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Opinions of Science Teachers Trained at the MoNE Academy on the Necessity of Digital Skills for Artificial Intelligence Applications in Education

Merve Dilara Unal

Necmettin Erbakan University

Serpil Kara

Necmettin Erbakan University

Abstract: The purpose of this study is to examine the views of science teachers enrolled in the MoNE Academy regarding the use of artificial intelligence (AI) in education. Conducted using a phenomenological design—one of the qualitative research methods—the study’s sample consisted of four science teachers selected through purposive sampling. Data were collected through semi-structured interviews, and analyzed using Interpretative Phenomenological Analysis (IPA) supported by thematic coding procedures. Research findings indicate that teachers view artificial intelligence as a tool that enhances efficiency in lesson planning, material development, and accessing information. Participants emphasized that digital skills and the ability to craft effective prompts are critical to achieving successful outcomes with AI. It has also been noted that AI holds strong potential for making abstract concepts more concrete in science education, for producing visual content, and for implementing differentiated instruction. However, teachers have emphasized the need to verify the accuracy of AI outputs, noting that strong subject matter expertise provides a fundamental safeguard against misinformation and misconceptions. In conclusion, artificial intelligence is not positioned as a technology that replaces teachers, but rather as a tool that supports and enriches pedagogical practices. Research findings indicate that the integration of artificial intelligence into education requires a holistic approach addressing both digital skills and pedagogical content knowledge.

Keywords: Science education, Artificial intelligence literacy, Digital skills, Qualitative research

Introduction

Theoretical Framework: From 21st-Century Skills to Artificial Intelligence Literacy

Rapid changes in information and technology are transforming the structure of education systems. Today, education is no longer expected to be merely about the transfer of knowledge. In addition, it has become increasingly important for individuals to develop skills such as problem-solving, critical thinking, communication, collaboration, and the effective use of digital tools. In the international literature on digital literacy and 21st-century skills, the Digital Competence Framework (DIGCOMP) serves as a key reference for defining digital skills (Ferrari, 2013).

Although different institutions and education systems classify these skills under various headings, the common thread is the individual’s ability to adapt to a changing world, interact with technology, and be a productive learner (Binkley et al., 2012). For this reason, areas such as communication, creativity, analytical thinking, and digital literacy are considered essential skills in many contexts. Table 1 presents a comparative overview of how different organizations classify 21st-century skills.

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Table 1. Classification of 21st-century skills by institution

P21	EnGauge	ATCS	ISTE	AB	OECD
Learning and Innovation Skills	Exploratory Thinking	Ways of Thinking	Creative Thinking and Innovation	Learning to Learn, Communication	Interacting with Diverse Groups
Creative Thinking and Innovation	Curiosity, Creativity, and Risk-Taking	Creative Thinking and Innovation	Creative Thinking, Knowledge Construction, Product Development, and Technology Adoption Processes	Contact	Good Relationships with Others
Analytical Thinking and Problem Solving	Adaptability, Chaos Management, and Individual Control	Analytical Thinking and Problem Solving, Decision Making	Analytical Thinking, Problem Solving, and Decision Making	Communication in One's Native Language	Conflict Resolution and Management
Communication and Collaborative Work	Higher-Order Thinking and Reasoning	Contact	Communication and Collaborative Work	Communication in a Foreign Language	Collaborative Work and Teamwork
Flexibility and Adaptability	Effective Communication	Collaborative Work (Teamwork)	The Use of Digital Media and Environments to Facilitate Student Collaboration and Communication	Digital Skills	Effective Use of Vehicles
Information, Media, and Technology Skills	Digital Literacy	Information and Communication Technology (ICT) Literacy	Technology Operations and Concepts	Cultural Awareness and Expression	The Interactive Use of Information and Science
Information Literacy	Basic, Scientific, Economic, and Technological Literacy	Information Literacy	Understanding Technology Concepts, Systems, and Processes	Social and Civic Competencies	Interactive Use of Technology
Media Literacy	Visual and Information Literacy	Ways to Work	Collection, Use, and Evaluation of Information Using Digital Tools	Sense of Initiative and Entrepreneurship	The Interactive Use of Language, Symbols, and Writing
Technology Literacy	Multicultural Literacy and Global Awareness	Work Tools	Digital Citizenship		Independent and Autonomous Action
Life and Career Skills	High Productivity	Learning Leadership, Metacognition	Understanding Social and Cultural Issues Related to Technology		Acting Within the "Big Picture"
Leadership and Responsibility	Team Spirit, Collaboration, and Interpersonal Skills	Life on Earth	Research and Information Flow		Future Planning and Individual Project Management
Entrepreneurs	Personal,	Local and			To Defend

hip and Self- Management	Social, and Civic Responsibility	Global Citizenship	and Assert One's Rights
Social and Intercultural Skills	Interactive Communication	Life and Career	
Productivity and Responsibility	Managing Results, Planning, and Setting Priorities Effective Use of Everyday Tools Manufacturing Expertise, High-Quality Products	Individual and Social Responsibility	

Source: Based on the international frameworks cited by Hamarat (2019, p. 9), the concepts have been restructured and adapted by the researcher while remaining faithful to their original terminology.

A review of Table 1 reveals that digital skills emerge as a common theme across nearly all approaches. In particular, competencies such as technological literacy, access to information, the use of digital tools, and media literacy are considered fundamental skills in today's educational framework. This has become even more significant with the increasing prevalence of artificial intelligence applications in educational settings. This is because the effective use of artificial intelligence technologies requires a certain level of digital literacy. In particular, the ISTE (International Society for Technology in Education) and P21 (Partnership for 21st Century Skills) frameworks emphasize the use of technology, digital communication, and problem-solving skills. P21 (2015) categorizes 21st-century skills under four main headings:

- Learning and innovation skills,
- Information, media, and technology skills,
- Core subjects and 21st-century themes,
- Life and career skills.

These skills influence not only individuals' academic achievements but also their ability to adapt to the challenges they face in daily life. As technology becomes more prevalent in educational settings, information and technology literacy are now considered essential requirements (Cansoy, 2018, p. 3119). ISTE, on the other hand, approaches digital skills with a greater focus on application and production. Updates made in 2016 highlighted areas such as digital citizenship, innovative design, productive communication, and global collaboration (Cansoy, 2018, pp. 3122-3123). This approach aims to position the individual not merely as a user of technology, but also as someone who questions, creates, and actively evaluates it in problem-solving processes. Computational thinking skills are particularly emphasized in this context.

Integration of Artificial Intelligence in Science Education: The Problem Statement

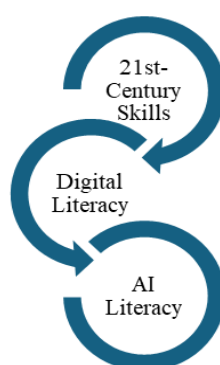


Figure 1. Evolutionary diagram

These approaches to digital skills have taken on a new dimension in recent years with the concept of AI literacy (Figure 1). In the literature, AI literacy is defined as an individual's ability to understand, evaluate, and use AI systems in an informed manner (Ng et al., 2021). While digital literacy focuses primarily on the use of technology, artificial intelligence literacy goes beyond that. In this process, it is not considered sufficient for individuals to merely use digital tools; they are also expected to understand how algorithmic structures work, question data, and reflect on ethical issues (Long & Magerko, 2020). Artificial intelligence literacy is currently regarded as a more advanced stage of digital competence (Ng et al., 2021).

This transformation becomes even more evident when viewed from the perspective of science education. This is because science education is a field that involves processes such as experimentation, observation, data analysis, modeling, and simulation. The use of digital technologies in these processes can support learning. In particular, AI-powered applications can contribute to the teaching process, especially during the stages of visualizing abstract concepts and interpreting experimental data. For this reason, it is not considered sufficient for teachers to possess only basic digital skills. It is also important for them to be able to use artificial intelligence tools for educational purposes, to understand the limitations of these tools, and to guide students effectively (UNESCO, 2023). A teacher's level of digital competence can directly influence how technology is used in the classroom.

In Turkey, this transformation is also linked to the Turkey Century Education Model (TCEM) as part of the curriculum reforms implemented by the MoNE Academy. In the TCEM, digital skills are not viewed merely as technical competencies; rather, they are considered essential life skills that students can apply in their daily lives (MoNE, 2024). This approach is also transforming teachers' roles in relation to technology. Teachers are no longer expected merely to impart knowledge; they are now expected to support learning processes using digital tools and guide students. The teacher training aspect of this process is addressed within the framework of the MoNE Academy. Pursuant to the Teaching Profession Law No. 7528 dated October 10, 2024, and Presidential Decree No. 176, the General Directorate of Teacher Training and Development was abolished and the "MoNE Academy" was established. At the center, the Presidency of the Ministry of National Education Academy provides preparatory training for Teacher Candidates who have achieved the required score on the Academy Entrance Exam (AGS) and have been placed at the center as Teacher Candidates. According to the schedule set by the MoNE Academy, the first term for teacher candidates assigned to training and practice centers within the Academy began on April 13, 2026, and the program—comprising four separate terms—is scheduled to conclude on the February 22, 2027. One of the primary objectives of the MoNE Academy is to support teachers in adapting to evolving digital technologies. For this reason, teachers' perspectives and experiences regarding artificial intelligence applications are of great importance.

This topic is of particular interest to science teachers, as digital simulations, data analysis tools, and modeling applications are widely used in this field. While some studies in the literature indicate that digital skills form an important foundation for the use of artificial intelligence (Ng et al., 2021; Ferrari, 2013), the increasing ease of use and accessibility of artificial intelligence tools may enable users to benefit from these technologies without requiring advanced technical expertise. It is important to examine these discussions within the Turkish context, particularly in the framework of the MoNE Academy and the Turkey Century Education Model. For this reason, it is considered important to examine science teachers' views on artificial intelligence applications, their perceptions of digital literacy, and their experiences using these technologies in the classroom. One of the issues that needs to be investigated is whether teachers view digital skills as a prerequisite for integrating artificial intelligence.

Research Problem and Objective

The primary objective of this study is to examine the views of science teachers enrolled in the MoNE Academy regarding the use of artificial intelligence in education. The study focuses on whether basic digital skills are necessary for the implementation of artificial intelligence applications in educational settings. The teachers' experiences and assessments on this topic were analyzed within a phenomenological framework. The central research question of the study is as follows:

"What are the experiences, perceptions, and insights of science teachers enrolled in the MoNE Academy regarding the necessity of digital skills for the effective use of artificial intelligence applications in education?"

The study also examines teachers' views on the relationship between their digital readiness and the integration of artificial intelligence. Additionally, it assesses how this process reflects on their perceptions of professional competence and classroom practices.

Method

Research Design

This study adopted a phenomenological research design, which is one of the qualitative research approaches. Phenomenology is a research approach that aims to uncover individuals' experiences of a phenomenon and the meanings they ascribe to those experiences (Creswell & Poth, 2018). The central phenomenon addressed in this study is the views of science teachers regarding the role and importance of digital skills in the integration of artificial intelligence applications into educational processes. In this context, the aim is to examine the experiences teachers gained during the MoNE Academy program through their own accounts.

The phenomenological design was chosen because it allows for a more direct exploration of teachers' perceptions of artificial intelligence and how they evaluate this technology as either a "supportive tool" or a "facilitator." This approach enables a deeper understanding of the meanings constructed regarding digital literacy (Yıldırım & Şimşek, 2016).

Study Group

The study group consists of four science teachers currently enrolled in the MoNE Academy. In selecting the sample, criterion sampling—one of the purposeful sampling methods—was used (Patton, 2015). The inclusion criterion for the study was working in the science field and actively participating in the MoNE Academy program. All participants are science teachers.

Fifty percent of the participants are women, and 50% are men. Additionally, one participant (25%) is pursuing graduate studies in physics education, while three (75%) are pursuing graduate studies in science education. Information regarding the study group is presented in Table 2. The fact that the participants are directly exposed to current educational practices within the framework of the MoNE Academy is considered significant for the study. In addition, it is believed that graduate education programs help teachers articulate their views on artificial intelligence and digital skills in greater detail.

Table 2. Descriptive data of teachers participating in the study

Participant Code	Gender	Academic Status	Current Status
T1	Woman	Master's Degree – Science Education	She is currently enrolled in the MoNE Academy.
T2	Woman	Master's Degree – Science Education	She is currently enrolled in the MoNE Academy.
T3	Man	Master's Degree – Science Education	He is currently enrolled in the MoNE Academy.
T4	Man	Master's Degree – Physics Education	He is currently enrolled in the MoNE Academy.

Data Collection Tool

In this study, a semi-structured interview form developed by the researcher was used to conduct an in-depth examination of science teachers enrolled at the MoNE Academy regarding the role of artificial intelligence technologies in educational processes, their digital self-efficacy, perceptions of academic integrity, and experiences with process management. The semi-structured interview technique was chosen because it allows participants to describe their experiences in their own words and enables the data to be explored in greater depth through follow-up questions during the interview process (Merriam, 2018).

The interview guide was designed around four themes developed by the researcher in line with the relevant literature. The questionnaire was reviewed by a subject matter expert for content validity and was revised based on the feedback received, then restructured to align with the research objectives. The questions focused on gaining an in-depth understanding of teachers' perspectives within the scope of the research are presented in Table 3, in alignment with the thematic structure of the analysis process.

Table 3. Themes addressed in the study and related research questions

Theme	Research Questions
Theme 1: The Conceptual Framework of Artificial Intelligence and Tool Selection	Q1, Q2, Q3
Theme 2: Digital Self-Efficacy and Process Management	Q4, Q5, Q6
Theme 3: Professional Role, the Future, and the Limits of Competence	Q7, Q8, Q11
Theme 4: Academic Integrity, Risks, and Educational Expectations	Q9, Q10, Q12

The interview questions included in the study's final interview form are as follows:

1. As a science educator, what comes to mind when you hear the term "artificial intelligence"?
2. Which artificial intelligence tools do you use in your daily life or academic work (such as literature reviews, data analysis, etc.)? What are your reasons for using them?
3. Where do you place the use of artificial intelligence in science education within the context of digital literacy skills?
4. To what extent do you feel confident in integrating AI tools with simulations (such as Algodoo, Phet, etc.) or digital materials used in science classes?
5. What kinds of prompts do you use to obtain effective output from an AI tool (such as ChatGPT or Gemini), and how do you assess the importance of digital literacy skills in academic work?
6. Do you think the ability to use AI-powered visual/video creation tools when teaching complex science concepts (such as cell division or force and motion) is a fundamental competency that a modern teacher should possess? What are your thoughts on this topic?
7. In your opinion, what kinds of transformations might artificial intelligence bring about in virtual science experiments?
8. Research is currently being conducted on personalized AI learning assistants. What are your thoughts on the role of personalized AI learning assistants in increasing students' interest in the sciences?
9. When preparing an academic paper or designing a lesson plan, where do you think the boundaries of AI use regarding "academic integrity" and "ethics" should begin and end?
10. What are your thoughts on including a "Artificial Intelligence in Education" course in academic education programs (3rd Semester)? What should the content of these lessons be?
11. Digital skills include information literacy, data literacy, digital content creation, communication and collaboration, security, and problem-solving. In your opinion, which of these skills will be the most important digital skills for future science teacher candidates to possess?
12. What can you say about the potential risks of AI technologies on science education (such as information overload, creating misconceptions, etc.)?

During the data collection process, interviews were conducted individually via an online platform (Zoom) based on the participants' availability. Conducting the interviews online allowed teachers to express themselves more comfortably in their own work environments. Each interview lasted between 25 and 35 minutes, with an average duration of 30 minutes, and was audio-recorded with the participants' consent.

Data Analysis

Data were analyzed through an Interpretative Phenomenological Analysis (IPA) framework supported by thematic coding procedures. IPA was employed to explore participants' lived experiences and the meanings they attributed to artificial intelligence applications (Smith et al., 2009). Thematic coding procedures were used as a complementary strategy to systematically organize emerging codes into meaningful categories and themes (Creswell, 2013; Miles & Huberman, 1994). This approach enabled both an in-depth interpretation of participants' experiences and the identification of common patterns across the data.

The data analysis was conducted in several stages. First, the interviews conducted via Zoom were audio-recorded and transcribed verbatim without any alterations. The transcripts were then reread to familiarize the researchers with the data and identify meaningful statements. At this stage, the participants' own words were preserved as much as possible. In the second stage, the interview transcripts were coded. During the coding process, codes were created that reflected both direct statements and included interpretations. Participants' views on artificial intelligence, their professional practices, and pedagogical assessments were analyzed using these codes. In the third stage, the codes were grouped based on their similarities and differences to form

themes. Throughout this process, the data was continuously compared and reorganized as necessary. In the final stage, not only common views but also distinct and noteworthy participant statements were included in the analysis process. This approach has contributed to a more balanced interpretation of the findings and has allowed for the preservation of data diversity.

Trustworthiness of the Study

In qualitative research, trustworthiness is evaluated through criteria such as credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). Various methodological measures were taken within the scope of this study to ensure these criteria were met.

- *Credibility*: During the development of the data collection instrument, input from a domain expert was sought to ensure the appropriateness and comprehensiveness of the interview questions. During the interviews, probing questions were used to elicit more detailed responses from participants, and direct participant quotes were included in the findings section to strengthen the representativeness of the data.
- *Transferability*: In this study, participant characteristics, the data collection process, and the analysis stages were described in detail, and the findings were presented in a manner that allows for interpretation (Creswell, 2013).
- *Dependability*: To enhance the consistency of the coding process, the data were independently evaluated by the researcher and a field expert, and the agreement between the codings was calculated using the Miles and Huberman formula. The agreement rate was determined to be 92%. This value exceeds the thresholds accepted in qualitative research (Miles & Huberman, 1994).
- *Confirmability*: All audio recordings and written transcripts were preserved during the research process, and the data analysis process was conducted transparently. Furthermore, the data-driven nature of the findings was maintained by taking into account not only common themes but also divergent viewpoints during the analysis process.

Limitations of the Study

This study is limited to four science teachers enrolled in the MoNE Academy. Although the small number of participants allows for more in-depth data collection—a characteristic inherent to qualitative research—it limits the generalizability of the findings. Therefore, the research results should be interpreted as being limited to the experiences of teachers within the context of the MoNE Academy. It is not expected that the same results will be replicated exactly in different samples or educational settings. In this regard, the study provides an explanatory framework that focuses on teachers' experiences within a specific context. The fact that participants were selected using a purposive sampling method allows for the development of insights that can serve as a guide for groups of teachers with similar characteristics.

Results and Discussion

The main themes identified through the analysis of the research data, the sub-codes that constitute these themes, and the relationships between them and the participants' views are summarized in Table 4. This table provides a comprehensive overview of the views of science teachers enrolled in the MoNE Academy regarding the integration of artificial intelligence. The themes identified reflect the teachers' perceptions of this process.

Theme I: The Conceptual Framework of Artificial Intelligence and Tool Preferences

It is observed that the perceptions of science teachers enrolled in the MoNE Academy regarding artificial intelligence technologies are shaped by their understanding of what this technology is, how it is used, and what role it plays in their professional practices. According to the findings of the interviews, all participants (T1, T2, T3, T4) view artificial intelligence as a tool that simplifies tasks in processes such as lesson planning, material preparation, and accessing information (Code 1.1: Role as a Work Simplifier). In the interviews, teachers independently noted that artificial intelligence particularly saves time and reduces the workload. T2 expressed this as follows:

Table 4. Perceptions of artificial intelligence: Themes, codes, and distributions

Themes	Codes	Participants
Theme I: The Conceptual Framework of Artificial Intelligence and Tool Selection	1.1. The Role of a Business Facilitator	T1, T2, T3, T4
	1.2. Concretizing Concepts in Science Education	T1, T3
	1.3. General Tool Usage (ChatGPT/Gemini)	T1, T2, T3, T4
	1.4. Academic-Oriented AI Tool Use (NotebookLM)	T3, T4
	1.5. Viewing Artificial Intelligence as a Subfield of Digital Skills	T1, T3, T4
	1.6. Viewing Artificial Intelligence as Equivalent to Digital Skills	T2
Theme II: Digital Self-Efficacy and Process (Prompt) Management	2.1. Perceived Competence	T1, T2
	2.2. Perception of Limited Competence	T3, T4
	2.3. Requirement for Detailed and Clear Instructions	T1, T2, T3, T4
	2.4. The Need for Digital Skills to Achieve Effective Outcomes	T4
	2.5. Corrections/Revisions Based on the Output	T1, T3
Theme III: Professional Role, the Future, and the Limits of Competence	3.1. AI-Powered Visual Content Creation	T1, T2, T3, T4
	3.2. The Barrier of Seniority and Professional Experience	T3
	3.3. Limitations of Science Literacy	T4
	3.4. The View That a Virtual Laboratory Cannot Replace a Teacher	T1, T3, T4
	3.5. The View That Virtual Laboratories Could Replace Teachers	T2
Theme IV: Academic Integrity, Risks, and Educational Expectations	3.6. Benefits of Differentiated Instruction	T1, T2, T3, T4
	4.1. Distrust of Artificial Intelligence	T1, T2, T3, T4
	4.2. Expectations for Practical Tool Training in Academic Education	T2, T3, T4
	4.3. The Holistic Necessity of Digital Skills	T1, T2, T3, T4
	4.4. Domain Knowledge Shield (Filtering Out Risk and Information Noise)	T1, T2, T3, T4

“In the teaching profession, when it comes to artificial intelligence in the teaching and learning process, I believe that—if used thoughtfully—it can be a useful tool that allows us to share students’ learning experiences, access information quickly, or make lessons more enjoyable and effective, thereby assisting us in our work.”

This view aligns with the literature, which frames artificial intelligence as a tool that reduces teachers’ workload and supports the teaching process (UNESCO, 2021). From the perspective of science education, Participants 1 and 3 noted that artificial intelligence is particularly effective in making abstract concepts more concrete (Code 1.2: Making Concepts Concrete in Science Education). T3 mentioned that they sought support from artificial intelligence when facing difficulties with electricity-related topics. Participants generally emphasize that artificial intelligence plays a supportive role in making science concepts more understandable for students. This finding is consistent with studies in the relevant literature indicating that artificial intelligence supports teachers and the learning process (Yurtsever & Yurtsever, 2025).

An analysis of tool preferences reveals that teachers predominantly prefer widely used AI tools such as ChatGPT and Gemini (Code 1.3: General Tool Use). However, T3 and T4 tend to use tools like NotebookLM primarily for academic research and literature reviews (Code 1.4: Academic-Oriented AI Tool Use (NotebookLM)). T3 explains this situation as follows:

“I sometimes use NotebookLM to access articles... When I upload a source, it produces a better translation, and when I ask it to summarize, it can provide the summary without making any changes.”

This approach by teachers demonstrates that tool preferences can vary depending on needs. It is also noted in the literature that there is a shift toward academic and analysis-focused tools in addition to general-purpose chatbots (Chassignol et al., 2018). Another key finding that emerged from the interviews concerns the role of artificial intelligence within digital skills. While T1, T3, and T4 view artificial intelligence as a component of digital skills (Code 1.5: Viewing Artificial Intelligence as a Subcategory of Digital Skills), T2 defines it as a separate field on par with digital skills (Code 1.6: Viewing Artificial Intelligence as Equivalent to Digital Skills). T3 expresses this situation (Code 1.5) as follows:

“In my opinion, artificial intelligence should be considered a subfield of this; after all, we were using technology even before artificial intelligence existed. Technology—in the form of phones, tablets, and computers—had already become a part of our lives, and we had already begun to use digital skills. As technology advanced, artificial intelligence emerged. I believe artificial intelligence is a concept developed to help us use technology more effectively.”

In contrast, T2 states that artificial intelligence is not a subset of digital skills but a separate field on the same level (Code 1.6.), as follows:

“When we talk about artificial intelligence ... it might be understood as if it were subordinate to digital literacy ... But when viewed broadly, since artificial intelligence is present in so many areas today ... I think it represents an entirely new world. That’s why it didn’t occur to me that the two are things that encompass one another. I define them as separate things that support one another or can touch one another. They have common ground, so we’re not talking about completely separate worlds; but of course, they aren’t two things that encompass one another, or that lie beneath or above one another. In a way, they overlap like two different things within the same category.”

The findings indicate that teachers perceive artificial intelligence in different ways and that this perception influences both their choice of tools and how they use them. The literature indicates that AI literacy is considered a field that is related to digital literacy but does not fully overlap with it, intersects with digital competencies, and encompasses unique skills (Long & Magerko, 2020; Ng et al., 2021).

Theme II: Digital Self-Efficacy and Process (Prompt) Management

Since science education is a field that requires the concretization of abstract concepts and the use of digital materials, it is becoming increasingly intertwined with digital technologies. In this context, the perceptions of digital self-efficacy and the ability to manage artificial intelligence processes among science teachers trained at the MoNE Academy stand out as factors that directly influence the quality of the teaching process. According to the analysis results, teachers T1 and T2 consider themselves competent in using digital simulations (PhET, Algodoo, etc.) and artificial intelligence tools in science education (Code 2.1: Perceived Competence). These teachers noted that they were able to adapt quickly to the process and integrate technology into their lessons. Participants describe their ability to adapt easily to the process as follows:

“...I’m going in having done my prep work... I think I grasp these concepts easily. I’m also able to integrate them seamlessly into the process when working with the children.” – T1

“I feel confident in my abilities... When I teach, I see that it’s important for students to be exposed to these kinds of different programs, and I can use them at a sufficient level during this process.” – T2

These statements indicate that when teachers have a high sense of self-efficacy regarding technology, integrating it into lessons occurs more smoothly. This finding is consistent with studies in the literature demonstrating that self-efficacy beliefs influence behavior (Bandura, 1997). Teachers’ use of technology for pedagogical purposes can also be linked to the technology and pedagogical knowledge dimensions of the Technological Pedagogical Content Knowledge (TPACK) model. TPACK consists of three main components: Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Pedagogical Content Knowledge (PCK) (Mishra & Koehler, 2006). In contrast to the high self-efficacy perceptions of T1, T2, T3 and T4 assess themselves more cautiously regarding digital integration processes. These teachers stated that they cannot use technology at the same level across all subjects and that their competence varies depending on the subject (Code 2.2: Perception of Limited Competence). T4 explains this situation as follows:

“...Right now, I don’t consider myself very proficient in terms of practical application because there are so many things—so many simulations we need to think through and convey to the students... For example, I used them in physics—say, force and motion... I felt quite confident with those simulations, but when it came to topics like transformers or certain parts of Newton’s laws of motion, I sometimes fell short; it really depended on the subject.”

This statement indicates that the use of digital tools does not occur at the same level across all subject areas and that subject knowledge and technology use must be considered together (TAB). Participants have differing views on this matter.

Although the interviews with the participants were conducted individually and independently, all of them (T1, T2, T3, T4) agreed that, in order to obtain educationally and academically valid output from an AI engine (such as ChatGPT or Gemini), it is necessary to provide highly detailed instructions rather than generic commands (Code 2.3: Requirement for Detailed and Clear Commands). Participants explain the AI's information processing logic and command structuring processes as follows:

"If you don't give these tools the specific commands they need, they might provide you with very general or inaccurate information. It's like baking a cake... you have to choose the right ingredients and batter—in other words, you have to write good code; you need to be able to specify exactly what you want." – T1

"When giving commands to artificial intelligence, I try to be as specific as possible. Since it's an algorithmic system, it's important to be clear, precise, and detailed... When we explain what we're working on in detail to the AI, it manages the process more effectively and accurately." – T2

The participants' emphasis on the system's "algorithmic structure" highlights the importance of the process management skill known as "prompt engineering" in the use of generative artificial intelligence. Their statements indicate that obtaining effective outputs from AI is not limited to mere tool usage but requires the ability to provide precise and purposeful guidance. This highlights that teachers must possess not only the proficiency to operate AI tools but also the capacity to critically evaluate and guide the use of AI-generated outputs throughout the interaction process (Mollick & Mollick, 2023). Going beyond technical process management, T4 states that in order to extract high-quality academic data from AI tools, teachers must first possess search engine literacy. According to him, general digital skills also constitute a fundamental prerequisite for AI literacy (Code 2.4: The Necessity of Digital Skills for Effective Outcomes). The participant explains this situation as follows:

"...Even to use ChatGPT, you have to search Google to figure out how to use it... When we feed the data we've gathered from indexing tools related to this field or from Google's advanced search option into the AI, it can provide us with a much more detailed analysis... And to access information easily, you first need to be media literate."

This statement aligns with the literature, which emphasizes that media literacy serves as a crucial starting point for the use of advanced technology (Hobbs, 2010). In addition, participants independently share the same view that outputs generated by artificial intelligence should not be directly transferred to the classroom and must be reviewed by the teacher (Code 2.5: Output-Based Correction/Revision). This finding demonstrates that the teacher's supervisory role continues throughout the process (Celik, 2023; Ouyang & Jiao, 2021).

Theme III: Professional Role, Future, and Limits of Competence

An examination of science teachers' views on how artificial intelligence technologies impact their professional identity, future professional standing, and limits of competence reveals a distinct thematic pattern in their perceptions of AI. All participants stated that one of the most concrete applications of AI in science education is its ability to transform abstract concepts into visual materials (Code 3.1: AI-Supported Visual Content Production). Emphasizing the critical role of visual pedagogy in science education, T1 states, "...I firmly believe that AI tools capable of providing visual and video content... must be utilized to the fullest. Because students understand concepts when they see, hear, or conduct the experiment themselves," viewing this competency as a prerequisite for modern teaching. T2, who approaches the inadequacy of current materials with critical irony, describes the current situation as follows:

"...When we cover the topic of cells in class, we put a black-and-white book in front of them—it's almost become a running joke... There's a new generation that's grown up with technology; that's why I think it's very beneficial to offer them a product in a language they understand."

It is stated that artificial intelligence technologies have the potential to enrich teaching processes and enhance learning experiences (Holmes et al., 2019). However, this process of technological interaction is not independent of teachers' personal and professional backgrounds. T3 argues that one of the most significant barriers to the effective use of artificial intelligence tools is the factor of seniority and age (Code 3.2: Seniority and Professional Experience Barrier). T3 expresses the view that the methodological expertise gained through professional experience can reduce the need for technology, stating: -

“...If a teacher has significant professional seniority—say, 10 or 15 years of experience—they may not need to use artificial intelligence... Because these teachers have already mastered the art of conveying knowledge through years of teaching. But for an educator like me, who is just starting out... this is absolutely necessary.”

This approach is linked to studies demonstrating that technology integration is shaped not only by technical proficiency but also by teachers' knowledge, beliefs, and pedagogical practices (Ertmer & Ottenbreit-Leftwich, 2010). T4, which imposes an epistemological boundary on the process, argues that in the absence of sufficient science literacy and foundational subject knowledge, artificial intelligence may transform into a risk factor rather than a pedagogical opportunity (Code 3.3: Limitations in Science Subject Knowledge). T4 states, *“...If artificial intelligence includes incorrect information in visuals, it can lead to new misconceptions in students' minds... Ultimately, it comes down to our own scientific competence, how successful we are in science education, and how well we master the subject,”* thereby emphasizing the decisive role of subject knowledge in overseeing autonomous systems. These findings indicate that if teachers lack sufficient subject matter knowledge and pedagogical content knowledge, they may not be able to interpret AI outputs correctly, which carries the risk of increasing conceptual misunderstandings (Shulman, 1986).

One of the key points of disagreement among teachers within this theme was their views on the future role of the teacher in AI-supported virtual laboratory applications. The majority of participants argue that artificial intelligence cannot replace teachers due to the sensory processes, psychomotor skills, and sense of tangible reality present in a laboratory setting (Code 3.4: The View That a Virtual Laboratory Cannot Replace a Teacher). Noting that the perception of reality cannot be fully captured on screen, T1 argues, *“...It just doesn't work. I absolutely have to touch those materials with my own hands and observe the experiment... The fact that the color changes on screen when one chemical is mixed with another is not surprising from a technological standpoint.”* T3, on the other hand, highlights the motivational power of the physical environment, stating, *“The laboratory is one thing, simulation is another... I expect laboratory support, which is why I see the laboratory as an element that will integrate students more deeply into the course.”* T4, who emphasizes the durability of experiential learning, supports this view by stating, *“...I don't think the walls of the laboratory will disappear in the future.”* In contrast, T2 presents a different vision of the future, arguing that artificial intelligence and 3D modeling could significantly reduce the need for physical laboratories (Code 3.5: The View That Virtual Laboratories Could Replace Teachers). T2 defends this approach with the following words:

“If we enhance the reality of the lab, it could take off. In other words, if we think big, we could see things like holograms... Middle school students aren't exactly walking out of the lab having learned anything significant anyway... By transferring this to the digital world... methods that can be implemented without labs... could emerge in the future.”

Participants' views align with the general discussions in the literature regarding the potential of AI-powered technologies to transform educational environments through simulations and virtual learning environments (Russell & Norvig, 2020). Despite all these discussions about barriers and roles, teachers generally share a common view regarding the potential of personalized AI applications to generate content tailored to each student's learning pace and needs (Code 3.6: Benefits of Differentiated Instruction). Highlighting the realities of classroom structures and special education in Turkey, T2 states, *“...I believe this will be very beneficial for students with disabilities who require special education... Because current classrooms are not well-suited for this, and unfortunately, teachers in our country are not currently able to focus on this effectively,”* suggesting that the gaps in the system could be partially addressed through AI-supported applications. T3, who highlights RAM processes and gifted students, states, *“...There may also be high-achieving (gifted) students; similarly, I may not be able to meet their needs based on my own knowledge or experience. When the process is supported by artificial intelligence, AI can provide them with an additional study program,”* thereby positioning artificial intelligence as a pedagogical support tool. T4, who assessed the situation in light of the new curriculum dynamics, stated, *“...After all, the primary focus of the Turkey Century Education Model is education tailored to the individual. It can be beneficial for a student at a lower level, a student with learning difficulties, or a student at an advanced level—all within the same classroom...”* thereby highlighting the alignment of the personalized learning approach with current education policies. These findings suggest that artificial intelligence can contribute to the individualization of learning by supporting teachers' in-class differentiation processes (Holmes et al., 2019).

Theme IV: Academic Integrity, Risks, and Educational Expectations

An examination of science teachers' perceptions regarding the ethical risks and epistemological threats posed by artificial intelligence technologies, as well as the institutional training models required in this process, reveals that technological caution coexists with expectations of systemic transformation. All participants demonstrate a critical approach toward the accuracy, limitations, and potential for manipulation of data generated by artificial intelligence models (Code 4.1: Distrust of Artificial Intelligence). T1, who empirically tested this critical approach to the reliability of technology, makes the following critical observations:

"...The first time I asked, it said the answer was 'A'; the second time, it said the answer was 'B'... Then it might say something like, 'I'm so sorry, the actual answer is C.'... When we tell it, 'Take this thesis and rewrite it using sentences that sound like they came from me,' we're essentially copying that thesis without adhering to any ethical boundaries... This situation is entirely up to the individual's conscience."

Rather than passively accepting artificial intelligence's autonomous knowledge-generation processes, T2 directly evaluates the resulting academic outputs for validity and ethical considerations; he explains this approach through applications based on his own experiences as follows:

"When giving commands to artificial intelligence, I try to be as specific as possible... Because when it fills in the blanks on its own, errors can occur, or it might sometimes provide incorrect information... In fact, even when it's responding to me during a conversation, I sometimes ask questions to verify its accuracy. For example, when asking it to conduct a literature review and collect some articles, I verify whether the data it provides is accurate by asking, 'Is this really accurate data?'... When submitting a paper to the academic community or the academic world, I want to use artificial intelligence only to a very limited extent for ethical reasons. This is because the academic world and its oversight mechanisms are not yet fully prepared to control and filter artificial intelligence."

Similarly, T3, who draws attention to the fake references and source manipulation generated by algorithms, adopts a critical stance regarding the epistemological reliability of artificial intelligence, stating, *"...It can present us with fabricated bibliographies... That is why we absolutely must not trust it."* T4, on the other hand, emphasizes the need to uphold the principle of originality in academic work, stating, *"...If we lack our own knowledge, or if we have nothing of our own to contribute beyond the work we are presenting... I try not to plagiarize. I try to express it in my own words... and cite my sources."* The findings provide an important analytical framework, particularly when T2's approach of cross-checking literature information provided by artificial intelligence is evaluated alongside T1 and T3's critiques of systemic errors. Rather than accepting AI outputs as a direct source of information, teachers' approach to these outputs with rational skepticism serves as a concrete indicator of the advanced digital literacy skills expected in science education.

Teachers emphasize that information generated by artificial intelligence must always be subject to human oversight. These findings are consistent with the literature on the risk of hallucinations, the potential for plagiarism, and the ethical boundaries in the information-generation processes of large language models (Celik, 2023; UNESCO, 2023).

In order to mitigate these risks and the prevailing climate of uncertainty, the vast majority of participants are requesting that the "Artificial Intelligence in Education" course—to be offered in the third term across all disciplines as part of the MoNE Academy—be structured around practical, science-pedagogy-based content rather than theoretical lectures (Code 4.2: Expectation for Practical Tool Training in Academic Education). Ö2, who takes a critical approach to current usage patterns, articulates this expectation as follows:

"...We're still pretty much in our comfort zone when it comes to this; we use AI like Google... it's basically become a matter of laziness... If I were to choose a course, it would be more productive if the content focused on questions like, 'How else can it be used? What can we do with it in cells?'"

T3, who illustrates his own professional transformation through the process of preparing presentations, expresses his expectations by saying, *"It used to be projected onto a screen, then we switched to PowerPoint; now I use NotebookLM... We need to know how to write effective code and prompts... The training must definitely address the ethical and critical aspects of artificial intelligence."* All participants argue that teachers must possess a comprehensive skill set—ranging from basic computer literacy to advanced prompt engineering—in order to use AI tools effectively (4.3: The Holistic Need for Digital Skills). T4 supports this view by stating, *"...This way, we can identify which assessments are involved in the process and which AI we are using. It should encompass critical thinking, but above all, we must focus on the question, 'Which AI should I use?'"* According to this finding, digital competencies exhibit a holistic structure composed of complementary

components. An educator's ability to demonstrate advanced artificial intelligence literacy is limited by their lack of basic media and search literacy (Ferrari, 2013).

In the face of all these risks and skill gaps, all teachers emphasize subject-matter expertise in science as a fundamental safeguard. Participants state that the teacher's mastery of the subject area serves as a critical filter in preventing the information overload and conceptual misunderstandings that artificial intelligence may cause (Code 4.4: Subject Matter Shield / Mitigating Risk and Information Overload). T2, noting that the nature of the science field makes it prone to conceptual misunderstandings, issues the following warning:

"...It's a field where there are so many misconceptions, even without artificial intelligence... A student teacher can pass these on to students like a rapidly spreading virus... If they filter artificial intelligence through their own knowledge and teaching experience and blend it with what they convey to the student, the result will be a much more effective science education."

T1, who demonstrates self-confidence and an epistemological stance in the face of information overload, draws attention to this risk by stating, *"...If we lack a foundation in science, and I don't have the knowledge to refute the argument presented by artificial intelligence... then, of course, the likelihood of information overload or conceptual misunderstanding is very high."* T4, meanwhile, emphasizes the importance of mastery of the curriculum and subject matter, stating, *"...If a science teacher, for example, has a solid understanding of the steps involved in cell division, they can easily filter out the misleading information found online or generated by artificial intelligence... I believe this situation is again tied to academic experience and subject-matter expertise."* This shared view among participants highlights the decisive role of human expertise and pedagogical subject knowledge in the face of autonomous systems, even in the age of artificial intelligence. In this sense, the teacher's strong subject knowledge serves as a fundamental "shield" that safeguards professional responsibility and scientific accuracy against algorithmic errors (Mishra & Koehler, 2006).

Conclusion

This study examines the views of science teachers who received training through the MoNE Academy regarding artificial intelligence applications. The findings indicate that teachers generally view artificial intelligence as a tool that simplifies their work in areas such as lesson planning, material development, and time management. All participants, however, agree that the primary responsibility in the teaching process remains with the teacher.

In general, science teachers place a high value on subject matter expertise and place it at the center of the teaching process. Participants do not consider the direct use of AI-generated content to be appropriate. They emphasize that such content must be vetted by the teacher. Here, the teacher is not viewed merely as someone who uses technology; rather, they are highlighted as a professional who interprets knowledge and adapts it as needed. For this reason, artificial intelligence is viewed more as a tool that supports the process rather than as a structure that replaces the teacher.

Regarding teachers' perceptions of artificial intelligence, it is observed that most position this technology as a subcategory of digital skills. However, the fact that a teacher defines artificial intelligence literacy as an independent field on par with digital literacy reveals that this perception is not homogeneous and that teachers interpret this technology within different frameworks. This indicates that teachers interpret artificial intelligence in different ways.

There are also differences among teachers regarding their views on laboratory practices. Most teachers consider physical laboratories indispensable for science education. However, one teacher notes that virtual laboratories offer significant advantages in terms of accessibility and safety. Although this study is limited to a small sample group, when these two approaches are considered together, it can be said that digital applications serve as a tool to support instruction rather than replace physical experiments.

In conclusion, this study demonstrates that artificial intelligence technologies do not eliminate the teacher's role in science education. Rather, they are viewed as a tool that supports and, in some ways, enhances the teaching process. Therefore, artificial intelligence is seen not as a system that takes over the teacher's decisions, but as a complementary structure that contributes to the process.

Recommendations

Based on the findings of this study, several recommendations regarding the use of artificial intelligence in science education can be developed. Since the study was conducted with only four teachers, although the results provide an in-depth perspective, their generalizability remains limited. Therefore, future research involving larger samples and including different groups of teachers could contribute to obtaining more comprehensive results.

In addition, the fact that the study was conducted exclusively with science teachers is considered a significant limitation. Studies comparing different subject areas could be useful in this regard. In particular, examining the perspectives of teachers in math and language arts on artificial intelligence could make interdisciplinary differences more apparent. Examining how artificial intelligence tools vary by discipline can help us understand how digital transformation takes shape across different fields.

A review of the findings on virtual laboratories reveals a range of differing perspectives. Therefore, future research could explore the impact of hybrid approaches that combine physical and virtual experiment. Such studies can provide stronger support for qualitative findings. As the number of these studies increases over time, it may become possible to synthesize the results through meta-analyses and systematic reviews. This could lead to a broader and more consistent picture.

Finally, this study also demonstrates that AI-based educational applications are not merely technical tools, but also require pedagogical attention and professional awareness. Therefore, it would be beneficial for future training programs to be designed in a way that develops both teachers' technical skills and their critical thinking and evaluation skills.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

* This study was conducted following the approval of the Ethics Committee for Social and Human Sciences at the university to which the researchers are affiliated, pursuant to Decision No. 2026/453 dated May 21, 2026 (Meeting No. 10).

Conflict of Interest

* The authors declare that they have no conflicts of interest.

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Author(s) Information

Merve Dilara Unal

Necmettin Erbakan University, Yaka Mah. Yeni Meram
Cad. Kasım Halife Sok. No:11/1, Meram, Konya, Türkiye
Contact e-mail: dilaraunal379@gmail.com
ORCID iD: <https://orcid.org/0009-0005-4432-4714>

Serpil Kara

Necmettin Erbakan University, Yaka Mah. Yeni Meram
Cad. Kasım Halife Sok. No:11/1, Meram, Konya, Türkiye
ORCID iD: <https://orcid.org/0000-0002-0482-7617>

*Corresponding author(s) contact email

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