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Artificial Intelligence in Science Learning within the Framework of Situated Learning Theory: A Qualitative Investigation of Teachers' Perspectives

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Abstract

This study explores how artificial intelligence (AI) tools influence science learning, classroom interaction, and teachers' evolving roles in K-12 education through the lens of Situated Learning Theory (SLT). While prior research has emphasized AI's potential to enhance STEM learning, few studies have grounded these effects in established learning theories. Drawing on semi-structured interviews and open-ended questionnaires with fourteen Chinese science teachers across elementary to high school levels, this study investigates how AI integration shapes students' learning processes and outcomes, social construction, and teachers' pedagogical identities. Findings reveal that AI technologies—particularly virtual labs, simulations, and intelligent tutoring systems—enhance students' conceptual understanding, foster higher-order scientific skills, and cultivate scientific identity by enabling contextualized, low-risk and inquiry-based participation. AI-supported collaboration also deepened classroom interaction, promoting joint meaning-making and peer learning. Moreover, teachers' roles shifted from knowledge transmitters to facilitators, co-investigators, and ethical supervisors, highlighting emerging responsibilities in guiding students' responsible use of AI. By integrating SLT with AI in science education, this study extends theoretical understanding of how digital tools mediate authentic participation and boundary crossing in learning. It also underscores the indispensable human dimension of teaching in the age of intelligent

technology.

Keywords

Artificial Intelligence, Science Education, Situated Learning Theory

1. Introduction

Artificial intelligence (AI) has recently become one of the most accelerating fields worldwide, drawing attention across disciplines (Mabungela, 2023; Vargas et al., 2024). In education, rapid advances in AI have generated growing interest from both computer science and education researchers, opening possibilities for more effective learning activities and technology-enhanced learning environments (Hwang et al., 2020; Lampropoulos, 2025). While AI has applications across educational domains, its potential is particularly significant in STEM education, where a fundamental challenge is bridging the gap between abstract theoretical concepts and real-world practice. In STEM education, AI can help address this challenge by providing interactive, hands-on learning opportunities. For instance, virtual labs and simulations allow students to experiment, observe, and analyze data in digital environments, helping them better grasp complex scientific concepts. In addition, intelligent tutoring systems can provide personalized guidance in complex STEM topics by adapting to each student's learning pace, offering immediate feedback on problem-solving strategies, and customizing courses to meet each learner's specific needs and preferences (Kotsis, 2024). These examples illustrate that AI's ability to provide situational, practical, and interactive learning experiences makes it especially valuable in enhancing science education.

There is a growing consensus in the literature that AI technologies hold significant potential to enhance science education. However, it is necessary to understand how and why AI technologies pose positive effects on science education. Chen et al. (2020) conducted a systematic review revealing that only several of 45 studies grounded their research in learning theories such as situated learning, collaborative learning, or adaptive learning. Ouyang and Jiao (2021) further indicated that the insufficient connection between AI technologies and educational theory undermines the effectiveness of AI implementation in education, and more recently, similarly emphasized that clarifying the conceptual and theoretical underpinnings of AIED is essential for building a cohesive understanding of how AI contributes to educational research and practice.

To address this, the present study employs Situated Learning Theory (SLT) as its theoretical lens, as its principles offer a robust framework for examining the transformative potential of AI in science education. SLT emphasizes that knowledge is best acquired in authentic contexts, where beginners engage in real-world activities, apply what they learn, and use tools in meaningful but low-risk ways, often through social interaction and collaboration within a "community of practice" (Besar, 2018). By integrating SLT with AI applications, it clarifies the embedded

rationale on how these technologies enhance science education. Integrating SLT with AI applications allows for an examination of how AI tools function as "mediational artifacts" that reconfigure learners' participation, identity formation, and social interaction within communities of practice.

The theoretical potential of AI to construct authentic learning environments, as advocated by SLT, cannot be realized without the active and informed participation of teachers. Authentic learning (AL) positions students as active participants who develop understanding by tackling complex, real-world challenges that require higher-order thinking skills (HOTS) and the practical use of tools and methods to solve genuine problems like professions (Baloyi & Mtshali, 2018; Redmond et al., 2018). Teachers are the critical intermediary between technological affordances and pedagogical implementation (Kim & Kim, 2022). However, these theoretical gaps cannot be bridged without understanding how teachers—who translate technological affordances into classroom practices—perceive and enact AI in science learning contexts. Their perceptions, ranging from its "effects on students" and "effects on teachers" to "effects on education-teaching process" are critical in determining whether and how AI applications can be effectively integrated into science education (Bagir et al., 2022). Within the SLT framework, teachers shaped situated learning contexts by mediating students' engagement with tools, tasks, and collaborative practices, underscoring the necessity of examining their perspectives on AI in science education. Building on existing research on teacher perceptions of AI in science education, this study moves beyond descriptive accounts of teacher attitudes but offers a distinctive contribution by grounding these perceptions within SLT, investigating how teachers, as mediators between students and AI, shape the ways AI generates authentic, situated learning experiences in the classroom. Further, while "communities of practice" is a broadly recognized concept, it is often discussed without connecting it to other important elements of situated learning theory, such as identity, joint enterprise, and boundary crossing (O'Brien & Battista, 2020). By investigating teachers' perceptions of AI in science education, this study also examines whether and how teacher involvement can support these underexplored but critical aspects of SLT, revealing additional ways in which AI applications foster authentic, situated learning.

In conclusion, this study has two main objectives. First, this study applies Situated Learning Theory (SLT) to explore how AI technologies can enhance science education. By integrating AI, SLT can address a key challenge in science teaching: making abstract scientific concepts concrete and visible for better understanding within the constraints of a traditional classroom. Second, because teachers play a crucial role in mediating between AI technologies and students, it is important to examine how their perceptions influence the interaction between AI tools and student learning. Focusing on China, one of the leading countries in AI research (Delen et al., 2024; Genc & Kocak, 2024; Lee et al., 2025), this study recruited 14 Chinese science teachers (teaching physics, mathematics, chemistry, and general

science). Through semi-structured interviews or open-ended questionnaires, it explores how AI technologies support K-12 students' science learning from a situated learning perspective. This study thus contributes to bridging the theoretical-practical gap in AI-integrated science education by reconceptualizing teachers as mediators of situated learning experiences.

2. Literature Review

2.1. Artificial Intelligence in Science Education

Conversations surrounding the integration of AI technologies into science education have become increasingly varied and in-depth, with AI playing a growing role in enriching both teaching and learning experiences (Genc & Kocak, 2024; Jia et al., 2023). Across recent reviews, a consistent trend emerges: AI is primarily used to leverage instructional efficiency rather than to transform the nature of science learning. For instance, Lee et al. (2025)'s review of 36 AI-related papers presented at the 2024 NARST conference pointed out that the main functions of AI in science education are supporting assessment and evaluation, improving teaching competency and profiling and predicting student outcomes, with only limited efforts aimed at facilitating personalized learning experiences and assisting with curriculum and lesson design. Similarly, Almasri (2024)'s review of empirical studies published between 2014 and 2023 found that AI tools are frequently employed in science education to evaluate students' assignment, predicting students' performance, and designing quizzes. This suggests that AI is predominantly used to strengthen evidence-based teaching and data-informed decision-making, with the focus remaining on teacher-centered analytic rather than student-centered improvement.

In terms of AI applications, Jia et al.'s (2023) identified five major categories of AI applications—educational robots, machine learning and data mining algorithms, intelligent tutoring systems, automation (e.g. automated feedback, subtitles), and detection or prediction tools—ranging from the most to the least commonly used in science learning contexts. Complementary evidence can be found in Kotsis (2025)'s study, it reported that personalized learning systems, virtual labs and simulations, adaptive assessments and feedback, and AI-driven tutoring platforms have promising impacts on improving science teaching and learning. Notably, Lee et al. (2025) pointed out that large language models such as ChatGPT and Google Gemini, due to their easy accessibility, user-friendly interfaces, ability to generate clear responses from well-crafted prompts, and capacity to produce multimodal outputs (e.g., text, images, and videos), are emerging as valuable tools for science teaching and learning. Collectively, these studies suggest that AI's expanding applications are reshaping science education because it personalizes learning, provides interactive and accessible tools, and delivers adaptive feedback and tutoring. However, their studies illustrate the wide-ranging but often fragmented nature of AI use in science classrooms. Moreover, their use often emphasizes what AI can do rather than how it supports meaningful scientific under-

standing. This highlights a theoretical gap: a limited understanding of the underlying learning mechanisms that explain how these tools support students' conceptual development. To address this theoretical gap, this study adopts Situated Learning Theory (SLT) as a lens to interpret AI-supported science teaching and learning.

2.2. Artificial Intelligence and Situated Learning Theory

Situated learning theory reflects the value of learning in real contexts while also recognizing the need to combine practice with knowledge acquisition. As an influential framework in educational research, it bridges the gap between theoretical understanding and practical application. Through this process, learners gradually move from peripheral participation toward full engagement within a learning community. The claim that learning must always be situated to be effective is overly rigid. Learners often need to acquire knowledge first before they can fully and meaningfully participate, since participation and acquisition serve complementary roles, combining both approaches may offer the most effective strategy for classroom instruction (Besar, 2018). Therefore, successful learning requires a dynamic balance between context-based experience and conceptual understanding. While "communities of practice" is a broadly recognized term, it is often used without linking it to other important ideas from situated learning theory, such as identity, joint enterprise, and boundary crossing (O'Brien & Battista, 2020). Reconnecting these concepts helps clarify how learning is not only a cognitive process but also a social and identity-forming experience.

Socially situated learning is still a challenge for AI agents, as they need to learn how to interact with humans to obtain missing information (Krishna et al., 2022). This limitation highlights the gap between human social intelligence and machine learning capabilities. AI powered adaptive systems can address students' changing needs in the ways of intelligent tutoring designed for real-world circumstances, automated administrative tasks, and data-driven support to assist tutors (Vargas et al., 2024). By integrating these systems into educational contexts, AI begins to simulate aspects of social learning through personalization and responsiveness. El Khayati et al. (2025) explored how AI is incorporated into Moroccan high-school computer science classes, advocating for a comprehensive review, as well as practical tools and resources to support AI education. Such empirical efforts demonstrate the growing relevance of AI in formal education and the need to align its use with pedagogical goals. Although AI faces challenges in socially situated learning, it is increasingly being used to support education through adaptive tutoring systems and classroom applications. Ultimately, advancing AI's social learning capacity will be key to realizing its full potential in human-centered educational environments.

2.3. Artificial Intelligence in Science Education in China

Artificial intelligence has increasingly influenced teaching and learning in science.

As technology continues to evolve, its role in transforming educational practices has become more evident across different disciplines. A recent review analyzed 76 studies published between 2013 and 2023, showing that research on AI in science education has grown significantly over the past decade (Jia et al., 2023). This surge reflects educators' growing interest in exploring how AI can enhance teaching effectiveness and student engagement. A review analyzed 4,673 articles published from 1975 to 2023, revealing that research output grew rapidly after 2010, with the USA, China, and Australia emerging as the most prolific contributors (Delen et al., 2024). These findings suggest that global collaboration and technological advancement have jointly fueled the expansion of this research field. Understanding the evolution of AI in science education is vital for shaping future technological applications in the classroom. By tracing research trends and identifying key contributors, scholars can better inform pedagogical strategies and policy development. An analysis of research between 2019 and 2023 revealed that the USA, China, and Australia were the primary sources of publications (Genc & Kocak, 2024). This indicates a sustained leadership role of these countries in advancing AI-related educational innovation. A systematic review of 36 AI-focused papers from the 2024 NARST conference revealed that AI is increasingly embedded in science education research with attention to ethics, reinforces rather than transforms existing educational frameworks, and is developing as a flexible, multimodal tool for both research and instructional purposes (Lee et al., 2025).These studies demonstrate a clear trend toward integrating AI not only as a technological aid but also as a catalyst for reflective and ethically grounded educational practice. Overall, research on artificial intelligence in science education has expanded rapidly worldwide.

Current research on AI in science education is dominated by studies from the USA and China, with most applications focusing on assessment, teacher development, and prediction rather than on learning support or classroom integration. This geographic concentration highlights the leading role of these nations in shaping global trends in AI-based educational innovation. The USA and China are representative of Western and Eastern countries which have conducted prominent research in this area (Lee et al., 2025). Their sustained contributions demonstrate both regional diversity and shared interest in advancing AI for science learning. The dominant applications of AI involved assessment and evaluation, followed by teaching competency development and profiling or prediction, whereas considerably fewer studies explored its use for learning support or curriculum design (Lee et al., 2025). This imbalance suggests that current efforts are more aligned with performance measurement and teacher preparation than with enhancing student-centered learning. Only a small portion of studies examined integrating AI into science teaching and situated learning, which primarily focuses on how teachers learn about AI or plan to use it in instructions (Lee et al., 2025). Most studies in China remain descriptive and focus on technological adoption rather than pedagogical transformation, leaving a gap in understanding how AI

supports situated, context-based learning from teachers' perspectives. Future research, therefore, should expand its focus toward practical classroom integration and explore how AI can meaningfully support authentic, context-based science learning.

Building upon the above-reviewed literature, it becomes evident that—while artificial intelligence has achieved substantial progress in enhancing instructional efficiency—its integration into science education still lacks a coherent theoretical foundation that explains how AI facilitates meaningful, situated learning. Prior studies have predominantly focused on assessment, prediction, and teacher development, leaving underexplored how AI tools foster authentic, context-based learning experiences and reshaping classroom interaction. By drawing upon Situated Learning Theory (SLT), this study responds to these gaps by examining AI not merely as a technological aid but as a pedagogical mediator that situates learning in real-world contexts through participation, collaboration, and tool use. Moreover, since teachers serve as the crucial link between AI technologies and students' engagement, understanding their perceptions offers key insights into how AI supports identity formation, social interaction, and knowledge construction in science classrooms. Therefore, guided by SLT, the following research questions are proposed—to investigate teachers' perspectives on the role of AI in promoting authentic, interactive, and ethically grounded science learning. These observations justify the need for a qualitative inquiry grounded in teachers' lived experiences to uncover how AI applications are domesticated within situated science learning contexts.

RQ1: How do AI tools influence students' science learning processes and outcomes?

RQ2: How do AI tools transform classroom interaction and social construction in science education?

RQ3: In what ways do AI tools enhance contextualized and authentic learning experiences in science education?

RQ4: How do teachers perceive the future development and application of AI in science education?

3. Methods

3.1. Research Design

To investigate these research questions this study adopts a qualitative, interpretivist-constructivist paradigm, which emphasizes understanding teachers' perspectives and experiences in context. This paradigm aligns with SLT's epistemological stance that knowledge and meaning emerge through social participation and contextual engagement. This approach was chosen because it enables an in-depth understanding of how teachers perceive the role of AI and integrate it into their classroom practices. Fourteen science teachers were recruited through the Chinese social media platform rednote, providing access to a diverse group of educators teaching subjects such as physics, chemistry, mathematics, and general sci-

ence. Recruitment and data collection took place between September 22, 2025, and October 12, 2025. Participants were informed of the study's purpose and provided written consent before participation. They were assured of confidentiality and could withdraw or skip any question at any time. Participants were given the flexibility to choose between completing an open-ended questionnaire or participating in a semi-structured interview. To ensure thoughtful and high-quality responses, they were encouraged to complete the questionnaire or schedule interviews at a time most convenient to them. Each participant received a 100-yuan reward after completing the questionnaire or interview as a token of appreciation for their time and contribution. This flexible and ethically grounded design aimed to create a comfortable environment for participants and to capture rich, authentic insights into how science teachers perceive and integrate AI technologies in their classrooms.

3.2. Pilot Study

Prior to full-scale data collection, a pilot study was conducted to refine the data collection instrument and ensure the questions were clear, relevant, and comprehensive. An initial draft of the questionnaire was first shared with all 14 enrolled participants for preliminary feedback. This step yielded valuable insights, such as one teacher from rural area highlighting that their use of AI was primarily for generating teaching materials rather than for direct student use. Following this, four teachers were purposively selected to participate in the pilot phase, comprising one semi-structured interview and three open-ended questionnaires. Analysis of their responses led to significant revisions of the questionnaire, including the removal of ambiguous items and the addition of new sections probing the perceived concerns, weaknesses, and ethical considerations of using AI in science education.

3.3. Data Collection

Following the verification of eligibility and the completion of the informed consent process, eligible teachers were admitted into the study. They were then given the researcher's WeChat contact information to serve as a primary point of contact for any issues or questions that arose during their involvement in the research.

Data collection employed a qualitative mixed-methods approach, offering participants a choice between completing an open-ended questionnaire or participating in a semi-structured interview to accommodate different preferences and encourage rich, detailed contributions. Both instruments were explicitly designed to address the study's four research questions.

The final open-ended questionnaire was organized into thematic sections corresponding to the research foci:

· Section 1: Demographic and Contextual Background

· Section 2: Influence on Learning Processes & Outcomes (RQ1)

· Section 3: Transformation of Classroom Interaction (RQ2)

· Section 4: Enhancement of Contextualized Learning (RQ3)

· Section 5: Perceptions on Future Development (RQ4)

Participants who selected this option completed the questionnaire online at their convenience.

Concurrently, the semi-structured interviews were conducted with participants who preferred a conversational format. The interview protocol was developed around the same core research questions, allowing for in-depth exploration of themes such as specific classroom interactions, the creation of authentic learning scenarios, and teachers' visionary outlook on AI. Each interview lasted approximately 30 - 40 minutes.

This approach ensured that data from both streams—the reflective, written narratives from the questionnaire and the dynamic, probed discussions from the interviews—could be synthesized to provide a comprehensive understanding of the research problem.

3.3.1. Recruitment

Participants were recruited through purposive sampling strategies to target in-service K-12 science teachers with direct experience using AI technologies in their classrooms. The recruitment process was conducted via posts on the social media platform rednote. Interested educators were directed to a preliminary screening form to determine their eligibility. To qualify for the study, participants were required to:

1. Be currently or recently employed as a K-12 science teacher;

2. Have direct experience using at least one specific AI tool in their science teaching practice;

3. Be available for a follow-up data collection session in October.

Teachers who met these initial criteria were then asked to provide a brief, open-ended narrative describing a memorable instance or insight from their use of AI in teaching, which served as an assessment of their experience and richness of perspective. To ensure a diverse sample, the recruitment strategy explicitly sought variation across key demographic and professional dimensions, including gender, age, teaching title, years of experience, school type (e.g., public, private), school geographical area, specific science subject taught, and grade level.

3.3.2. Participant Demographics

Table 1 presents the demographic and professional background of the fourteen science teachers who participated in this study. The sample included both male and female educators, with a slightly higher proportion of females (eight) than males (six). The reason that the present used 14 interviewees since the data saturation principle served as the basis for the choice to interview 12 participants (Guest et al., 2006). According to their analysis, by the time they had looked at twelve interviews, data saturation had mostly occurred. Most participants were between 26 and 35 years old, indicating a cohort of early- to mid-career teachers actively engaged in educational innovation. Only one participant was over 35, sug-

gesting that the sample largely represents a younger generation of teachers adapting to technology-enhanced learning environments. In terms of educational qualifications, the majority held undergraduate degrees, while two participants had graduate-level education, providing a balanced representation of professional training levels within the K-12 science teaching workforce.

Regarding teaching experience, most participants had four to ten years of experience, while a smaller number (five teachers) had one to three years, reflecting both seasoned practitioners and newer entrants to the profession. Professional titles ranged from elementary to intermediate, demonstrating varied ranks within the Chinese education system. This diversity in age, experience, and professional status ensured that the dataset captured a wide spectrum of insights—from teachers experimenting with AI in the early stages of their careers to those with more established pedagogical approaches—thereby enriching the study's qualitative understanding of how AI tools are integrated into science education across different teaching contexts.

Table 1. Teacher participant information.

Code	Gender	Age	Educational Level	Teaching Experiences	Professional Title
Teacher 01	Female	26 - 35	Graduate	4 - 10	Intermediate
Teacher 02	Female	Below 25	Undergraduate	1 - 3	Elementary
Teacher 03	Female	26 - 35	Undergraduate	4 - 10	Elementary
Teacher 04	Female	26 - 35	Undergraduate	4 - 10	Intermediate
Teacher 05	Female	26 - 35	Undergraduate	4 - 10	Elementary
Teacher 06	Male	26 - 35	Undergraduate	1 - 3	Elementary
Teacher 07	Male	26 - 35	Undergraduate	4 - 10	Elementary
Teacher 08	Female	26 - 35	Undergraduate	4 - 10	Intermediate
Teacher 09	Male	26 - 35	Undergraduate	4 - 10	Elementary
Teacher 10	Male	26 - 35	Graduate	4 - 10	Intermediate
Teacher 11	Female	36 - 45	Undergraduate	4 - 10	Intermediate
Teacher 12	Male	26 - 35	Undergraduate	1 - 3	Elementary
Teacher 13	Female	26 - 35	Undergraduate	1 - 3	Intermediate
Teacher 14	Male	26 - 35	Undergraduate	1 - 3	Elementary

Admittedly, the teacher participants were recruited via Red, a social media platform whose user base is predominantly younger adults. This recruitment channel may have introduced a generational bias, as these teachers were relatively young and potentially more open to technology adoption than the broader population of STEM educators.

3.4. Reflexivity

As the researcher for this study, my positionality is shaped by my background as

an educational technology enthusiast and graduate student in reading/writing/literacy. My own positive experiences with AI tools created a prior assumption that AI is primarily an empowering and transformative force in education. This positioned me with an inherent "pro-innovation" bias at the outset of the research. While I am not currently a practicing K-12 teacher, my past experiences create a shared understanding with participants, making me a partial 'insider' regarding pedagogical challenges, yet an "outsider" to the current daily realities of implementing AI in diverse classroom settings. I recognized that this bias could lead me to overlook challenges or ethical concerns, and I therefore engaged in ongoing reflexive practices to mitigate its influence.

3.5. Data Analysis

All qualitative data from semi-structured interviews and open-ended questionnaires were analyzed using reflective thematic analysis (Byrne, 2022) with systematic data management and manual coding. Reflective thematic analysis was selected for its flexibility in identifying patterned meanings across participants while allowing researcher reflexivity—an essential feature given the interpretivist-constructivist orientation and the Situated Learning Theory (SLT) framework guiding this study.

3.6. Ethical Considerations

This study followed strict ethical guidelines. Before taking part, all participants received a informed consent form explaining the study's purpose, procedures, potential risks and benefits, and how their privacy would be protected. It explicitly stated their voluntary participation and unconditional right to withdraw from the study at any point without penalty. We also reminded participants that they could skip any question they did not wish to answer. To ensure confidentiality, all personal information was removed from the data. As appreciation for their time and contribution, each participant received 100 RMB upon completion of the study.

4. Findings

4.1. RQ1: How Do AI Tools Influence Students' Science Learning Processes and Outcomes?

1. Lowering Cognitive Barriers and Deepening Conceptual Understanding

Teachers generally perceived that the integration of AI tools has significantly transformed students' science learning processes by lowering cognitive barriers and enhancing conceptual understanding. Through dynamic simulations and visualized representations, abstract scientific knowledge was converted into perceptible and interactive forms, enabling students to move beyond rote memorization toward deeper comprehension. As one teacher (Teacher 01) noted, AI tools "lower the cognitive threshold" and help students "gradually understand models rather than mechanically memorize formulas", while even those who previously struggled "could accurately describe that temperature change is the key to state trans-

formation" (Teacher 02). This shift from abstract formulas to concrete models was vividly demonstrated in the development of students' spatial reasoning. For instance, learners could adjust 3D structures to explore relationships between variables, a process that allowed them to "clearly explain how the length, width, and height of a cuboid relate to its volume" (Teacher 07).

In addition to improving understanding, AI-generated visual and narrative content effectively captured students' attention and deepened students' memory retention by transforming abstract concepts into vivid, emotionally engaging learning experiences (Teacher 10). Moreover, AI-supported environments appeared particularly beneficial for lower-achieving or less motivated students by providing individualized scaffolds that made complex ideas comprehensible and encouraged confidence, whereas the impact on already high-achieving students was less pronounced (Teacher 10). Overall, teachers highlighted a shift from passive reception to active, multimodal learning, where AI tools bridge abstraction and experience, enhance attention and spatial reasoning, and create more inclusive, engaging experiences for diverse learners.

2. Growth of Higher-Order Scientific Skills

Teachers reported that AI tools significantly enhanced students' acquisition of higher-order scientific skills, including experimental design, inquiry, hypothesis testing, data analysis, modeling, argumentation, and creative exploration.

One of the most prominent themes was the enhancement of students' experimental design and planning abilities. Teachers observed that AI tools supported students in independently designing and refining experiments. As one teacher explained, AI tools allowed students "to design an experimental plan autonomously," resulting in "more logical and persuasive expression" (Teacher 01). Similarly, another teacher noted that AI "provided students with ideas for experimental design and allowed them to optimize their plans further" (Teacher 9). These observations indicate that AI helps students think systematically about experimental procedures and make data-driven adjustments to improve their designs.

Closely linked to design was the role of AI in fostering inquiry and questioning. With AI's guidance, students developed stronger curiosity and problem awareness, moving beyond descriptive observation toward causal reasoning. As one teacher described, the learning cycle of "observation-questioning-AI verification" greatly stimulated students' inquiry awareness, encouraging them to ask "Why does this happen?" and "How can I prove my hypothesis?" (Teacher 05). This iterative process naturally extended to formulating and testing hypotheses. One teacher explained that "AI tools supported students in generating hypotheses, collecting data, and constructing argument models to verify their assumptions" (Teacher 9). This process strengthened students' understanding of the relationship between empirical evidence and theoretical reasoning.

Another area of skill development observed by teachers was data collection, analysis, and interpretation. AI's capacity for rapid data processing and visualiza-

tion allowed students to handle complex datasets more effectively. For example, one teacher shared that students used AI to analyze long-term plant growth data, create growth curves, and identify relationships between environmental factors and plant development (Teacher 9).

Teachers also emphasized that AI tools promoted students' competence in modeling and simulation. By engaging in AI-based virtual experiments, students could visualize abstract scientific concepts, manipulate variables, and observe outcomes in a risk-free environment. For instance, students employed sound wave simulation software to model sound transmission across different media and independently concluded that "density affects propagation efficiency" (Teacher 05). In another case, AI helped students "adjust experimental parameters through virtual simulations" to better understand experimental principles (Teacher 12). As one teacher summarized, such activities enabled students to "demonstrate a complete chain of scientific thinking from modeling to argumentation" (Teacher 05), fostering conceptual understanding and reinforcing the iterative nature of scientific modeling.

Furthermore, teachers observed that AI enhanced students' argumentation, reasoning, and communication skills. Through AI-assisted feedback, students learned to construct logical arguments, support their claims with data, and communicate their reasoning more coherently. One teacher commented that students' expression became "more logical and persuasive" (Teacher 01), while another noted that AI helped students "clarify theoretical logic, optimize language expression, and identify weaknesses in their arguments" (Teacher 12). These experiences suggest that AI tools not only aid cognitive development but also nurture students' ability to engage in structured scientific discourse.

3. Transformation of Learner Identity and Agency

A salient theme across teachers' accounts was that AI tools helped students develop a stronger sense of ownership, agency, and scientific identity. Students began to see themselves not merely as learners but as active investigators and creators. One teacher highlighted that AI "significantly enhanced students' interest in science learning and promoted their transformation from 'knowledge learners' to 'scientific practitioners'" (Teacher 05). Similarly, another teacher noted that "active learning is the best guarantee for all subjects… this process allowed students to recognize themselves as owners of their learning" (Teacher 13). Other teachers observed students exploring "like little mathematicians who verify and discover knowledge using AI tools" (Teacher 07) or expressing aspirations such as "I want to be an inventor in the future" (Teacher 02). Through authentic tasks and opportunities for self-directed exploration, AI tools enabled students to internalize autonomy and capability, fostering a learner identity aligned with scientific thinking and practice.

4. Promotion of Active Inquiry through Low-Risk Experimentation

Teachers emphasized that AI tools encouraged students to engage in active, hands-on inquiry by lowering the perceived risks associated with experimentation

and by providing timely feedback during the learning process. The digital environment offered a safe space for students to test hypotheses, make mistakes, and refine their ideas. For instance, one teacher described how "some students tried more than ten times until they finally discovered the rule that ships loaded with more cargo are less likely to sink… the process of trying without fear of failure made them more willing to explore complex experimental designs" (Teacher 02). Another teacher explained that "this kind of self-generated questioning was encouraged by the AI tool's instant feedback, which made students confident to propose creative ideas and test them" (Teacher 08). Such reflections suggest that AI-enabled simulations promote perseverance, risk-taking, and deeper understanding by allowing students to learn iteratively in a low-risk, feedback-rich environment.

5. Enhanced Interest and Motivation in Science Learning

AI tools were widely perceived by teachers to surge students' interest, enjoyment, and motivation in science learning. Teachers consistently observed that interactive and playful AI features transformed science from an abstract or intimidating subject into an engaging and curiosity-driven experience. As one teacher noted, AI "significantly increased students' interest in science learning… from feeling anxious about abstract content to becoming proactive and passionate participants" (Teacher 01). Similarly, another teacher described how students who once disliked mathematics "changed from hating math to liking it (Teacher 07)," reflecting a marked shift in their learning attitudes. The accessible, exploratory nature of AI activities—"turning learning from something students 'have to learn' into something they 'can play with'" (Teacher 14)—allowed students to reframe science as enjoyable and attainable. This emotional engagement, in turn, sustained motivation and fostered a more positive disposition toward scientific learning.

4.2. RQ2: How Do AI Tools Transform Classroom Interaction and Social Construction in Science Education?

1. Fostering Collaborative and Socially Constructed Learning

Teachers widely observed that AI tools significantly enhance collaborative inquiry and social interaction among students. By enabling real-time feedback and shared access to experimental data, AI encouraged students to move away from working individually toward more collective and interactive participation. For example, one teacher explained that AI's synchronized data system meant "students no longer work separately… now they willingly collaborate" (Teacher 01). Others described how students developed clear role divisions in teamwork and maintained active discussion while adjusting experimental designs (Teacher 02). Beyond cooperation, students engaged in deeper cognitive exchange—reviewing, questioning, and refining AI-generated outputs rather than accepting them passively. As one teacher highlighted, "it promotes 'thinking-negotiating-optimizing' collaboration; students review, question, and debate the AI's proposals" (Teacher 05). Such experiences show that AI tools not only facilitate communication and

joint problem-solving but also foster a culture of critical conversation and shared meaning-making in science learning communities.

2. Transforming Teacher-Student Interaction and Pedagogical Roles

The introduction of AI has also redefined teacher-student interactions and reshaped pedagogical roles. Teachers noted that AI functions as a responsive assistant that handles routine questions or provides immediate feedback, allowing them to focus on guiding deeper inquiry. One teacher shared that "AI teaching assistants can answer basic questions, so I have more time to help students who are truly struggling" (Teacher 02). Similarly, teachers could monitor group progress in real time, offer precise guidance, and design personalized interventions (Teacher 03). Rather than serving merely as transmitters of knowledge, teachers became facilitators, questioners, and co-investigators—"I now target my questions to help students discover patterns themselves," one explained (Teacher 01). Students also became more proactive in seeking clarification, engaging teachers in richer, more purposeful dialogue after interacting with AI tools (Teacher 07; Teacher 9; Teacher 13). Overall, AI integration has deepened teacher-student communication, promoted learner autonomy, and established a more reciprocal form of classroom interaction.

3. Establishing the Teacher as a Supervisor and Ethicist of AI Use

Another prominent theme concerns the teacher's evolving responsibility as a moral guide and regulator of AI use in the classroom. Many teachers designed explicit activities to foster ethical awareness—such as conducting "AI ethics lessons," signing usage pledges, or showcasing model cases of responsible use (Teacher 01; Teacher 08; Teacher 9). They emphasized the importance of honesty, critical verification, and transparency in AI-assisted scientific work. For instance, one teacher explained that students are required to mark which parts of their reports were generated with AI and to articulate their own reasoning (Teacher 07). Others adopted practices like "cross-validation," "retaining AI dialogue records," and even awarding an "AI Integrity Star" to recognize responsible use (Teacher 05; Teacher 9). These efforts highlight teachers' dual roles as both facilitators of learning and supervisors of ethical conduct. By embedding integrity, verification, and reflection into AI-supported activities, teachers cultivate a classroom culture that values authenticity, responsibility, and scientific honesty in the age of intelligent technology.

4.3. RQ3: in What Ways Do AI Tools Enhance Contextualized and Authentic Learning Experiences in Science Education?

1. Simulating Diverse and Authentic Scientific Contexts Beyond Classroom Constraints

AI tools enhance contextualized and authentic learning by allowing students to experience scientific phenomena that are normally distant, risky, or beyond the limits of human perception. Teachers described that AI could recreate environments such as "polar regions, national museum, laboratories with toxic gas"

(Teacher 02, 03, 10, 11, 14), making abstract or inaccessible science content directly observable. For example, AI simulations enabled students to safely explore what would happen if "a wire is directly connected to both ends of a battery," allowing them to witness the battery "burn out" without any danger (Teacher 03). Similarly, AI virtual labs could simulate high-voltage conditions. Students could "touch a 220 V wire" in a virtual circuit and visually observe how current passes through the body, understanding the principle of electric shock through direct observation rather than verbal explanation (Teacher 9). In addition, AI can reconstruct environmental or historical conditions, such as "weather from last year or even ten years ago" (Teacher 04), to situate learning within authentic temporal and spatial contexts.

Such phenomena that occur too quickly, too slowly, or at imperceptible scales are turned into observable and interactive processes with acceleration, magnification, reverse playback etc. features of AI tools. Teachers emphasized that AI allows students to "see the chain reactions triggered by changing one factor" (Teacher 05), turning abstract dynamic systems into concrete visual experiences. These capabilities enable students to observe, interact, and understand scientific processes as evolving systems, thus fostering deeper comprehension of cause-effect relationships and enhancing conceptual realism.

2. Bridging Virtual and Real-world Practice

AI tools bridge the gap between virtual experimentation and real-world scientific practice by allowing students to practice, refine, and transfer procedural skills across settings. Teachers noted that students could "try all materials virtually first, then use real ones," which made learning "both enjoyable and clearer" (Teacher 08). Through repeated virtual practice, students became more proficient, as "their operations became more standardized" during actual lab work (Teacher 10). This integration of virtual and real contexts supports the development of practical competence while preserving the motivational and exploratory nature of learning.

The ability to experiment virtually before and after formal class time also extends students' opportunities for authentic engagement. As one teacher described, "some students would go home and continue to connect electronic components on their own," showing that AI tools "make experiments easily accessible and stimulate self-driven inquiry" (Teacher 03). This extended engagement helps students build confidence and procedural fluency, ensuring that hands-on experimentation is both more focused and more meaningful. In this way, AI acts as a pre-lab scaffold and post-lab extension, allowing learners to transition seamlessly from simulation to authentic scientific practice.

3. Connecting Scientific Knowledge with Real-life and Cross-disciplinary Contexts

AI enhances the authenticity of science learning by situating it within real-life experiences and interdisciplinary applications. Teachers highlighted that students could connect classroom knowledge with everyday contexts, such as linking a lesson on filtration to the "principle of the home water purifier," after which "stu-

dents even tried making their own with sand and charcoal" (Teacher 02). Others noted that AI helped students "discover science in life and life in science" (Teacher 04), indicating a shift from abstract conceptualization to applied understanding. This contextualization motivates students to view scientific inquiry as personally and socially relevant.

AI tools also foster cross-disciplinary integration by helping students perceive how scientific principles operate across domains. For instance, one teacher described using AI to "apply mathematical ratios to art and map scale," thereby connecting abstract math to real-world uses (Teacher 07). Another teacher noted that AI simulations allowed students to "analyze problems from multiple disciplinary perspectives," cultivating their ability to synthesize knowledge (Teacher 12). Such integration deepens authenticity by mirroring the interconnected nature of real scientific and societal issues. As a result, AI supports not only knowledge transfer across disciplines but also students' development of holistic scientific literacy grounded in lived experience.

4. The Effects of Different Types of AI tools

Analysis of the teacher responses indicates that two primary categories of AI tools are employed in science instruction: virtual lab and simulations, and generative AI applications such as intelligent tutoring systems, KIMI, and Deepseek. Rather than adopting these tools in isolation, teachers tend to integrate them strategically in accordance with their pedagogical objectives, selecting and combining them to align with the specific goals and contexts of their science lessons.

Virtual lab and simulations emphasize visualization of scientific phenomena and hands-on exploration. By engaging in AI-based virtual experiments, students can visualize abstract scientific concepts, manipulate variables, and observe outcomes in a risk-free environment. For instance, as Teacher 01 explained, virtual physics laboratories allow students to simulate complex experiments such as particle motion in magnetic fields, where they can adjust parameters like magnetic field strength or particle velocity and observe trajectory changes in real time. This makes invisible physical phenomena observable and supports students' conceptual understanding of difficult topics such as Lorentz force. Similarly, Teacher 11 noted that virtual labs can simulate chemical reactions that are too dangerous, too fast or slow, or otherwise difficult to perform in real classrooms, making it easier for students to observe and analyze reactions safely. Teacher 02 further emphasized that such tools enhance classroom interaction and inquiry motivation, helping students actively explore scientific questions through hands-on digital experimentation.

Generative AI tools serve as intelligent assistants that provide personalized guidance and learning support. Teacher 01 pointed out that AI-assisted tutoring systems can analyze students' learning data, such as common mistakes and participation levels, and deliver tailored feedback, targeted resources, and step-by-step problem-solving guidance. This individualized support enables students at different proficiency levels to progress at their own pace and improve learning

outcomes. Likewise, Teacher 11 mentioned that generative AI tools like KIMI require active student interaction through questioning and reflection, encouraging them to evaluate their experimental designs and reasoning processes. Teacher 02 added that such tools can answer scientific questions in real time and offer personalized tutoring, saving teachers' time while fostering self-directed learning. As Teacher 05 summarized, generative AI stimulates students' thinking, while virtual labs emphasize hands-on practice. Together, virtual laboratories and generative AI tools create a complementary learning ecosystem in which cognitive reasoning and experiential exploration mutually reinforce one another, thereby deepening students' conceptual understanding, enhancing inquiry competence, and fostering more integrated and autonomous science learning.

4.4. RQ4: How Do Teachers Perceive the Future Development and Application of AI in Science Education?

1. AI as a Catalyst for Immersive and Personalized Science Learning

Teachers expressed optimism that future AI applications will make science learning more immersive, interactive, and personalized. Several envisioned the integration of AR and VR technologies to simulate authentic experimental environments, enhancing students' emotional engagement and conceptual understanding. For example, Teacher 12 anticipated that AI would "provide personalized learning methods and paths" and "create immersive learning experiences" through AR and VR integration, ensuring that "more students enjoy quality science education resources." Others emphasized AI's potential to make learning more engaging and playful; Teacher 02 hoped AI could "design more interactive content, making science learning as attractive as playing games." Teachers also highlighted that AI could extend science learning beyond the classroom to diverse spaces such as homes, museums, and libraries (Teacher 13). Collectively, these perspectives suggest that teachers view AI as a transformative tool capable of deepening engagement and broadening access through interactive and adaptive learning environments.

2. Reimagining the Teacher's Role in the AI Future

Teachers envisioned that AI would reshape their professional identities, shifting their role from knowledge transmitters to facilitators of deep learning. While many appreciated that AI could take over repetitive instructional or assessment tasks, they also recognized the need to develop new competencies and maintain distinctly human qualities. As one teacher stated, "AI helps teachers undertake part of the work, but teachers must keep learning and take on higher-value roles." Several also voiced concerns about being replaced or losing authority in the AI-driven classroom. Teacher 04 noted, "We're worried about being replaced by AI—it doesn't have human emotion," while Teacher 10 warned that "students might trust AI more than teachers." These views reveal a dual perception: teachers acknowledge AI's assistance in teaching efficiency and data analytics, yet remain cautious about its emotional limitations and its potential to alter traditional

teacher-student relationships.

3. Concerns About Overreliance and the Degradation of Core Scientific Abilities

Despite their optimism, teachers consistently expressed concerns about students' overdependence on AI. Many feared that excessive reliance could weaken essential scientific skills such as independent thinking, hands-on experimentation, and problem-solving. As Teacher 07 warned, "If students rely too much on AI, they might lose the ability to think independently," and Teacher 05 added that such dependence could "weaken students' hands-on ability." Teacher 9 similarly worried that "overreliance on AI may lead to the degradation of students' autonomous problem-solving and practical skills." Others highlighted potential shifts in students' trust and authority perceptions—Teacher 10 remarked that students "might trust AI more than teachers," and Teacher 13 cautioned that "traditional scientific tools might be replaced by AI virtual laboratories." These concerns underscore teachers' awareness that, while AI can enhance learning, its unbalanced use may hinder the cultivation of inquiry-based habits and authentic scientific practice.

5. Discussion

Research using grounded theory to explore K-12 teachers' and students' experiences of science teaching and learning with AI technologies remains limited. A previous grounded study guided by Rogers' (2003) Diffusion of Innovations Theory proposed the substantive theory of "what works," highlighting that teachers' technology adoption is shaped by a continuous negotiation between internal pedagogical beliefs and external contextual demands to promote student-centered instruction. (Webster & Son, 2015). Building on this line of research, the present study extends the conversation by situating AI integration in K-12 science classrooms within the framework of Situated Learning Theory (SLT). Specifically, it examines how AI technologies influence students' learning processes and outcomes, transform classroom interaction and social construction, and shape teachers' perceptions of AI's future roles in science education.

While traditional SLT emphasizes that learning must occur within authentic contexts, later scholars have noted that this stance can be overly rigid, as learners often require initial conceptual scaffolding before meaningful participation can occur (Besar, 2018). The findings of this study align with and extend SLT by illustrating how AI tools mediate the interplay between knowledge acquisition and contextualized participation, rather than treating understanding and participation as sequential or separate. AI-supported visualization and simulation environments enable the integration of conceptual acquisition with authentic participation in scientific practice. Students are provided with conceptual entry points into modeling, testing, and reasoning, allowing them to actively engage in scientific inquiry rather than passively receive information. These environments also help lower-achieving students enter the community of practice more confidently, fos-

tering motivation, curiosity, and sustained engagement in science learning. Virtual labs, in particular, allow students to rehearse and refine scientific practices in safe, flexible, and repeatable environments that approximate real-world laboratory contexts. Through iterative experimentation, students develop procedural fluency and transferable skills, illustrating a clear movement from knowledge acquisition to meaningful participation.

Moreover, AI-enabled environments extend learning beyond the physical classroom, supporting both pre-lab preparation and post-lab exploration. In this way, virtual labs expand the boundaries of situated learning, allowing students to engage authentically across formal and informal settings. This boundary-crossing potential helps students connect scientific knowledge across disciplinary and everyday contexts, promoting the integration of school-based learning with real-world applications. By simulating distant, hazardous, or imperceptible phenomena, AI technologies allow learners to transcend the physical and temporal limits of school learning, thereby deepening their participation in the broader, situated realities of science.

This study further adds to those that have previously explored identity formation participation within communities of practice among students. Orsmond et al. (2022) conceptualized Professional Identity Formation (PIF) as a non-linear process supported by reflection-in-action and increasing relational participation within clinical settings, while Tal-Saban et al. (2024) demonstrated that early engagement in a tutoring community strengthened participants' sense of belonging and professional identity. Similarly, the present findings show that AI tools in K-12 science classrooms can facilitate parallel trajectories of identity development and collective participation. Through virtual interaction, low-risk experimentation, and reflective iteration, students transitioned from peripheral observers to active scientific participants, developing ownership, confidence, and a sense of belonging to the scientific community. Moreover, AI-supported collaborative inquiry enabled mutual engagement and shared meaning-making, as students negotiated, questioned, and co-constructed understanding around AI-generated data. Together, these findings suggests that AI-supported environments can serve as digital communities of practice, where participation, reflection, and iterative engagement with low risk (whether in individual or collaborative form) collectively nurture the formation of scientific learner identities.

In addition, the findings clearly illustrate that teachers are transitioning from being mere instructors to assuming a broader array of roles. Prior research that conceptualizes STEM teacher identity as dynamic, socially situated, and reconstructed through practice and participation (Zhai et al., 2024). Similar to teachers in Zhai et al.'s work, participants in this study enacted new professional identities through their interaction with AI tools—moving from knowledge transmitters to facilitators, co-investigators, and ethical supervisors. This shift represents both performative identity work (changing what they do in classrooms) and discursive identity work (repositioning themselves as moral and epistemic guides in the use

of AI). Consistent with Parker and Lehn's (2024) study of the SABES project, which showed how community engagement fostered justice-oriented and student-centered teaching identities, this study reveals that technological mediation can similarly serve as a catalyst for identity transformation. However, unlike previous studies focused on professional communities, AI integration offered teachers a new arena for negotiating their roles, values, and agency. Their reflections, balancing optimism about AI's affordances with concerns about being replaced, illustrate that teachers see the need for continuous learning and for cultivating uniquely human, higher-value roles that cannot be replicated by AI.

5.1. Contribution to Situated Learning Theory by the Findings

The present study extends the conversation by situating AI integration in K-12 science classrooms within the framework of Situated Learning Theory (SLT). Specifically, it examines how AI technologies influence students' learning processes and outcomes, transform classroom interaction and social construction, and shape teachers' perceptions of AI's future roles in science education. While traditional SLT emphasizes that learning must occur within authentic contexts, later scholars have noted that this stance can be overly rigid, as learners often require initial conceptual scaffolding before meaningful participation can occur (Besar, 2018). The findings of this study align with and extend SLT by illustrating how AI tools mediate the interplay between knowledge acquisition and contextualized participation, rather than treating understanding and participation as sequential or separate. AI-supported visualization and simulation environments enable the integration of conceptual acquisition with authentic participation in scientific practice. Students are provided with conceptual entry points into modeling, testing, and reasoning, allowing them to actively engage in scientific inquiry rather than passively receive information. These environments also help lower-achieving students enter the community of practice more confidently, fostering motivation, curiosity, and sustained engagement in science learning. Virtual labs in particular, allow students to rehearse and refine scientific practices in safe, flexible, and repeatable environments that approximate real-world laboratory contexts. Through iterative experimentation, students develop procedural fluency and transferable skills, illustrating a clear movement from knowledge acquisition to meaningful participation.

5.2. Practical Contribution

The findings offer practical insights for educators and policymakers—particularly within the Chinese educational context, where high-stakes examinations shape teachers' perceptions and adoption of AI tools. Teachers in the present study often framed AI as a mechanism to improve efficiency and raise academic performance—reflecting China's culturally rooted emphasis on academic achievement and measurable outcomes (Zhang & Muhammad, 2025). At the same time, many teachers reveal AI's value in supporting inquiry-based learning and experimenta-

tion—aligning with recent national reforms encouraging competency-based and innovative science education. Not only did national rhetoric about AI as a driver of future competitiveness encourage teachers to experiment with AI, but it also compelled them to remain wary of excessive reliance, authenticity concerns, and ethical responsibilities. Teachers' interest in adopting AI technologies is shaped through a sociocultural lens—guided by educational goals and simultaneously reinforced by policy momentum, collective social values, and a high-stakes testing environment. Recognizing these influences is essential for understanding the transferability of findings to other educational systems.

6. Limitations and Future Research

As with all qualitative studies, this one has several limitations that requires consideration. First, the student participants represented a wide range of grade levels, from elementary to high school. As a result, their conceptual development, curricular focus, and learning goals likely differed substantially across contexts. Future studies may benefit from narrowing the grade range or conducting comparative analyses across educational levels to better capture developmental differences in AI-supported science learning.

Second, students' opportunities to interact with AI and related technologies varied considerably. This study did not specifically investigate whether all students engaged with AI tools individually, collaboratively, or as a whole class, nor did it account for the frequency or duration of use. Consequently, disparities in technological mastery may have influenced students' learning processes and outcomes. Subsequent research could adopt a more systematic design to document variations in access, use mode, and frequency of AI engagement.

Third, the teacher participants were recruited via Red, a social media platform whose user base is predominantly younger adults. This recruitment channel may have introduced a generational bias, as these teachers were relatively younger and potentially more open to technology adoption than the broader population of STEM educators. Future research could incorporate more diverse teacher demographics to enhance representativeness.

Finally, teachers' responses reflected disparate experiences with AI tools. Some primarily utilized generative AI applications, others focused on virtual labs or simulation, while a few integrated both. This variation limited the comparability of their experiences and interpretations. Future studies might consider differentiating between AI tool types to explore how distinct affordances contribute to students' science learning and teachers' pedagogical adaptation.

7. Conclusion

This study sought to examine how AI technologies, analyzed with the principles of SLT, transform students' learning processes and outcomes, reshape classroom interaction and social construction, and influence teachers' perceptions of science education. By grounding AI integration within SLT, the study progresses from

descriptive accounts of AI's potential to offer theoretical insight into how AI functions as a mediational tool that bridges conceptual understanding with authentic participation in scientific practices.

Findings supported and extended key propositions of SLT. AI-enabled visualizations and simulations facilitated the transition from knowledge acquisition to meaningful participation, helping students develop higher-order inquiry skills, confidence, and scientific identity. Furthermore, AI fostered collaborative learning communities where students and teachers jointly constructed knowledge and negotiated shared meaning around AI-generated data. These findings also highlight AI's capacity to extend the boundaries of situated learning, allowing learners to connect school-based inquiry with real-world and interdisciplinary contexts that transcend the limits of time, space, and safety in traditional classrooms.

The study additionally contributes to emerging research on teacher identity in technology-mediated environments. Teachers in this study redefined their professional roles from knowledge transmitters to facilitators, co-investigators, and ethical supervisors of AI use. While expressing optimism about AI's potential to enhance engagement and personalization, teachers also voiced concerns about overreliance on automation and the erosion of core scientific abilities. Their reflections underscore the need for ongoing professional learning and for cultivating human capacities that cannot be replicated by AI, such as ethical judgment, empathy, and creativity.

To summarize, these findings suggest that AI technologies, when implemented with theoretical grounding and pedagogical intent, can serve as powerful tools for enacting situated and authentic science learning. They also point to the importance of sustained teacher development and ethical reflection in ensuring that AI enriches rather than replaces the human dimensions of teaching and learning.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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