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Pedagogical Beliefs and Reasoning in the Age of Artificial Intelligence: Bridging the Theory Practice Gap

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Abstract

The rapid development of Artificial Intelligence (AI), particularly generative AI applications, is transforming educational practices and creating new opportunities and challenges for teachers. In chemistry education, AI tools can support lesson planning, conceptual explanations, assessment, visualization of abstract chemical phenomena, and students' engagement with scientific concepts. However, the effective integration of AI into classroom teaching depends not only on teachers' technological competencies but also on their pedagogical beliefs, professional reasoning and understanding of the nature of scientific knowledge. This qualitative study aims to explore secondary school chemistry teachers' pedagogical beliefs and reasoning in the age of Artificial Intelligence, with particular attention to the relationship between their beliefs and actual classroom practices. The proposed study involves ten chemistry teachers working in public secondary schools in district Mardan. Data was collected through semi-structured interviews and analyzed thematically. The study is informed by constructivist learning theory, epistemological beliefs theory and the Technological Pedagogical Content Knowledge (TPACK) framework. The proposed thematic analysis focuses on teachers' perceptions of AI, pedagogical beliefs, reasoning, instructional decision-making, classroom applications, professional challenges and the relationship between espoused beliefs and enacted practices. This research unravelled the importance of maintaining teachers' professional judgment while integrating AI into chemistry instruction. It argues that meaningful AI integration requires more than technological access; it requires pedagogically informed, scientifically responsible and critically reflective teaching practices. The study will contribute in the areas of chemistry teacher education, professional development and the responsible use of AI in secondary science education.

Keywords: Artificial Intelligence, Chemistry Education, Pedagogical Beliefs, Teacher Reasoning, Epistemological Beliefs, Secondary School Teachers

Introduction

Artificial Intelligence (AI) has emerged as an influential technological development in contemporary education. The increasing availability of generative AI applications, including conversational systems and AI-supported educational platforms, has introduced new possibilities for teaching, learning, assessment, and professional development. These technologies can generate explanations, provide examples, assist in lesson planning, support formative

assessment, and offer alternative representations of complex scientific concepts. Their growing presence in educational environments has also raised important questions concerning teachers' professional responsibilities, pedagogical decision-making, scientific accuracy, and the nature of knowledge construction (Tan et al., 2025).

Chemistry is a discipline that presents distinctive teaching and learning challenges. Students are required to understand abstract concepts, interpret symbolic representations, connect macroscopic observations with submicroscopic explanations, and apply mathematical reasoning to chemical phenomena. Concepts such as atomic structure, chemical bonding, equilibrium, acids and bases, reaction mechanisms, and molecular interactions frequently require teachers to employ multiple representations and instructional strategies (Taber, 2013).

Traditional chemistry instruction in many secondary schools relies heavily on textbooks, lectures, memorization, and examination-oriented teaching. Although these approaches may support the acquisition of factual knowledge, they do not always provide sufficient opportunities for students to develop conceptual understanding, scientific reasoning, evidence-based argumentation, and independent problem-solving abilities (Ahmad et al., 2023). Teachers' pedagogical beliefs play an important role in determining how they interpret educational knowledge and translate it into instructional practices. These beliefs influence their understanding of teaching, learning, student participation, assessment, classroom interaction, and the role of technology. Teachers may express support for student-centred and constructivist approaches while continuing to employ teacher-centred instructional methods in their classrooms. This difference between professed beliefs and actual practices represents an important dimension of the theory–practice gap in education (Aguilar-Valdes et al., 2024). The emergence of AI adds another dimension to this relationship. Although AI can provide explanations and instructional resources, its educational value depends on how teachers evaluate, adapt, and integrate its outputs into subject-specific teaching. For example, a chemistry teacher may use AI to generate an explanation of ionic bonding. However, the teacher must determine whether the explanation is scientifically accurate, developmentally appropriate, and consistent with the intended learning objectives. Similarly, AI-generated answers may contain scientific inaccuracies, oversimplifications, or misleading explanations. Teachers therefore need scientific reasoning skills and epistemological awareness to distinguish reliable scientific knowledge from unsupported claims. They must also consider the ethical implications of AI use, including academic integrity, data privacy, student dependence and unequal access to technology (Blonder & Feldman-Maggor, 2024). Despite increasing attention to AI in education, understanding how secondary chemistry teachers' pedagogical beliefs influence their reasoning and instructional decisions remains important. In particular, there is a need to explore how teachers understand AI, how they evaluate its educational possibilities and limitations, and how they reconcile their existing pedagogical beliefs with emerging AI-supported practices.

The present study therefore explores secondary school chemistry teachers' pedagogical beliefs and reasoning in the age of Artificial Intelligence. It focuses on teachers' experiences, perceptions, instructional decisions, and challenges in integrating AI into chemistry education.

Statement of the Problem

Although AI applications are becoming increasingly accessible, their integration into secondary chemistry education is not necessarily accompanied by corresponding changes in teachers' pedagogical beliefs and instructional practices. Some teachers may perceive AI primarily as a source of information or a tool for preparing teaching materials, whereas others may recognize its potential for promoting conceptual understanding, scientific inquiry and critical thinking. A

central concern is that teachers may adopt AI tools without critically examining their scientific accuracy or considering their alignment with pedagogical objectives. Conversely, teachers with limited technological confidence may avoid AI-supported instructional approaches despite recognizing their potential benefits.

The problem is therefore not simply whether chemistry teachers use AI, but how their pedagogical beliefs, professional reasoning, and subject-specific knowledge influence their decisions about its use. Understanding these relationships is essential for bridging the gap between teachers' educational beliefs and their actual instructional practices.

Significance of the Study

This study is significant for several reasons:

1. It contributes to understanding chemistry teachers' pedagogical beliefs in the context of emerging AI technologies.
2. It explores the relationship between teachers' professional reasoning and their instructional decisions.
3. It highlights the importance of scientific accuracy and critical evaluation of AI-generated content.
4. It provides insights into the challenges faced by public-school teachers in adopting AI-supported teaching approaches.
5. It will inform teacher education programmes, curriculum development and professional development initiatives.
6. It contributes to discussions about responsible and pedagogically meaningful AI integration in secondary chemistry education.

Literature Review

Pedagogical Beliefs and Teachers' Instructional Practices

Pedagogical beliefs refer to teachers' understandings and assumptions about teaching, learning, knowledge, students and classroom instruction. These beliefs influence the ways teachers interpret educational situations and make instructional decisions. Pajares (1992) emphasized that teachers' beliefs are influential in educational decision-making and are closely connected to their professional practices. Similarly, Richardson (1996) explained that teachers' beliefs and attitudes are important considerations in understanding teaching and teacher education. Teachers may hold different beliefs about the nature of learning. Some view learning as the transmission and reproduction of established knowledge, while others consider learning an active process in which students construct understanding through experience, discussion, investigation, and reflection. Constructivist pedagogical beliefs emphasize students' active involvement in learning, the importance of prior knowledge and the development of conceptual understanding. In chemistry education, these beliefs may encourage teachers to use demonstrations, experiments, problem-based activities, visual models and scientific discussions. However, teachers' beliefs do not always translate directly into classroom practices. Institutional expectations, examination systems, limited resources, curriculum requirements and classroom management challenges may influence instructional decisions.

Epistemological Beliefs and Scientific Knowledge

Epistemological beliefs concern individuals' understandings of the nature, source, certainty and justification of knowledge. Hofer and Pintrich (1997) identified epistemological beliefs as important dimensions of learning and educational development. In chemistry education, teachers' epistemological beliefs influence how they understand scientific knowledge and communicate it to students. For example, teachers may regard scientific knowledge as a collection of established

facts or as an evolving body of explanations supported by evidence, experimentation, and scientific argumentation. This distinction is particularly important in the age of AI. AI systems can generate scientific explanations that appear convincing but may contain errors. Teachers must therefore consider the reliability of information, examine supporting evidence, and distinguish between scientifically justified explanations and plausible-sounding responses. Kuhn (1999) emphasized the importance of developing reasoning skills that enable individuals to evaluate evidence and construct justified conclusions. Such reasoning is essential for chemistry teachers who increasingly encounter AI-generated scientific content.

AI in Education

Artificial Intelligence has created new opportunities for personalized learning, instructional support, educational assessment and content development. AI can respond to questions, explain scientific concepts, produce examples and assist teachers in preparing educational materials. Zawacki-Richter et al. (2019) reviewed applications of AI in higher education and identified important opportunities as well as concerns relating to the role of educators and the pedagogical foundations of AI-supported learning. Holmes et al. (2019) discussed the potential of AI to support educational processes while emphasizing the importance of human judgement, transparency and ethical considerations. The introduction of ChatGPT and similar generative AI applications has further expanded the discussion. Kasneci et al. (2023) highlighted potential applications of large language models in education, alongside challenges related to reliability, bias, assessment and academic integrity. UNESCO (2023) also emphasized the importance of a human-centred approach to generative AI in education and research. This approach recognizes that technological innovation should support rather than replace human educational judgement.

AI and Chemistry Education

Chemistry education requires students to interpret multiple representations of chemical phenomena. AI-supported tools may help teachers develop alternative explanations, generate examples, prepare formative questions, and support the visualization of abstract concepts. For instance, AI can assist teachers in explaining the relationship between atomic structure and periodic properties, illustrating chemical bonding, and developing questions about chemical reactions. Consequently, chemistry teachers require subject-specific knowledge to evaluate AI outputs. Their professional judgement is particularly important when deciding whether AI-generated representations accurately reflect chemical phenomena and are appropriate for secondary-school students.

Technological Pedagogical Content Knowledge

Mishra and Koehler (2006) introduced the Technological Pedagogical Content Knowledge (TPACK) framework to explain the complex relationship between technology, pedagogy and subject matter knowledge. The framework suggests that effective technology integration requires teachers to understand not only the technology itself but also how it interacts with pedagogical approaches and specific subject content. For chemistry teachers, technological knowledge involves understanding available AI tools and their functions. Pedagogical knowledge involves understanding teaching strategies, learning processes and assessment. Content knowledge involves understanding chemistry concepts and scientific principles. The effective integration of AI requires the interaction of all three knowledge domains. A teacher may be technologically competent but unable to identify an inaccurate chemical explanation. Similarly, a teacher may possess strong chemistry knowledge but lack the pedagogical understanding needed to integrate AI meaningfully.

The Theory Practice Gap

The theory practice gap refers to the difference between educational principles that teacher's support and the instructional practices they implement. Teachers may value inquiry-based learning, student-centred instruction and critical thinking but continue to use traditional teaching approaches because of contextual and institutional constraints. In the context of AI, this gap may become more visible. Teachers may express support for AI-assisted personalized learning while using AI primarily to prepare notes, generate examination questions, or simplify textbook content. Bridging this gap requires more than providing access to technology. It requires opportunities for reflection, professional development, collaborative learning and pedagogical experimentation.

In particular, there is a need to understand:

- How secondary chemistry teachers interpret the relationship between AI and their existing pedagogical beliefs.
- How they exercise scientific reasoning when evaluating AI-generated chemical explanations.
- How their beliefs influence the selection and use of AI-supported instructional strategies.
- What contextual barriers prevent teachers from translating their pedagogical intentions into classroom practices?

This study addresses these issues through an in-depth exploration of secondary public-school chemistry teachers' experiences and perceptions.

Research Questions

The study is guided by the following research questions:

1. What pedagogical beliefs do secondary school chemistry teachers hold about teaching and learning in the age of Artificial Intelligence, and how do they perceive the potential benefits, limitations, and challenges of integrating AI into chemistry instruction?
2. How do chemistry teachers draw upon their professional reasoning to evaluate AI-generated chemistry content, and how do their pedagogical beliefs influence their decisions regarding AI-supported teaching practices?
3. How do secondary school chemistry teachers perceive the role of Artificial Intelligence in bridging the theory practice gap in chemistry education?

Theoretical Framework

The study is informed by three complementary theoretical perspectives: constructivist learning theory, epistemological beliefs theory and the TPACK framework.

Constructivist Learning Theory

Constructivism views learning as an active process through which individuals develop knowledge and understanding by connecting new experiences with prior knowledge. Piaget (1970) emphasized cognitive development and knowledge construction, while Vygotsky (1978) highlighted the social and cultural dimensions of learning. In chemistry education, constructivism supports instructional approaches that encourage students to investigate chemical phenomena, discuss scientific explanations, interpret evidence and develop conceptual understanding.

Epistemological Beliefs Theory

Epistemological beliefs concern how individuals understand knowledge and knowing. They include beliefs about the certainty, simplicity, source and justification of knowledge. In this study, epistemological beliefs are important because AI-generated information may be presented with considerable confidence even when it is inaccurate. Chemistry teachers therefore need to evaluate the sources, scientific evidence, logical consistency, and validity of AI-generated

explanations. The framework helps examine whether teachers encourage students to accept information uncritically or evaluate scientific claims through evidence-based reasoning.

Technological Pedagogical Content Knowledge (TPACK)

The TPACK framework provides a perspective for understanding the integration of technological, pedagogical and content knowledge.

In this study:

- Technological knowledge concerns teachers' understanding and use of AI applications.
- Pedagogical knowledge concerns teachers' instructional beliefs, teaching strategies and assessment practices.
- Content knowledge concerns teachers' understanding of chemistry and scientific concepts.
- Integrated knowledge concerns the ability to combine AI tools, chemistry content and effective pedagogical approaches.

Methodology

The study adopts a qualitative research design to explore teachers' experiences, perceptions, beliefs, and professional reasoning concerning AI integration in secondary chemistry education. A qualitative approach is appropriate because the purpose is to understand how teachers interpret educational experiences and make instructional decisions. The study used a qualitative interpretive approach, with semi-structured interviews as the primary data collection method. The proposed participants were consisted of ten secondary school chemistry teachers working in public-sector schools. Participants were selected through purposive sampling to ensure that they have relevant teaching experience and can provide meaningful insights into chemistry instruction and the use or perceptions of AI. Interview data were analyzed using thematic analysis approach

Findings: Teachers' Experiences and Perceptions

Research Question 1

Theme 1: I Believe Chemistry Should Be Understood Through Conceptual Learning Rather Than Memorisation

Chemistry is not simply a subject of memorising definitions, chemical equations and textbook information. Students should understand the scientific principles behind chemical reactions, atomic structures, chemical bonding, and other concepts. Unfortunately, in our schools, students are often more concerned with preparing answers for examinations than developing conceptual understanding. I believe effective chemistry teaching should involve questioning, practical activities, experimentation, and connecting scientific concepts with everyday life. AI can provide additional explanations, but students still need proper guidance to understand the actual scientific concepts.

Theme 2: AI Provides New Opportunities to Explain Difficult Chemistry Concepts and Prepare Lessons

AI can make our teaching preparation easier because it provides different explanations, examples, and questions within a short time. Sometimes students cannot understand concepts such as atomic structure, and chemical bonding through textbook explanations alone. I can use AI to prepare alternative explanations, develop lesson plans, generate classroom activities, and prepare assessment questions. It gives teachers additional instructional support, particularly when they want to explain a difficult concept in a different way.

Theme 3: AI Can Make Abstract Chemistry Concepts Easier to Visualise and Understand

Chemistry contains many concepts that students cannot directly observe. They can see a chemical reaction, but they cannot see the actual movement of electrons or the arrangement of

atoms and molecules. AI-supported visual explanations can help students understand these invisible processes. For example ionic bonding and chemical reactions can be explained through different representations. However, teachers must ensure that these visual explanations are scientifically correct and appropriate for students' understanding.

Theme 4: AI Is Helpful, but It Cannot Replace Teachers' Professional Knowledge and Classroom Interaction

AI provides information quickly but teaching involves much more than providing information. A teacher understands students' learning difficulties, classroom behaviour, educational backgrounds, and individual differences. Sometimes students do not understand a concept even after receiving several explanations. The teacher has to recognise the problem and change the teaching approach accordingly. AI may generate an explanation, but it cannot independently understand every classroom situation. Therefore, I consider AI a supporting resource rather than a replacement for the chemistry teacher.

Theme 5: Limited Resources and Digital Facilities Make AI Integration Difficult in Government Schools

I am interested in using modern technologies but the situation in many government schools is challenging. Internet connectivity is not always available, electricity interruptions affect technology use, and students do not have equal access to smartphones or computers. In some schools, even basic laboratory facilities are limited. We cannot expect teachers to integrate AI regularly when the necessary facilities are unavailable. Therefore, the availability of technology and institutional support is essential for meaningful AI integration.

Theme 6: Students Must Learn to Use AI Responsibly Rather Than Depend on Ready-Made Answers

My concern is that students may start depending on AI for every assignment, question, and homework activity. They can obtain an answer within seconds without making an effort to understand the scientific concept. This may affect their independent thinking and problem-solving abilities. I believe students should use AI to clarify concepts and explore scientific information, but they must also verify the answers and explain them in their own words. Responsible use of AI is becoming an important part of chemistry education.

Research Question 2

Theme 7: I Always Verify AI-Generated Chemical Information before Using It in My Classroom

AI sometimes generates explanations that appear scientifically correct, but when we examine them carefully, there may be errors or incomplete information. In chemistry, a small mistake in a chemical equation, oxidation state, or reaction explanation can create serious conceptual misunderstandings. Therefore, I do not consider AI-generated information automatically reliable. I compare the information with textbooks, established chemical principles, and my own subject knowledge before using it in teaching. A chemistry teacher must take responsibility for the accuracy of the information presented to students.

Theme 8: My Beliefs about Teaching Determine How I Use AI in Chemistry Instruction

The way a teacher uses AI depends largely on what that teacher believes about teaching and learning. If I believe students learn through active participation, I will try to use AI to develop questions, activities, and opportunities for discussion. If a teacher believes that teaching mainly involves explaining textbook content and preparing students for examinations, that teacher may use AI primarily for preparing notes and examination questions. Therefore, the availability of AI

does not automatically change teaching practices. Teachers' existing pedagogical beliefs influence how they select and use these technologies.

Theme 9: I Use AI to Encourage Scientific Questioning, Evidence Evaluation, and Independent Thinking

I believe AI can become useful when students are encouraged to question the information it provides. Instead of asking students simply to copy an explanation, I can ask them to examine whether the explanation is scientifically correct. For example, students can compare an AI-generated explanation of reaction rates with their textbook knowledge and identify any scientific errors. Such activities can encourage them to evaluate evidence, justify their conclusions, and develop scientific reasoning. The important thing is not obtaining an answer from AI but understanding how and why those answers are scientifically valid.

Theme 10: My Professional Experience Helps Me Decide When AI Is Appropriate for Teaching Chemistry

Not every chemistry topic requires the use of AI. Some concepts can be explained effectively through classroom discussion, laboratory experiments, demonstrations, and textbook activities. Other topics may benefit from digital explanations and visual representations. As an experienced teacher, I have to decide whether AI will genuinely improve students' understanding or simply introduce unnecessary technology into the lesson. My decision depends on the learning objectives, students' abilities, the nature of the topic, and the available resources.

Research Question 3

Theme 11: I Understand Modern Teaching Theories but Classroom Conditions Often Prevent Me from Applying Them

In teacher education programmes, we learn about constructivism, inquiry-based learning, collaborative learning, and student-centred teaching. We understand that students should actively participate in the learning process rather than simply listen to teachers. However, when we return to our classrooms, the situation is different. We have large numbers of students, limited teaching time, examination pressure, and insufficient laboratory facilities. Sometimes we want to organise activities and encourage students to investigate scientific questions, but practical classroom conditions make it difficult. This creates a difference between what we believe about effective teaching and what we actually practise.

Theme 12: AI Can Help Me Translate My Teaching Beliefs into Practical Classroom Activities, but I Need Training and Institutional Support

I believe AI has the potential to help teachers apply modern teaching approaches in practical classroom situations. For example, it can help us develop inquiry-based questions, prepare collaborative learning activities, generate alternative explanations, and design formative assessments. However, knowing that AI exists is not enough. Teachers need practical training on how to integrate it into chemistry lessons according to curriculum objectives and students' learning needs. We also need institutional support, internet facilities, digital resources, and opportunities to share experiences with other teachers. Without these conditions, AI may remain limited to preparing notes and examination questions rather than transforming classroom teaching.

Discussion

The proposed study brings together three important dimensions of chemistry education: teachers' pedagogical beliefs, professional reasoning and AI-supported instructional practices. Secondary school chemistry teachers' pedagogical beliefs play a significant role in shaping their perceptions and use of Artificial Intelligence in teaching and learning. Teachers generally recognise that

effective chemistry instruction should move beyond rote memorisation towards conceptual understanding, scientific inquiry, practical engagement and independent thinking. They perceive AI as a potentially valuable instructional resource for preparing lessons, generating assessment questions, simplifying difficult chemical concepts and developing visual explanations of abstract phenomena such as atomic structure, chemical bonding, and molecular interactions. However, they also recognise its limitations, particularly the possibility of scientifically inaccurate explanations, students' overdependence on generated answers, and the inability of AI to replace teachers' professional knowledge and classroom interaction. These perceptions indicate that AI integration is not simply a technological decision but is closely connected with teachers' beliefs about the nature of scientific knowledge, effective teaching and meaningful student learning (Hammoud, 2025).

The findings demonstrate that teachers' professional reasoning and pedagogical beliefs influence how they evaluate and use AI-generated chemistry content. Teachers' subject knowledge enables them to examine the scientific accuracy of chemical equations, explanations, molecular representations, and conceptual interpretations before incorporating them into classroom instruction. This professional judgement is particularly important because AI-generated information may appear convincing while containing scientific inaccuracies or incomplete explanations. The findings also suggest that teachers' pedagogical orientations influence their instructional decisions: those who emphasise student-centred and constructivist learning may use AI to encourage questioning, inquiry, discussion, and scientific reasoning, whereas examination-oriented approaches may lead to its use primarily for preparing notes, explanations, and assessment materials. Nevertheless, teachers' decisions are not determined by beliefs alone; they are also influenced by curriculum requirements, students' learning needs, available resources, and classroom circumstances. AI can contribute to reasoning when teachers use it to encourage students to evaluate evidence, compare explanations, identify inaccuracies and justify scientific conclusions rather than simply reproduce generated answers. Artificial Intelligence has the potential to contribute to bridging the theory practice gap in chemistry education by helping teachers translate pedagogical knowledge into practical classroom activities. Although teachers may understand and support constructivist, inquiry-based, and student-centred approaches, their implementation is frequently constrained by examination pressure, large class sizes, limited teaching time, inadequate laboratory facilities, and insufficient professional development. AI may provide practical assistance through inquiry-based questions, alternative conceptual explanations, collaborative learning activities and formative assessment strategies; however, technological availability alone cannot overcome these institutional barriers. Meaningful integration therefore requires subject-specific professional development, improved digital infrastructure, institutional support and opportunities for reflective teaching. The TPACK framework provides a useful perspective for understanding this relationship, emphasising the integration of technological, pedagogical, and chemistry content knowledge. Artificial Intelligence should not be viewed as a substitute for teachers or an automatic solution to educational challenges. Rather, it should be understood as a pedagogically mediated resource whose effectiveness depends on teachers' professional reasoning and judgement, pedagogical beliefs, instructional decisions and the broader educational conditions in which they work (Dogan et al., 2025).

Conclusion

This study examined secondary school chemistry teachers' pedagogical beliefs and professional reasoning in the age of Artificial Intelligence, with particular attention to the potential of AI to

bridge the theory practice gap in chemistry education. The study explores that teachers' perceptions of effective chemistry teaching extend beyond the transmission and memorisation of scientific information towards conceptual understanding, inquiry-based learning, practical engagement and the development of students' independent reasoning. AI offers opportunities to support these educational objectives through lesson planning, alternative conceptual explanations, visual representations, assessment development and interactive learning activities. However, its educational effectiveness depends on teachers' ability to critically evaluate AI-generated chemistry content, identify scientific inaccuracies and make informed pedagogical decisions. The findings emphasise that AI cannot replace teachers' subject expertise, professional judgement and responsibility for students' learning.

The study establishes that the integration of AI into chemistry instruction is closely associated with teachers' pedagogical beliefs, professional knowledge and institutional circumstances. Although teachers may support constructivist and student-centred approaches, their ability to translate these beliefs into classroom practices is frequently influenced by examination-oriented curricula, large class sizes, limited teaching time, inadequate laboratory facilities, insufficient digital infrastructure, and a lack of subject-specific professional development. In this regard, AI has the potential to facilitate the practical implementation of pedagogical approaches by providing instructional resources and opportunities for scientific questioning, evidence evaluation, and conceptual exploration. Nevertheless, access to AI tools alone cannot eliminate the theory–practice gap without appropriate institutional support and pedagogically informed teacher preparation.

The study concludes that meaningful AI integration in secondary chemistry education requires a balanced relationship between technological capabilities, teachers' pedagogical beliefs, professional reasoning and chemistry content knowledge. AI should be regarded as a complementary educational resource that strengthens teachers' instructional decision-making and promotes students' conceptual understanding and reasoning rather than replacing professional teaching responsibilities.

Recommendations

1. Strengthening Teachers' AI Professional Development: Education departments should provide continuous, subject-specific training to help chemistry teachers use AI for lesson planning, conceptual explanations, assessment, and inquiry-based learning.
2. Improving Digital Infrastructure: The Elementary and Secondary Education Department, Khyber Pakhtunkhwa, should ensure reliable internet, electricity, digital devices, and technological facilities for equitable AI integration in public schools.
3. Bridging the Theory–Practice Gap: Schools should encourage reflective teaching, collaborative lesson planning, and classroom experimentation to translate teachers' pedagogical beliefs into effective AI-supported practices.
4. Promoting Professional Reasoning and Rationalistic Thinking: Chemistry teachers should critically evaluate AI-generated explanations, question assumptions, examine scientific evidence, and make informed instructional decisions based on their subject knowledge and professional judgement.

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