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An Examination of Science Teachers' Views, Uses, and Pedagogical Approaches Regarding Artificial Intelligence Technologies

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Abstract

The purpose of this study is to examine science teachers' views on artificial intelligence (AI) technologies, their areas of use, and their pedagogical approaches. Conducted within a qualitative research design, the study involved semi-structured interviews with 24 science teachers from different educational levels, selected through maximum variation sampling. The collected data were analyzed using thematic analysis. The findings indicate that the majority of teachers perceive AI tools as practical and time-saving resources, particularly for content creation, lesson planning, presentation preparation, and assessment processes. The study reveals notable differences in teachers' experiences with AI tools, usage patterns, integration practices, and ethical awareness depending on their educational levels. Specifically, as teachers' educational levels increase, greater diversity in AI use, deeper pedagogical integration, and a more critical perspective toward AI technologies emerge. These findings suggest that in-service professional development programs for science teachers should be differentiated according to teachers' educational levels. In particular, teachers holding undergraduate degrees and non-thesis master's degrees require more intensive support to enhance the pedagogical integration of AI technologies.

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Introduction

Artificial intelligence (AI) is widely recognized as one of the most significant technological developments of the 21st century due to its capacity to perform cognitive tasks that typically require human intelligence, such as learning, reasoning, problem solving, decision-making, creativity, and autonomy (Norvig & Russell, 2020). In recent years, AI applications have become a major focus in the field of education because of their potential to transform traditional learning, teaching, and assessment processes (Abualrob, 2025; Adli, 2024; Al-Huwail et al., 2025; Alkanaan, 2022; Barsoum et al., 2022; Zhang & Aslan, 2021). The rapid growth of generative AI in education has been particularly driven by the proliferation of large language models such as ChatGPT, Claude, and Gemini (Ishmuradova et al., 2025; Michel-Villarreal et al., 2023; Su & Yang, 2023). These systems offer significant opportunities for teachers to create personalized and interactive learning environments by supporting content generation, optimizing time management, facilitating individualized learning, providing personalized feedback, and enabling automated assessment (Baidoo-Anu & Owusu Ansah, 2023; Michel-Villarreal et al., 2023; Su & Yang, 2023). However, concerns related to accuracy, reliability, bias, academic dishonesty, plagiarism, privacy, security, and ethical issues remain central to ongoing debates regarding the use of AI technologies in education (Alasadi & Baiz, 2023; Michel-Villarreal et al., 2023; Su & Yang, 2023). Recent qualitative research further emphasizes that AI should be conceptualized as an instructional support tool rather than a replacement for teachers, highlighting the irreplaceable human dimensions of empathy, mentorship, and ethical guidance in educational contexts (Jesus & Caumeran, 2026).

These transformations are particularly evident in science education where AI tools are increasingly becoming integral to scientific practices such as posing questions, generating hypotheses, designing experiments, collecting, analyzing, and interpreting data (Erduran & Levrini, 2024). Recent systematic reviews indicate that research on AI in science education has grown substantially, especially in areas including educational robotics, data mining, machine learning, intelligent tutoring systems, and automation (Jia et al., 2024). AI technologies have the potential to enrich science teaching by enabling the design of interactive learning environments and the modeling of experiments in virtual settings, which can enhance students' engagement, motivation, academic achievement, problem-solving abilities, and critical thinking skills (Barsoum et al., 2022; Joseph, 2023; Nugroho et al., 2024). Nevertheless, studies report that science teachers face multiple challenges, such as limited access to technological resources, the complexity of AI tools, insufficient professional development opportunities, and ethical concerns related to privacy, bias, data protection, and appropriate use in educational contexts (Adli, 2024; Nugroho et al., 2024). Accordingly, there is a clear need to support teachers in realizing the pedagogical potential of AI in science education and overcoming these barriers through targeted professional development programs, practical guidelines, and ethically grounded frameworks aligned with instructional goals (Alshorman, 2024; Nazaretsky et al., 2022; Nugroho et al., 2024; Ayasrah et al., 2023).

Teachers' perceptions of AI, their levels of enthusiasm, and their pedagogical competencies are among the key determinants of effective AI integration in educational settings (Abualrob, 2025). Yau et al. (2023) emphasized the importance of examining teachers' conceptions of AI education to inform instructional design and classroom implementation, thereby enhancing teachers' competence in teaching with AI. Moreover, teachers' acceptance of

AI in classrooms has been associated with perceived usefulness, ease of use, attitudes, self-efficacy, and behavioral intentions (Al Darayseh, 2023; Guo et al., 2024). Recent studies further suggest the need for education-specific AI acceptance models that account for factors unique to subject-specific integration (Nugroho et al., 2024; Sanusi et al., 2023; Xue et al., 2025).

Overall, the integration of AI into education represents a multifaceted process shaped by teachers' pedagogical knowledge, attitudes, and access to technological resources. Despite the growing body of research, there remains limited qualitative evidence regarding how science teachers perceive AI technologies, how they use them in instructional contexts, and which pedagogical strategies they employ in practice. Existing studies have predominantly relied on quantitative methods to examine teachers' attitudes and acceptance of AI (e.g., Al Darayseh, 2023; Çolak Yazıcı & Erkoç, 2024). To address this gap, the present study adopts a qualitative perspective to explore science teachers' experiences with AI and to examine variations in AI use across different educational levels. By providing a comprehensive understanding of science teachers' perceptions, usage practices, and perceived barriers, this study aims to inform teacher education programs, policy development, and classroom practices. This study contributes to the literature by demonstrating how science teachers' educational backgrounds shape not only their acceptance of AI, but also the depth, purpose, and ethical framing of its pedagogical integration. Accordingly, the study seeks to answer the following research question:

> *What are science teachers' perceptions of artificial intelligence technologies, how do they use these technologies in educational settings, and how do these usage patterns differ according to teachers' educational levels?*

Method

Research Design

This qualitative research study employed a case study design in which the researcher intentionally examined situations relevant to the investigated phenomenon within a real-life context (Yin, 2018). The study was designed as an embedded single-case study to explore science teachers' views on artificial intelligence technologies, usage practices, and pedagogical approaches.

The case was bounded by science teachers' experiences with AI technologies within secondary school contexts in a single province in Türkiye. In this case study, the case and the main unit of analysis were science teachers' experiences with artificial intelligence technologies, while the embedded units of analysis were the teachers' educational levels (undergraduate, non-thesis master's, thesis-based master's, and doctoral).

Participants

The study group consisted of 24 science teachers who had experience using artificial intelligence in education and were working in different public and private secondary schools in a province in the western region of Türkiye. Participants were selected from different educational levels (undergraduate, non-thesis master's, thesis-based master's, and doctoral) through maximum variation sampling. This sampling method enables the collection of rich and multidimensional data by selecting participants based on criteria that reflect differences related to the phenomenon under investigation. Accordingly, it allows for an in-depth understanding of contextual similarities and differences by revealing common and divergent themes across diverse participant profiles (Yıldırım & Şimşek, 2022). Table 1 presents the demographic characteristics of the study group.

Table 1. The Demographic Background of the Participants

Teacher	Education qualification	Gender	Participation in AI training	Teaching experience (in years)	Type of school
T1	Non-thesis master’s	M	-	23	Public
T2	Bachelor	F	Received training	12	Public
T3	Bachelor	F	-	12	Public
T4	Non-thesis master’s	F	-	14	Public
T5	Non-thesis master’s	F	-	18	Public
T6	Doctoral	M	-	18	Public
T7	Bachelor	M	-	18	Public
T8	Thesis-based master’s	M	-	21	Public
T9	Thesis-based master’s	F	Received training	17	Public
T10	Thesis-based master’s	F	Received training	6	Public
T11	Doctoral	F	-	12	Public
T12	Thesis-based master’s	F	Received training	8	Private
T13	Thesis-based master’s	F	Received training	1	Private
T14	Bachelor	M	Received training	20	Public
T 15	Thesis-based master’s	F	-	1	Private
T16	Bachelor	M	-	8	Public
T17	Thesis-based master’s	F	-	1	Private
T18	Doctoral	F	Received training	1	Private
T19	Doctoral	M	-	29	Public
T20	Non-thesis master’s	M	-	21	Public
T21	Doctoral	F	Received training	20	Private
T22	Doctoral	F	Received training	15	Public
T23	Doctoral	M	-	20	Public
T24	Thesis-based master’s	F	Received training	13	Public

Fifteen participants (62.5%) were male and nine (37.5%) were female. The teachers held different academic qualifications in science education, including a bachelor’s degree (five teachers), a thesis-based master’s degree (eight teachers), a non-thesis master’s degree (four teachers), and a doctoral degree (seven teachers). Ten of the participants had received training related to artificial intelligence through various courses or projects. The teachers’ professional experience ranged from 1 to 29 years; eighteen teachers were employed in public schools, while six worked in private schools. To ensure participant confidentiality, teachers were coded using the letter

"T" followed by a number (e.g., T1).

Data Collection

A semi-structured interview form consisting of 12 open-ended questions was used as the data collection tool. The interview form was developed by the researchers. The draft form was first reviewed by academicians specializing in science education, and revisions were made based on their feedback. Subsequently, the revised form was pilot-tested with a science teacher who was not included in the study group to ensure clarity and comprehensibility, and the form was finalized accordingly. Individual face-to-face interviews were conducted with all participants, each lasting approximately 25–35 minutes. The interviews were audio-recorded with participants' consent and later transcribed verbatim for analysis.

Data Analysis

The qualitative data obtained within the scope of the study were analyzed based on the thematic analysis approach proposed by Braun and Clarke (2006). Accordingly, the data collected through semi-structured interviews were first transcribed verbatim and independently read by the researchers. Subsequently, meaningful units of data were identified and initial codes were generated. Similar codes were then grouped together to form themes; these themes were reviewed to ensure internal consistency, and the researchers met to calculate the percentage of agreement among themes in order to reach the final results. In the final stage of the analysis, the identified themes were reported and supported by direct quotations from the participants.

Trustworthiness of the Study

To ensure the trustworthiness of the qualitative findings, the criteria proposed by Lincoln and Guba as credibility, dependability, confirmability, and transferability were systematically addressed throughout the research process. (Lincoln & Guba, 1985).

Credibility was enhanced through prolonged engagement with the data and the use of rich, verbatim quotations from participants to support the identified themes. In addition, the semi-structured interview form was reviewed by experts in science education and pilot-tested with a science teacher who was not included in the study group to ensure the clarity and relevance of the questions. These strategies helped ensure that the findings accurately reflected participants' perspectives.

Dependability was ensured by clearly documenting each stage of the research process, including data collection, coding, and theme development. Two researchers involved in the study independently coded the interview transcripts, and inter-coder reliability was calculated using the formula agreement / (agreement + disagreement) × 100. The resulting agreement rate of 92% indicates a high level of consistency in the coding process and supports the dependability of the analysis.

Confirmability was addressed by minimizing researcher bias through collaborative analysis and researcher consensus. The researchers engaged in regular discussions to compare codes and themes and to resolve discrepancies. Furthermore, the use of direct participant quotations allows readers to trace the findings back to the original data, thereby strengthening the objectivity of the interpretations.

Transferability was supported by providing a detailed description of the research context, purposeful sampling, participant characteristics, and data collection procedures. By presenting rich contextual information about the study group and educational setting, readers are enabled to judge the applicability of the findings to similar contexts.

Results

This section presents the findings of the study within the logic of a qualitative case study, focusing on both shared patterns across participants and variations that emerged in relation to science teachers' views, usage practices, and pedagogical approaches to artificial intelligence. Consistent with a pattern–variation analytic approach, the findings first highlight dominant trends observed across the case and then document meaningful differences in teachers' experiences and practices. All findings are grounded in the thematic analysis and supported by direct quotations from the participants.

Pattern–Variation Findings on Science Teachers' Views, Usage Practices, and Pedagogical Approaches Toward Artificial Intelligence

Theme 1: Perceptions and Definitions of Artificial Intelligence

A clear shared pattern emerged in teachers' conceptualizations of artificial intelligence. Twenty- one out of 24 teachers consistently described artificial intelligence as a tool that enables rapid access to information, facilitates instructional tasks, and functions as a digital assistant. This dominant perception reflects a common understanding of AI as a supportive and efficiency-enhancing technology. Even the fact that the other three teachers reported an initial sense of prejudice or skepticism toward artificial intelligence noted that their perceptions positively shifted over time as they gained practical experience with AI tools.

> *"It reminds me of points I might overlook; it is almost like an assistant." (T19)*
> *"Talking to ChatGPT sometimes feels easier than asking a question to a person." (T24)*
> *"Instead of searching for sources on the internet, I ask ChatGPT directly and organize the information in a much shorter time." (T3)*
> *"To me, artificial intelligence is an intelligent consultant. I feel as if it understands me." (T20)*

Theme 2: The Use of Artificial Intelligence in Science Education

Across the case, a strong pattern of positive orientation toward the use of artificial intelligence in science education was identified. All teachers stated that AI is beneficial for science teaching. Eighteen teachers described direct classroom-related uses, including lesson planning, activity design, virtual experiments, presentation preparation, and content development. In contrast, a variation was observed among six teachers who emphasized the potential or anticipated benefits of AI rather than reporting direct classroom implementation, indicating differing levels of practical engagement.

> *"We do not have a laboratory, but I can conduct virtual experiments using artificial intelligence." (T6)*
> *"While teaching the topic of acid rain, I prepared a scenario with ChatGPT and conducted a drama activity." (T14)*
> *"I used to struggle to connect science topics with everyday life for my students. With the help of artificial intelligence, I linked science concepts to current, real-life examples." (T10)*

Theme 3: Use of Artificial Intelligence Tools

A highly consistent usage pattern emerged with respect to AI tools. All teachers reported being familiar with and actively using ChatGPT, indicating its central role within the case. Beyond this commonality, tool diversity varied among participants: 14 teachers used Canva, nine used MagicSchool, six used Gamma App, and five used Playground, alongside other AI-supported tools.

> *"We prepare posters using Canva's AI-supported templates." (T8)*
> *"I prepare presentations suitable for science experiments with Gamma App, and students show greater interest." (T13)*
> *"I create short quizzes using Magic School. It is particularly practical for assessment purposes." (T24)*

Theme 4: Positive Aspects of Artificial Intelligence

A dominant pattern of perceived benefits was evident across the case. Twenty-two teachers emphasized AI's time-saving nature, its contribution to productivity, and its ability to capture students' attention. These perceptions were shared across different school contexts and experience levels.

> *"You no longer spend hours writing lesson plans; a framework is generated almost immediately." (T19)*
> *"When preparing presentations, I do not deal with the design; I write the topic, and the rest follows." (T11)*
> *"When technology is used, students participate more actively in the lesson, and their attention increases." (T7)*

Theme 5: Negative Aspects of Artificial Intelligence from the Perspective of Students

Alongside positive perceptions, a strong shared concern pattern emerged regarding potential negative effects of AI on students. Twenty-two teachers reported risks such as students' tendency to take shortcuts, reduced creative thinking, loss of writing habits, and concerns about information accuracy.

> *"They no longer want to write because they can have everything written by artificial intelligence." (T24)*
> *"They do not question whether the given answer is correct; they accept it as it is." (T2)*
> *"They were already unmotivated, and now they tend to take even more shortcuts." (T5)*

Theme 6: Need for Training and Competency Development

Teachers' accounts revealed a pattern–variation structure regarding professional development. Ten teachers reported having received AI-related training; however, five of them considered this training insufficient. In contrast, a larger group of 15 teachers consistently expressed the need for more comprehensive, practice-oriented, and long-term professional development opportunities.

> *"Even learning how to write effective prompts takes time." (T19)*
> *"Superficial introductions were provided, but we need longer training for real-world use." (T24)*
> *"I learned some tools, but I do not know which purposes they are suitable for." (T4)*

Theme 7: Ethical Concerns

Ethical issues constituted another prominent shared pattern. Eighteen teachers raised concerns related to plagiarism, misinformation, and academic integrity, while nine teachers specifically emphasized the importance of verifying the accuracy of AI-generated content in students' assignments.

> *"ChatGPT sometimes provides incorrect information about books." (T24)*
> *"Without teaching how to cite sources, students become accustomed to ready-made information." (T22)*
> *"The student did not write it themselves but directly copied the output generated by artificial intelligence. This is a serious issue." (T1)*

Theme 8: Advanced and Reflective AI-Based Instructional Practices

Most teachers (n = 20) reported active experiential use of AI for lesson planning, question generation, STEM scenario design, and instructional activities. A smaller group of four teachers represented a variation, using AI tools primarily for informational purposes rather than instructional design.

> *"I offered students project ideas generated with artificial intelligence, and much more creative ideas emerged." (T23)*
> *"I have ChatGPT review my STEM plans. It draws attention to my shortcomings." (T10)*
> *"When designing exam questions, I take AI-supported test analyses into account." (T6)*

Theme 9: Student Guidance and Teacher-Imposed Limitations

A partial pattern emerged regarding student guidance. Sixteen teachers reported guiding students or setting specific rules for AI use, whereas eight teachers indicated that they had not yet developed a systematic approach, reflecting variation in regulatory practices within the case.

> *"In some assignments, I specifically require students to use artificial intelligence, but I emphasize ethical boundaries." (T18)*
> *"I recommend that they use Canva or Magic School, but I always ask them to interpret and comment on the generated content." (T9)*
> *"I have not set formal rules, but I frequently explain how to use it appropriately." (T17)*

Theme 10: Technical Limitations and School Resources

Finally, a strong contextual pattern emerged regarding infrastructural constraints. Nineteen teachers identified limited technical infrastructure—such as inadequate internet access, lack of devices, insufficient software, and hardware limitations—as primary barriers to classroom integration of artificial intelligence.

> *"We do not have a laboratory; the library has been converted into a classroom. My only resource is the interactive whiteboard." (T24)*
> *"My classroom is in the basement, and there is no internet access. I cannot even deliver presentations." (T12)*
> *"There are no computers at the school, so I use my personal laptop." (T15)*

Findings Based on Science Teachers' Views on Artificial Intelligence According to Their Educational Levels

Based on the findings obtained from the study, science teachers' views on artificial intelligence technologies, their use of AI, and their pedagogical approaches were analyzed according to their educational levels. The results of this analysis are presented in Table 2.

Table 2. Findings on Science Teachers' Views on Artificial Intelligence according to Educational Level

Educational Level	Positive Aspects	Negative Aspects	Direct Quotations
Doctorate	Concretizing abstract concepts, STEM integration, virtual laboratories, time efficiency	Source reliability, plagiarism, decline in students' thinking skills	"I use GitHub Copilot to analyze my project codes and employ artificial intelligence for error checking in STEM scenarios." (T23) "ChatGPT sometimes provides fabricated references… I told it 'this source does not exist,' and it replied, 'I might have made it up." (T6) "Lesson plans, assessment forms, project proposals… I create all of them with ChatGPT and then make the final adjustments myself." (T19)

Educational Level	Positive Aspects	Negative Aspects	Direct Quotations
Thesis-Based Master's	Rapid access to information, visual support, ease of lesson preparation	Ethical issues, reliance on ready-made information, reduced learning permanence	"When preparing lesson plans, I ask ChatGPT and then blend the output with my own knowledge." (T10) "I see it as a kind of secretary; I ask whatever comes to my mind." (T13) "Preparing instructions for a laboratory activity used to take one or two hours; now I have it prepared in five minutes." (T12) "My daughter, who is in middle school, has ChatGPT do her homework; it prevents her from thinking." (T9)
Non-Thesis Master's	Practicality, speed, visualization of abstract concepts	Tendency toward overreliance, ethical risks, information reliability	"I tried ChatGPT only to get ideas, but I could not fully trust it." (T20) "It creates an environment that makes life easier and allows us to allocate time for ourselves." (T4) "ChatGPT offered me 30 different project ideas, most of which would never have occurred to me." (T1) "Because ChatGPT thinks of everything, we stop thinking ourselves." (T5)
Undergraduate	Time-saving, practical source of information, increased student engagement	Superficial learning, reduced creativity, plagiarism concerns	"I use it to get ideas for projects; you enter the topic and duration, and it suggests ideas." (Teacher 2) "It completes a two- or three-hour task in 10 to 15 minutes." (T14) "We do not have a laboratory, so we cannot conduct experiments. At least I want visuals that offer an almost real experimental environment, like animations." (T7) "Receiving ready-made files is another version of plagiarism; submitting a file without contributing anything is a complicated issue." (T14)

The findings obtained through purposive sampling indicate clear differences in science teachers' perceptions of artificial intelligence, usage practices, and levels of pedagogical integration according to their educational backgrounds. Teachers holding doctoral degrees demonstrate advanced and creative integration of artificial intelligence by employing it not only for content generation but also in STEM projects, algorithm analysis, and interdisciplinary applications. Teachers with thesis-based master's degrees tend to conceptualize artificial intelligence as a secretary or assistant and adapt the generated content to their lessons after filtering it through a pedagogical lens. In contrast, teachers with non-thesis master's degrees primarily use artificial intelligence at a more surface level during individual preparation stages, and their classroom integration remains limited due to insufficient knowledge and experience. Teachers holding undergraduate degrees predominantly perceive artificial intelligence as a time-saving and practical source of information; however, due to limited awareness of tool diversity, their use of artificial intelligence is largely confined to pre-lesson preparation processes.

Discussion and Conclusion

This study examined science teachers' views, usage experiences, and pedagogical approaches toward artificial intelligence (AI) technologies through an in-depth thematic analysis. Overall, the findings indicate that science teachers predominantly perceive AI as a practical and time-saving resource that supports instructional preparation and efficiency. Rather than positioning AI solely as a content-generation tool, teachers described its use as enhancing productivity in lesson planning, presentation development, and assessment processes. In particular, the widespread and frequent use of ChatGPT across all teacher groups suggests that generative AI functions as a pedagogical productivity amplifier in science education. This finding aligns with prior research demonstrating that AI-supported tools can facilitate instructional design, assessment practices, and differentiated learning while contributing to teachers' professional development (Baidoo-Anu & Owusu Ansah, 2023; Kasneci et al., 2023; Shi et al., 2024).

A key contribution of this study lies in revealing that both the variety of AI tools used and the purposes for which they are employed differ substantially according to teachers' educational levels. Teachers holding doctoral degrees demonstrated advanced and creative integration by employing AI not only for instructional preparation but also in STEM projects, algorithm analysis, interdisciplinary applications, and assessment processes. In contrast, teachers with master's degrees tended to focus on pedagogically filtering and adapting AI-generated content, while non-thesis master's and undergraduate teachers primarily used AI for individual preparation and time-saving purposes. These findings suggest that educational level is a critical factor shaping teachers' AI competence, pedagogical confidence, and integration depth. This interpretation is consistent with Alshorman's (2024) findings, which associate higher educational attainment with greater readiness for AI integration in science teaching.

Beyond tool diversity, the findings indicate that teachers' educational backgrounds also influence how AI is positioned pedagogically. Teachers with higher academic qualifications were more likely to conceptualize AI as a pedagogical partner that supports inquiry-based learning, STEM integration, and reflective instructional design. Conversely, teachers with lower qualifications tended to view AI as a supplementary or extracurricular support tool rather than an integral component of classroom pedagogy. This distinction mirrors Shi's et al. (2024) observation that teachers' pedagogical orientations shape whether AI is perceived as a collaborator or merely a technical aid. From this perspective, the study highlights that insufficient pedagogical framing may limit teachers' ability to recognize AI's instructional potential beyond efficiency gains.

Ethical awareness and student guidance emerged as another dimension differentiating teachers by educational level. Teachers with doctoral and thesis-based master's degrees reported adopting more systematic approaches to guiding students' AI use and establishing ethical boundaries. These teachers demonstrated heightened sensitivity to issues such as data privacy, plagiarism, and information reliability, suggesting that ethical reasoning operates as a regulatory mechanism rather than a barrier to AI integration. This finding supports Guo et al. (2024), who noted that higher ethical awareness encourages more cautious and reflective technology use. Accordingly, the results imply that advancing teachers' AI literacy should encompass not only technical skills but also ethical judgment and critical evaluation capacities. These findings are consistent with Jesus and Caumeran (2026), who argue that ethical awareness, teacher agency, and human-centered pedagogy are critical in preventing AI from undermining professional judgment and relational teaching practices.

Despite differences in educational background, teachers across all groups expressed concern about students' uncritical reliance on AI as a ready-made source of information. Participants highlighted risks related to diminished critical thinking, loss of originality, and weakened writing habits, echoing prior studies that emphasize data privacy and academic integrity as central ethical challenges in AI-supported education (Ahmed et al., 2024; Alshorman, 2024). The concerns expressed by science teachers regarding students' overreliance on AI and the decline in critical thinking skills are consistent with findings reported in studies conducted with pre-service teachers, where excessive dependence on generative AI and ethical challenges were highlighted as major risks (Espino, 2025).

Finally, the findings indicate that structural and institutional barriers—such as limited technical infrastructure, insufficient training opportunities, and lack of time—continue to constrain effective classroom integration of AI technologies. While some teachers reported attempting to overcome these barriers through self-directed learning or external training, others lacked access to systematic professional support. This pattern reinforces previous research emphasizing the need for sustained, practice-oriented professional development programs to foster trust, competence, and pedagogical confidence in AI integration (Nazaretsky et al., 2022; Çolak Yazıcı & Erkoç, 2024). Similarly, in the study conducted by Akanzire et al. (2025) with teacher educators who accepted the potential benefits of artificial intelligence in terms of improving students' success, engagement, and communication in educational settings, but it is emphasized that more training and professional support is needed for technology integration. This finding indicated that it is essential to consider the role of teachers in realizing AI's potential and identifying effective strategies for transforming new technologies into their classroom (Panjani & Mudgal, 2024). Consistent with these findings, prior research has shown that the effectiveness of AI-based educational systems is strongly influenced by technological infrastructure, teachers' readiness, and students' digital literacy levels, which may then constrain equitable implementation (Alenezi, 2024). The findings indicate that teachers' engagement with AI technologies is shaped not only by access and attitudes but also by educational background, pedagogical orientation, and ethical awareness. Despite these differences, structural and institutional barriers—such as limited technical infrastructure, insufficient training opportunities, and lack of time—continue to constrain effective classroom integration of AI technologies. These findings are consistent with prior research indicating that teachers' familiarity and experience with AI tools are associated with more positive attitudes toward classroom integration, while ethical concerns and infrastructural limitations continue to hinder effective implementation (Škobo & Šović, 2025).

By moving beyond technology acceptance models that primarily emphasize perceived usefulness and ease of use, the findings extend existing frameworks by highlighting the role of academic capital in explaining qualitative differences in how AI is pedagogically conceptualized and enacted in classroom practice. In summary, this study demonstrates that science teachers' engagement with AI technologies is shaped not only by access and attitudes but also by educational background, pedagogical orientation, and ethical awareness. While teachers widely acknowledge the instructional potential of AI, realizing this potential requires differentiated professional development that integrates pedagogical, ethical, and disciplinary perspectives. By conceptualizing science teachers' AI engagement as a bounded case shaped by educational level, this study provides case-based insights that can inform similar contexts. Supporting teachers in this way is essential for transforming AI from a productivity tool into a meaningful pedagogical resource in science education.

Limitations and Recommendations

This research revealed that science teachers' educational levels are associated with differences in their experiences with artificial intelligence (AI) tools, levels of pedagogical integration, and ethical awareness. However, several limitations should be acknowledged to appropriately contextualize the scope and interpretation of the findings.

First, this study is qualitative in nature. As is typical of qualitative research, the findings are not intended to be statistically generalizable but rather transferable to similar educational contexts. Accordingly, the results of this study are transferable within the context of Türkiye, based on in-depth interview data obtained from 24 in-service science teachers with diverse educational backgrounds, professional experiences, and demographic characteristics.

Second, the findings rely solely on teachers' self-reported perceptions collected through interviews. As such, discrepancies may exist between teachers' expressed views and their actual classroom practices. Future studies could benefit from incorporating additional data sources—such as classroom observations, reflective diaries, student artifacts, worksheets, or quantitative instruments—to triangulate the data and provide a more comprehensive understanding of AI integration in educational settings.

Third, the study sample consisted exclusively of science teachers. While this focus allowed for an in-depth examination within a specific disciplinary context, future research should include teachers from both technical and non-technical subject areas to enable cross-disciplinary comparisons and to better understand how AI integration varies across different fields of teaching.

Beyond these limitations, the findings highlight important implications for practice. For AI-supported education to be sustainable and pedagogically meaningful, teachers should be positioned not merely as users of technology but as pedagogical leaders who design, guide, and critically evaluate instructional content in collaboration with AI tools. In this regard, teachers should be supported not only in technical competencies but also in ethical reasoning, pedagogical decision-making, and content knowledge.

As striking findings of the study indicate that as teachers' educational levels increase, the diversity of artificial intelligence use, the depth of pedagogical integration, and the level of critical perspective toward AI technologies also increase. This suggests that in-service professional development programs for science teachers should be differentiated according to teachers' educational levels. In particular, providing more intensive support for teachers at the undergraduate and non-thesis master's levels is crucial for strengthening the pedagogical integration of artificial intelligence in science education.

Teacher education programs should therefore extend beyond tool-oriented training to include critical thinking, ethical awareness, information literacy, and interdisciplinary integration skills. In addition, practical, long-term, and field-oriented in-service professional development programs should be developed to support teachers in the pedagogical application of AI technologies. At the institutional level, schools should strengthen their technical infrastructure by ensuring reliable internet access, adequate hardware, and access to licensed software. Furthermore, students should be guided toward the ethical use of AI technologies, the critical evaluation of information sources, and the development of digital responsibility. Finally, teachers' attitudes toward technology, professional development needs, and AI usage practices should be periodically assessed, and data-informed teacher education strategies should be designed accordingly.

Statements and Declarations

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During the preparation of this article, the authors did not use ChatGPT.

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