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Mapping Teachers Need for Generative AI Integration in Chemistry Education: A Needs Assessment Study

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ABSTRACT

This study maps chemistry teachers' needs in integrating generative AI into instruction using the Borich Needs Assessment Model. 43 high school chemistry teachers from South and West Sulawesi, Indonesia, completed a self-reported questionnaire. Mean Weighted Discrepancy Scores (MWDS) revealed the highest needs in AI training provision, followed by AI utilization for chemistry content visualization and institutional infrastructure support. Lower needs were observed in basic digital literacy and AI ethics. Findings emphasize that effective AI integration requires sustained, context-specific professional development and systemic institutional support tailored to the unique demands of chemistry education.

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INTRODUCTION

The development of Artificial Intelligence (AI) in recent years has demonstrated remarkably rapid and transformative growth across various sectors of life. AI has evolved into intelligent systems capable of mimicking human cognitive abilities through data processing and decision-making automation. This progression has been further accelerated by the emergence of generative AI, which can independently produce text, images, and various other forms of content. Globally, AI has been described as a technology advancing at an unprecedented pace, serving as a primary catalyst for digital transformation across diverse fields (Darwis & Ginting, 2024). Within the educational context, the advancement of AI has driven significant changes, ranging from personalized learning and automated evaluation to enhanced efficiency in instructional processes (Isnain, 2025).

AI holds significant transformative potential in education, particularly in creating more personalized and adaptive learning experiences. Various studies indicate that AI is capable of analyzing students' learning characteristics and needs, thereby enabling the delivery of materials tailored to individual abilities and preferences (Hariyanto et al., 2025). Furthermore, AI can function as an assistant for teachers in designing science instruction, such as developing materials, creating assessments, and explaining abstract concepts, ultimately enhancing the quality of the learning process (Thesen & Park, 2025). This potential becomes especially relevant when confronted with the pedagogical challenges inherent in chemistry education, as the subject possesses unique characteristics that necessitate a personalized and adaptive approach.

Chemistry is a scientific domain characterized by unique learning attributes. Many concepts in chemistry are abstract and cannot be directly observed such as atomic structures, molecular interactions, and reaction mechanisms thereby posing conceptual difficulties for learners (Tümay, 2016). Moreover, the subject demands the ability to integrate three levels of representation: macroscopic, submicroscopic, and symbolic, all of which must be comprehended by students simultaneously (M. Nyachwaya & Gillaspie, 2016). This complexity results in a high cognitive load during chemistry instruction, as learners are required to process diverse types of information concurrently. Consequently, students often encounter difficulties in constructing a coherent understanding and are prone to developing misconceptions (Tümay, 2016).

The complex nature of chemistry necessitates that teachers possess supportive tools capable of reducing students' cognitive load. The integration of Generative AI could serve as a viable solution to these issues. However, the majority of research on AI in education remains focused on perceptions, effectiveness, or technological development rather than the actual, contextual needs of chemistry teachers. A review of existing literature reveals that AI studies tend to emphasize the exploration of technological potential and usage by both students and teachers, yet they offer limited insight into the practical requirements of teachers for classroom implementation (Mekadenaumporn, 2025). Studies involving teachers generally concentrate on perceptions, attitudes, or levels of technology acceptance without delving into more specific pedagogical needs (Al-Mutawah, 2026). Although some literature reviews have addressed teachers' professional development needs regarding AI integration, these reviews are often general and cross-disciplinary, failing to address the contextual demands of specific subjects, particularly chemistry (Aravantinos et al., 2026). In the context of chemistry education, existing research is still dominated by studies on the perceptions and knowledge of in-service or pre-service teachers regarding AI. As a result, the specific needs of chemistry teachers for integrating AI into instruction remain largely unexplored (Harianti et al., 2025). Therefore, research is required to specifically map teachers' needs especially within the context of chemistry education to ensure that AI integration can be implemented effectively and relevantly to the discipline's characteristics.

Conducting a needs assessment study is critically important to identify gaps between the actual conditions and the desired state, and to ensure that AI integration is designed in alignment with the needs and context of chemistry teaching. The urgency of this matter is underscored by the fact that various education policymakers have begun to advocate for AI integration in learning environments. Educators are being encouraged to continuously enhance their capacity to master AI technology to effectively guide students in the digital era. However, the adoption of this technology is not always accompanied by adequate teacher readiness. Studies indicate a gap between the demands of AI integration and the competencies possessed by teachers in the field, which potentially hinders effective implementation (Aravantinos et al., 2026). Many teachers continue to face limitations in both pedagogical and technical aspects when integrating technology into instruction (Afnani & Attalina, 2025; Wahyuni et al., 2022). Furthermore, many AI integration initiatives in education have not been grounded in the actual needs of teachers, thereby running the risk of being misdirected (Salas-Pilco et al., 2022). For this reason, a needs assessment is essential. Without systematic mapping of requirements, the implementation of AI in education particularly in chemistry instruction may proceed suboptimally and fail to yield a significant impact on learning quality.

Based on the aforementioned rationale, this study was formulated to map the needs of chemistry teachers in integrating Generative AI into instruction, to assess the urgency level of these needs, and to determine whether differences in needs exist based on teacher characteristics. Accordingly, the objective of this research is to map chemistry teachers' needs across pedagogical, technical, content, and infrastructural/institutional support aspects, and to analyze the urgency level of each identified need. The results of this mapping are expected to provide an empirical foundation for developing contextual training programs and policies for AI integration in chemistry education.

THEORETICAL REVIEW

Generative AI in Education

Generative Artificial Intelligence (Generative AI) is an artificial intelligence technology capable of producing new content such as text, images, and other media and is significantly transforming the learning paradigm into one that is more adaptive, interactive, and student-centered. Within the educational context, Generative AI supports personalized learning, adaptive feedback, and the multimodal presentation of materials, all of which can enhance conceptual understanding, including the comprehension of abstract concepts in chemistry. This is corroborated by various studies indicating that Generative AI contributes to pedagogical innovation and the improvement of learning quality, primarily through personalization and interactivity (Marzano, 2025; Ogunleye et al., 2024).

However, the implementation of Generative AI in education also presents significant challenges, particularly concerning teacher readiness, information accuracy, and the ethical aspects of technology use. Studies indicate that although AI holds substantial potential to support learning, there remain limitations in usage guidelines and a pressing need to enhance teachers' competencies in integrating AI pedagogically. Furthermore, a critical understanding of risks such as information bias and technological dependency is required. Consequently, a needs assessment approach becomes essential to identify the gaps between actual competencies and those required for the effective utilization of Generative AI, thereby enabling the design of more effective and contextual professional development programs (Bond et al., 2024; Xiaoyu et al., 2025).

Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK) is a theoretical framework developed to explain the types of knowledge teachers require to integrate technology effectively into instruction. This model emphasizes that teacher competence comprises not only Content Knowledge, Pedagogical Knowledge, and Technological Knowledge as separate entities, but also the complex interactions among these three domains that form integrated knowledge (TPACK). This integration enables teachers to design instruction that is not only appropriate for the subject matter but also pedagogically effective and relevant to technological advancements. As such, TPACK serves as a robust framework for understanding how teachers can meaningfully integrate technologies like Generative AI into teaching practice.

In the context of Generative AI integration, the TPACK framework becomes increasingly relevant, as this technology demands that teachers possess the ability not only to understand the technical operation of the tools but also to discern how the technology can be utilized to support pedagogical strategies and effective content delivery. Studies demonstrate that the successful integration of technology in education is heavily dependent on teachers' capacity to combine these three knowledge domains in a contextual and flexible manner (Archambault & Barnett, 2010).

METHODOLOGY

Research Design

This study employs a quantitative approach with a cross-sectional survey design aimed at mapping teachers' needs in integrating generative artificial intelligence (AI) into chemistry instruction. The quantitative approach was selected as it enables the researcher to measure phenomena objectively through numerical data and statistical analysis (Sugiyono, 2019). This research design adopts a needs assessment approach, which is a method used to identify discrepancies between actual conditions and desired conditions. In this study, the actual condition refers to teachers' current proficiency level in using generative AI, whereas the desired condition refers to the perceived importance level of that competency for chemistry instruction.

Population and Sample

The population in this study comprises all Chemistry subject teachers instructing at the Senior High School level or its equivalent within the provinces of South Sulawesi and West Sulawesi. Based on preliminary data obtained from the Chemistry Subject Teacher Association coordinators across several districts, the total population meeting the initial criteria and accessible to the researcher amounts to 43 teachers.

Data Collection and Analysis

Data collection was conducted using an instrument in the form of a questionnaire distributed online via Google Form. To objectively identify and prioritize teacher training needs, this study employed the Borich Needs Assessment Model. This model calculates the discrepancy between teachers' perceptions of the importance level of a specific competency and their current proficiency level. The calculation procedure is carried out through several mathematical stages, beginning with the calculation of the discrepancy score for each individual respondent on each competency item. Subsequently, the Weighted Discrepancy Score (WDS) is calculated, wherein the individual discrepancy score is weighted based on the overall average importance rating for that particular competency across all respondents. Finally, the Mean Weighted Discrepancy Score (MWDS) is obtained by dividing the total WDS of all respondents by the number of respondents.

The results of the MWDS calculation serve as the basis for determining training priorities. The interpretation of a positive MWDS value indicates the existence of a training need. The higher the positive MWDS value for a specific competency, the greater the gap between its perceived importance and current proficiency, thus establishing that competency as a top priority for intervention through a training program. Conversely, an MWDS value of zero or negative indicates the absence of a significant training need, as teachers perceive their current ability to be equal to or exceeding its level of importance.

The calculated MWDS results are subsequently ranked from the highest to the lowest value to formulate recommendations for a Generative AI training curriculum most relevant to Chemistry teachers in South and West Sulawesi. The entire MWDS calculation process was performed using Microsoft Excel software to ensure data accuracy and transparency.

RESULTS

This study involved 43 chemistry teachers instructing at the senior high school level or its equivalent, originating from various districts/cities within the provinces of South Sulawesi and West Sulawesi. All respondents were selected purposively based on the following criteria: actively teaching chemistry, having prior experience using generative AI tools (ChatGPT, Gemini, Copilot) in an educational context, and willingness to complete the questionnaire in full.

Based on the data collected from the 43 teachers who met the purposive criteria, calculations were performed using the Borich Needs Assessment Model to identify the discrepancies between the perceived level of importance and the actual level of proficiency (knowledge) for each competency. The calculation yielded Mean Weighted Discrepancy Score (MWDS) values, which were subsequently ranked to determine training priorities. Table 1 presents the ten competencies with the highest MWDS values, indicating the most urgent training needs for chemistry teachers in the South Sulawesi and West Sulawesi regions.

Table 1. Top Ten Priorities for Training Needs Based on the Borich Model

Competency	**Knowledge**		**Importance**		**MWDS**	**Rank**
	Mean	**SD**	**Mean**	**SD**		
G5	2.83	0.92	4.32	0.71	6.44	1st
G3	2.86	0.91	4.32	0.71	6.34	2nd
C2	2.97	0.71	4.39	0.73	6.24	3rd
F4	3.06	0.96	4.39	0.73	5.83	4th
G1	2.95	0.87	4.30	0.71	5.80	5th
G2	3.00	0.93	4.32	0.71	5.73	6th
C1	3.06	0.74	4.37	0.76	5.69	7th
G4	3.02	0.96	4.32	0.71	5.63	8th
A4	3.06	0.70	4.32	0.81	5.43	9th
E4	3.25	0.73	4.39	0.73	5.01	10th

Note: Competency G5 = AI Learning Community; G3 = AI Ethics Training; C2 = Chemical Reaction Simulation; F4 = Availability of AI Training; G1 = AI Usage Training; G2 = AI Integration Training; C1 = Chemistry Concept Visualization; G4 = AI Practical Workshop; A4 = Evaluating AI Output; E4 = Strategies for Controlling Students' AI Use.

The results of the MWDS analysis indicate that the ten competency items with the highest discrepancy scores reflect the most urgent training needs. Generally, these competencies fall within the domains of specific AI training needs, the utilization of AI for visual and simulated chemistry content, and the evaluation and control of AI output.

1. Training Needs
   Five of the top ten priorities originate from the training needs dimension (G), namely: AI Learning Community (G5), AI Ethics Training (G3), AI Usage Training (G1), AI Integration Training in Instruction (G2), and AI Practical Workshop (G4). The mean actual proficiency scores for these items are moderate (ranging from 2.83 to 3.02); however, the very high importance ratings (ranging from 4.30 to 4.32) result in substantial discrepancy gaps. This finding indicates that chemistry teachers recognize the urgency of various forms of AI training, yet their access to and experience with such training remain limited. The fact that community-

based learning ranks first suggests that teachers prefer collaborative and sustainable learning models over one-time training sessions.

2. Simulation and Visualization of Chemical Reactions
Competencies involving the use of AI for simulating chemical reactions (C2) and visualizing chemistry concepts (C1) also constitute very high priorities. The average actual proficiency scores for C2 and C1 are only 2.97 and 3.06, respectively, while their importance levels reach 4.39 and 4.37. Chemistry, as a discipline replete with abstract concepts, requires visual aids and interactive simulations. Teachers perceive that AI can address these pedagogical needs; however, they currently lack adequate skills to leverage this potential effectively.
3. Institutional Training Support
Item F4, concerning the availability of AI-related training, ranks fourth with an MWDS of 5.83. The relatively low actual proficiency score indicates that the availability of AI training in schools across the provinces of South Sulawesi and West Sulawesi remains very limited. The high importance rating (4.39) underscores that teachers require systemic support from their institutions.
4. Evaluation of AI Output and Control of Students AI Use
The ability to evaluate AI output (A4) and strategies for controlling students' use of AI (E4) are also included in the priority list. Both competencies are closely related to critical literacy and learning ethics. The mean proficiency score for A4 is 3.06, which falls below its importance level of 4.32. Meanwhile, the actual proficiency score for E4 is relatively high at 3.25, yet its corresponding importance level is also very high at 4.39. This finding suggests that while teachers have begun to recognize the importance of supervising students' use of AI, they have not yet developed sufficient practical strategies to do so effectively.

After identifying the ten competencies with the highest discrepancy scores that require immediate training intervention, it is also important to examine the competencies ranked at the bottom. Competencies with the lowest MWDS values indicate that the gap between the level of importance and actual proficiency is relatively small, meaning that teachers already consider themselves sufficiently competent or that the training need in these areas is not urgent. Table 2 presents the five competencies with the lowest MWDS values identified in this study.

Table 2. Bottom Five Competencie for Training Need Based on the Borich Model

Competency	Knowledge		Importance		MWDS	Rank
	Mean	SD	Mean	SD		
D1	3.58	0.73	4.39	0.76	3.58	31st
C4	3.37	0.79	4.20	0.83	3.52	32nd
E2	3.58	0.73	4.37	0.72	3.46	33rd
D5	3.62	0.72	4.37	0.72	3.25	34th
E1	3.62	0.76	4.37	0.72	3.25	35th

Note: Competency D1 = Digital technology proficiency; C4 = Using AI to create chemistry questions/exercises; E2 = Understanding AI plagiarism risks; D5 = Ability to adapt to new technology; E1 = Understanding ethics of AI use in education.

The five competencies with the lowest MWDS values (ranging from 3.25 to 3.58) indicate relatively small discrepancy gaps, meaning that teachers perceive their current proficiency to be sufficiently close to the level of importance.

1. Basic Digital Skills and Adaptability
   The competencies of using digital technology (D1, MWDS = 3.58) and adapting to new technology (D5, MWDS = 3.25) recorded the highest mean actual proficiency scores among all items (3.58 and 3.62, respectively). This suggests that chemistry teachers in the study area are already quite competent in terms of general digital literacy, likely due to their experience utilizing online learning platforms during the pandemic. While the importance ratings for these competencies are also high (4.39 and 4.37), the discrepancy gaps remain small because the baseline proficiency levels are already substantial.
2. Plagiarism and General Understanding
   Competencies related to understanding the risks of AI-facilitated plagiarism (E2, MWDS = 3.46) and comprehending the general ethics of AI use in education (E1, MWDS = 3.25) were ranked among the lowest. This indicates that teachers already possess a relatively strong ethical awareness (mean proficiency scores ranging from 3.58 to 3.62), thereby reducing the immediate need for intensive training in these specific areas.
3. Creating Chemistry Questions Using AI
   Item C4 (creating chemistry questions/exercises using AI) recorded an MWDS of 3.52, making it the second lowest. The actual proficiency score (3.37) relative to its importance (4.20) suggests that teachers feel reasonably capable of generating AI-assisted questions. This may be attributed to the relative ease of using tools such as ChatGPT to produce test items. This lower priority ranking is understandable, as question generation represents one of the more straightforward and commonly explored functions of AI among teachers.

Analysis by dimension allows for the identification of areas that, as a whole, require greater attention in the development of training programs, irrespective of variations among individual items within them. Table 3 presents a summary of the average MWDS for each dimension, the number of items within the dimension, and the item with the highest MWDS value within that dimension as a representation of internal priorities.

Table 3. Summary of Training Needs by Competency Dimension

Dimension	Number of Items	Average MWDS	Items with Highest Priority	Rank
AI Competency	5	4.72	A4 (5.43)	4th
Pedagogical Competency	5	4.20	B3 (4.60)	5th

Utilization of AI in Chemistry Content	5	4.89	C2 (6.24)	2nd
Digital and AI Literacy	5	3.87	D3 (4.53)	6th
Ethics and Risks of AI	5	3.83	E4 (5.01)	7th
Infrastructure and School Support	5	4.73	F4 (5.83)	3rd
Training Needs	5	5.99	G5 (6.44)	1st

As shown in Table 3, the Training Needs dimension exhibits the highest average MWDS (5.99), followed by Utilization of AI in Chemistry Content (4.89) and Infrastructure and School Support (4.73). Conversely, the Ethics and Risks of AI dimension and the Digital and AI Literacy dimension demonstrate the lowest average MWDS values (3.83 and 3.87, respectively), which aligns with the findings presented in Table 2 indicating that several items within these dimensions rank among the lowest priorities. This suggests that chemistry teachers feel more competent in aspects of basic digital literacy and ethics, yet they still express a strong need for technical training, hands-on practice, and infrastructural support to effectively integrate AI into chemistry instruction.

DISCUSSION

The findings of this study reveal a significant discrepancy between teachers' actual proficiency levels and the perceived importance of competencies related to the integration of generative AI, as illustrated by the high Mean Weighted Discrepancy Score (MWDS) values observed across several priority competencies. This finding indicates that although teachers possess a high level of awareness regarding the importance of utilizing AI in chemistry instruction, their capacity for implementation remains relatively limited. From a needs assessment perspective, this condition reflects a gap between actual and desired conditions, which serves as the foundation for determining competency development priorities. The greater the discrepancy, the higher the urgency for the required training. Competencies characterized by high importance ratings and large discrepancy gaps are categorized as top priorities for training development (Park et al., 2023). This finding is further supported by other research indicating that priorities for teacher competency development are determined by the magnitude of the gap between actual and expected conditions (Rina & Mirsa, 2024).

The implementation of AI in education continues to face significant challenges related to teacher readiness. Although AI holds substantial potential to enhance learning through personalization, evaluation, and adaptive systems, many educators still lack an optimal understanding of how to utilize this technology pedagogically (Zawacki-Richter et al., 2019). This highlights a discrepancy between technological advancement and the readiness of educational practitioners in the field. Subsequent research by Zawacki-Richter et al. (2024) affirms that AI integration necessitates strengthening pedagogical, ethical, and instructional design aspects, rather than focusing solely on technical operational skills. Therefore, the high MWDS values observed in the training needs dimension within this study further reinforce the importance of contextually grounded, needs-based training programs.

The predominance of needs in competencies related to utilizing AI for visualizing and simulating chemistry concepts indicates a strong interconnection with the characteristics of the chemistry discipline. Chemistry instruction demands an understanding of three levels of representation macroscopic, submicroscopic, and symbolic which are often difficult for students to grasp without adequate visualization aids. According to Rahmawati et al. (2022), the difficulties encountered in learning chemistry stem from the complexity of conceptual representations that cannot be observed directly. In this context, AI possesses potential as a cognitive tool capable of presenting visual representations and interactive simulations to assist students in comprehending abstract concepts (Dai & Ke, 2022; Iyamuremye et al., 2024). However, without teachers' ability to integrate AI pedagogically, this potential will not be fully realized (Erümit & Sarıalioğlu, 2025). Consequently, the results of this study affirm that strengthening teacher competencies should focus not only on technological literacy but also on the capacity to integrate AI contextually, in alignment with the distinctive characteristics of chemistry education.

The identification of discrepancies in technical and pedagogical competencies must be followed by the provision of training that is relevant, contextual, and aligned with the actual needs of teachers in the field. Therefore, the training needs dimension warrants further analysis, as this dimension directly reflects teachers' perceptions of the urgency and the forms of support they anticipate. The following section presents a discussion of the training needs dimension based on the results obtained from the Borich Needs Assessment Model.

1. Training Needs
   The MWDS values within the training needs dimension indicate that chemistry teachers exhibit a significant discrepancy between the level of importance and their actual proficiency in integrating AI. This suggests that the need for professional development constitutes the most urgent aspect. The successful integration of AI in education is highly contingent upon the availability and quality of teacher training. Research by Tan et al. (2025) indicates that despite the increasing use of AI, many teachers have yet to receive adequate training to integrate it effectively into instruction. Furthermore, teachers often encounter difficulties in utilizing AI in the absence of relevant and contextual training, even when they possess a high level of interest in the technology (Rehman, 2025). The high MWDS values within this dimension indicate that training must extend beyond theoretical or one-off sessions, instead requiring a sustained development approach grounded in communities of practice and ongoing mentorship.
2. Utilization of AI in Chemistry Content
   This dimension demonstrates a high level of need, particularly in supporting the comprehension of abstract concepts. AI has the capacity to enhance chemistry learning through visualization and simulation, thereby assisting students in understanding phenomena that cannot be directly observed (Erümit & Sarıalioğlu, 2025). Moreover, AI enables the

representation of molecular structures and chemical reactions in a more concrete manner, which can alleviate students' conceptual difficulties (Iyamuremye et al., 2024). Molecular visualizations generated through generative AI have been shown to create more interactive and profound learning experiences (Hu-Au, 2024). Therefore, the elevated need in this dimension suggests that teachers require not only the ability to use AI but also the pedagogical capacity to integrate it in a manner that supports the specific characteristics of chemistry instruction.

3. Infrastructure and School Support
   This dimension highlights that AI integration depends not solely on teacher competence but also on the readiness of facilities and support systems. Research indicates that limitations in devices, internet access, and technological resources constitute primary barriers to AI implementation in schools (Filiz et al., 2025). Institutional support, including school policies and leadership, also plays a critical role in promoting the effective adoption of AI (Somabut et al., 2025).
4. AI Competency and Pedagogical Competency
   These dimensions indicate that teachers face challenges in ensuring the appropriate use of AI within instruction. Research suggests that AI usage can create ambiguity between learning activities and academic dishonesty; thus, teachers must possess the ability to critically evaluate the quality and accuracy of AI-generated outputs (Mah et al., 2024). Although AI can facilitate more objective evaluation processes, the teacher's role remains essential as a validator to ensure that the outcomes align with the instructional context (Ben Zion et al., 2025). Conversely, from a pedagogical perspective, AI is not yet capable of replacing the teacher's role in guiding student understanding; therefore, AI integration must remain grounded in sound pedagogical principles. Consequently, these findings affirm that teachers' competencies in evaluating AI output and integrating it pedagogically constitute crucial aspects of supporting effective instruction.
5. Digital Literacy and AI Ethics
   The relatively low need scores in the dimensions of digital literacy and AI ethics indicate that teachers possess a relatively adequate foundational ability in both areas. This is reflected in the MWDS values for the digital literacy and AI ethics dimensions, which stand at only 3.87 and 3.83, respectively lower than those of other dimensions. Teachers generally already possess initial awareness regarding the ethics of AI use and the risks of plagiarism; thus, the discrepancy in these aspects tends to be smaller compared to that of technical and pedagogical competencies (Lund et al., 2025). Accordingly, the lower need in these dimensions does not imply that these aspects are unimportant; rather, it suggests that teachers have already established a sufficient foundation, thereby warranting that development priorities be directed more toward competencies for specific and contextual AI integration in chemistry education.

The findings of this study carry important practical implications for the development of AI-based learning, particularly in enhancing teacher competencies. The results indicate that the integration of AI in education necessitates professional development programs that are systematically designed and grounded in the actual needs of teachers, given the persistent gap between the demands of AI utilization and the readiness of teacher competencies in the field (Tan et al., 2025). Therefore, training initiatives should be focused on professional aspects specific to the field of chemistry and should be conducted sustainably through learning communities and professional mentoring (Li et al., 2025). The implementation of AI also requires robust institutional support, including educational policies, provision of infrastructure, and structured training programs from both schools and government entities (Panjani & Mudgal, 2024). Accordingly, the findings of this study affirm that the successful integration of generative AI is highly dependent upon a comprehensively supportive educational ecosystem.

CONCLUSIONS AND RECOMMENDATIONS

This study reveals a significant discrepancy between teachers' perceived importance and their actual proficiency in integrating generative AI into chemistry instruction. The training needs dimension emerges as the top priority, followed by the utilization of AI in chemistry content and infrastructural or institutional support, indicating that teachers require more specific and contextual competency development. Conversely, digital literacy and AI ethics dimensions exhibit relatively lower needs, suggesting that teachers already possess an adequate foundational understanding in these areas. Overall, these findings underscore that AI integration in chemistry education depends not only on individual teacher readiness but also on the availability of relevant training and adequate systemic support.

Based on these findings, efforts are needed to strengthen teacher competencies through needs-based, sustained AI training programs that emphasize pedagogical integration in chemistry instruction. Institutional support from schools and government, encompassing infrastructure provision, enabling policies, and facilitation of teacher learning communities remains essential. Teachers are also expected to develop competencies extending beyond technical AI operation to include output evaluation and ethical management of AI use in the classroom. Future research should focus on developing and testing more contextual AI training models to enhance the effectiveness of AI implementation in chemistry education.

FURTHER STUDY

This study has several limitations. First, the relatively small sample confined to specific regions limits the generalizability of the findings to similar contexts only. Second, the use of self-reported questionnaire data introduces potential subjective bias. Third, the cross-sectional design precludes longitudinal assessment of evolving teacher needs amid rapidly advancing AI technology. Finally, the quantitative approach restricts deeper exploration of teachers' actual experiences and challenges in classroom AI integration.

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