87

Ramesh, M. R. (2025). Challenges of integrating artificial intelligence with language curriculum: Addressing pedagogical, technological, and ethical barriers. In *Modern Methods for AI-Integrated Language Curriculum* (pp. 205–229). https://doi.org/10.4018/979-8-3693-9606-3.ch008

Ratul, Q. E. A., Zaman, E., Das, S., & Memari, M. (2025). The Role of AI in Transforming Education: A Systematic Review of Trends. *2025 Intermountain Engineering, Technology and Computing, IETC 2025*. https://doi.org/10.1109/IETC64455.2025.11039329

Reyes-Villalba, E., Reyes-Arco, R. E., & Maraza-Quispe, B. (2024). EDUCATIONAL PRACTICES AND THE USE OF ARTIFICIAL INTELLIGENCE: A MULTIFACETED ANALYSIS IN THE CURRENT CONTEXT. *Revista de Gestao Social e Ambiental*, *18*(8). https://doi.org/10.24857/rgsa.v18n8-017

Runge, I., Hebibi, F., & Lazarides, R. (2025). Acceptance of Pre-Service Teachers Towards Artificial Intelligence (AI): The Role of AI-Related Teacher Training Courses and AI-TPACK Within the Technology Acceptance Model. *Education Sciences*, *15*(2). https://doi.org/10.3390/educsci15020167

Salgado-Reyes, N., Nicolalde-Rodriguez, D., Meza, J., & Vaca-Cardenas, M. (2024). Artificial Intelligence and Its Impact on Digital Transformation Processes. *Smart Innovation, Systems and Technologies*, *380*, 37–44. https://doi.org/10.1007/978-981-99-8894-5_4

Schwedler, S., & Kaldewey, M. (2020). Linking the submicroscopic and symbolic level in physical chemistry: How voluntary simulation-based learning activities foster first-year university students' conceptual understanding. *Chemistry Education Research and Practice*, *21*(4), 1132–1147. https://doi.org/10.1039/c9rp00211a

Selevičienė, E., & Koloda, D. (2025). UNIVERSITY STUDENTS' ACCEPTANCE OF CHATGPT AS A WRITING ASSISTANCE TOOL IN ESL AND ESP STUDIES. *Analele Universitatii Ovidius Constanta, Seria Filologie*, *36*(1), 550–565. https://www.scopus.com/inward/record.uri?eid=2-s2.0-105012927546&partnerID=40&md5=16d9ea01c1e1b5e1a15d2d5c928c52ab

Shafik, W. (2024). The role of artificial intelligence in the emerging digital economy era. In *Artificial Intelligence Enabled Management: An Emerging Economy Perspective* (pp. 33–49). https://doi.org/10.1515/9783111172408003

Singh, S. V., & Hiran, K. K. (2022). The Impact of AI on Teaching and Learning in Higher Education Technology. *Journal of Higher Education Theory and Practice*, *22*(13), 135–148. https://doi.org/10.33423/jhetp.v22i13.5514

Sorenson, B., & Hanson, K. (2024). Identifying Generative Artificial Intelligence Chatbot Use on Multiple-Choice, General Chemistry Exams Using Rasch Analysis. *Journal of Chemical Education*, *101*(8), 3216–3223. https://doi.org/10.1021/acs.jchemed.4c00165

Supriyanto, E., Setiawan, A., Chamsudin, A., Yuliana, I., & Wantoro, J. (2024). Exploring Student Perceptions and Acceptance of ChatGPT in Enhanced AI-Assisted Learning. *2024 International Conference on Smart Computing, IoT and Machine Learning, SIML 2024*, 291–295. https://doi.org/10.1109/SIML61815.2024.10578145

Tanveer, S., Tanveer, M., & Tanveer, A. (2024). Role of artificial intelligence in teaching and learning chemical sciences. In *Artificial Intelligence: A Multidisciplinary Approach towards Teaching and Learning* (pp. 148–172). https://doi.org/10.2174/9789815305180124010010

Téllez, A. R., Ortiz, L. M. F., & Domínguez, F. C. T. (2024). Artificial Intelligence in University Administration: An Overview of its Uses and Applications. *Revista Interamericana de Bibliotecologia*, *47*(2). https://doi.org/10.17533/udea.rib.v47n2e353620

Ursavaş, Ö. F., Yalçın, Y., İslamoğlu, H., Bakır-Yalçın, E., & Cukurova, M. (2025). Rethinking the importance of social norms in generative AI adoption: investigating the acceptance and use of generative AI among higher education students. *International Journal of Educational Technology in Higher Education*, *22*(1). https://doi.org/10.1186/s41239-025-00535-z

van Berkel, B., Pilot, A., & Bulte, A. M. W. (2009). Micro–Macro Thinking in Chemical Education: Why and How to Escape. In J. Gilbert K & D. Treagust (Eds.), *Multiple Representations in Chemical Education, Models and Modeling in Science Education* (pp. 31–54). Springer. https://doi.org/10.1007/978-1-4020-8872-8_3

Vieriu, A. M., & Petrea, G. (2025). The Impact of Artificial Intelligence (AI) on Students' Academic Development. *Education Sciences*, *15*(3). https://doi.org/10.3390/educsci15030343

Wang, P. (2021). Research and Development Trend of Artificial Intelligence Technology Innovation Under the Internet Background. *Advances in Intelligent Systems and Computing*, *1342 AISC*, 266–273. https://doi.org/10.1007/978-3-030-70042-3_39

Wisudawati, A. W., Barke, H. D., Lemma, A., & Agung, S. (2022). Students' and teachers' perceptions for composition of ionic compounds. *Chemistry Teacher International*, *4*(3), 221–230. https://doi.org/10.1515/cti-2021-0032

Yamtinah, S., Wiyarsi, A., Widarti, H. R., Shidiq, A. S., & Ramadhani, D. G. (2025). Fine-tuning AI models for enhanced consistency and precision in chemistry educational assessments. *Computers and Education: Artificial Intelligence*, *8*, 100399.

Yusoff, M. S. B. (2019). ABC of Content Validation and Content Validity Index Calculation. *Education in Medicine Journal*, *11*(2), 49–54. https://doi.org/10.21315/eimj2019.11.2.6

Zhao, Y., Li, Y., Xiao, Y., Chang, H., & Liu, B. (2024). Factors Influencing the Acceptance of ChatGPT in High Education: An Integrated Model With PLS-SEM and fsQCA Approach. *SAGE Open*, *14*(4). https://doi.org/10.1177/21582440241289835

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