

Identifying and Developing Teachers' Competencies in Artificial Intelligence-Supported Education

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Abstract

Artificial Intelligence (AI) can assist teachers in various areas such as monitoring student performance, creating personalized learning environments, and optimizing teaching materials. This study identifies the key competencies teachers need for effective AI integration in education. The research was conducted with 14 academics from Romania and Turkey. The data were collected using the Storage technique, which allowed the participants to share information without being influenced by each other's views. The findings were analyzed using content analysis and categorized under six main themes: educational planning and content development, AI utilization and integration, assessment and decision-making, student-focused strategies and personalization, technology and resource usage, and collaboration and teamwork. The results suggest that teacher competencies in AI use and integration are multifaceted, covering a wide range of areas including educational technology, personalization, assessment, and collaboration. These competencies are crucial for teachers to enhance their professional development and provide more effective education to students. The study offers several recommendations, including restructuring teacher education programs to integrate AI, increasing opportunities for continuous professional development, and facilitating access to digital tools and resources.

Key words: Artificial intelligence, teacher competencies, AI integration in teaching, personalized learning strategies, educational technology.

Introduction

The rapid development of AI technologies is bringing significant changes and innovations to the field of education (Duan et al., 2024; Tan, 2023). The use of AI in education has the potential to transform teaching methods and student learning experiences (Luckin & Holmes, 2016; Onesi-Ozigagun et al., 2024; Pratama et al., 2023). AI can assist teachers in monitoring student performance, creating personalized learning environments, and optimizing teaching materials. AI applications are increasingly used in educational contexts beyond the classroom environment, where they support students with adaptable, personalized content (Ayeni et al., 2024; Karacaoğlu et al., 2025). However, for these technologies to be effectively utilized, teachers need to possess specific competencies. Therefore, identifying and developing teacher competencies in AI use and integration is of paramount importance. Understanding how teachers can effectively integrate AI technologies into classroom practices is crucial for enhancing the quality of education.

AI is a technology that brings revolutionary changes to areas ranging from social interactions to education systems. In education, the innovations offered by AI have the potential to transform teaching and learning methods, but it is also a fact that these technologies require advanced infrastructures and innovative ecosystems (Chen et al., 2020). Profiling and prediction, assessment and evaluation, adaptive systems and personalization, and intelligent tutoring systems are frequently encountered areas where AI is used in education (Zawacki-Richter et al., 2019). In developed countries, the integration of these technologies is often more easily realized with more advanced infrastructure and resources, while in developing countries these processes can often be more challenging and time-consuming (Pedro et al., 2019).

In this context, research on the role of AI in education and teachers' ability to adapt to these technologies contributes to developing strategies to improve equity and quality in education in both developed and developing countries (Lameras & Arnab, 2021). In particular, studies on the competencies required for teachers to use AI effectively are important to support the integration of these technologies into education systems (Caena & Redecker, 2019; Polak et al., 2022). This research aims to identify the most important

competencies of teachers related to AI as a result of storage application with a total of 14 scientists from Romania and Turkey. The data obtained by using the storage technique developed by Karacaoğlu and Bayrakçı (2020) were analyzed by content analysis method and main themes were formed. The findings of this study aim to support the integration of AI in education by providing suggestions for improving teachers' competencies in the use of AI.

In the introduction part of this study, the role of AI in education, the importance of teachers' competencies in the use of AI and the purpose of the research were discussed. In this context, it is foreseen that the findings and results of the research may have significant impacts on educational policies and teacher curricula.

Method

This research is based on content analysis, a qualitative research design. Instead of traditional interviews or focus groups, the storage technique was chosen to minimize interaction among participants and allow for the emergence of unique individual perspectives. This method, with its anonymity and independent thinking, allowed participants greater freedom in sharing information. In this study, a storage technique was employed to identify the most important AI-related competencies for teachers. Data were collected using the Storage Technique from 14 scholars, including 10 from Romania and 4 from Turkey. Following the researcher's opening speech at the workshop titled "AI and Quantum Learning Competencies of Teachers in Curriculum Development," participants were asked the question, "What is the most important AI competency of teachers?" Their responses were categorized using thematic content analysis, leading to the development of main themes that were systematically organized to align with the research objectives. The researcher also moderated the workshop. While this contributed positively to the data collection process, care was taken to ensure that the data analysis adhered to the participants' statements, taking into account potential risks of bias and manipulation.

Participants

Participants were selected from volunteer experts attending the ICLEL 2024 conference and conducting academic research in the field of AI education. Participant selection criteria included active participation in the conference, academic interest in AI and education, and experience in the field. All participants were academics, with no practicing teachers. This is a limitation of the research findings.

The participants of this study consist of 14 scientists with academic interests in AI in education who shared their knowledge and experiences on AI in a workshop titled "Artificial Intelligence Competencies of Teachers and Curriculum Development Tendencies" moderated by the researcher at the ICLEL 2024 conference held in Budapest, Hungary on July 9, 2024. There are also 10 Romanian and 4 Turkish scientists among the participants. Within the scope of the research, the question "What is the most important AI competency of teachers?" was asked to determine the most important competencies of teachers related to AI and the answers were categorized using thematic qualitative analysis.

The research sample consisted of 14 participants, a number considered sufficient for in-depth analysis in qualitative research. However, the fact that the sample consisted solely of academics and included limited representation from different educational levels or countries limits generalizability. Therefore, the results should be evaluated contextually.

Prior to the research, participants had been informed about the study's purpose, methodology, and data use. Participation was voluntary, and informed consent was obtained from all participants. The research process was conducted in accordance with ethical principles, no personal information was collected, and confidentiality was strictly adhered to.

Data collection

In this study, a storage technique developed by Karacaoğlu and Bayrakçı (2020) was used. The aim of this technique is to enable the participants to interact without being affected by each other's opinions and to share the information they have accumulated. A glass jar and six different colored papers were used in the application. The stages of the application are shown below (Fig.1).

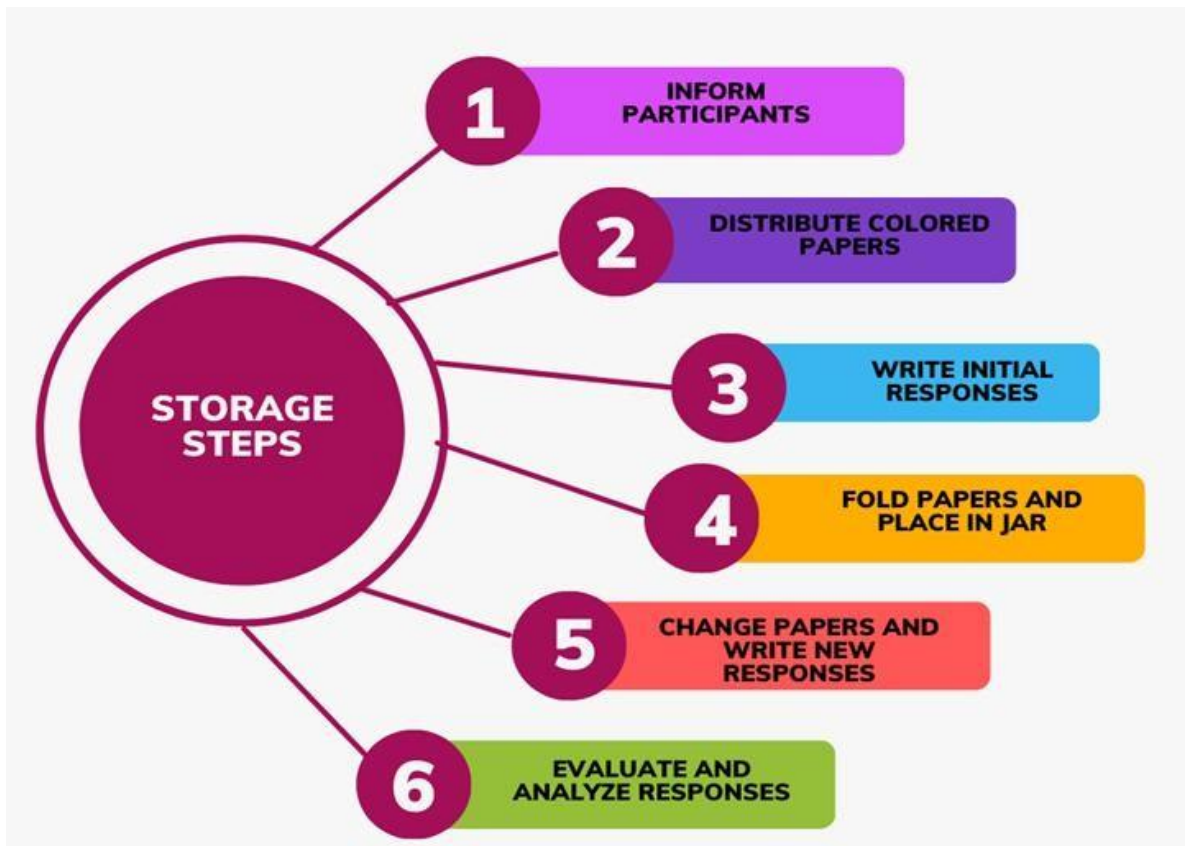


Figure 1. Steps of storage technique.

The implementation steps were carried out as follows:

1. Inform Participants: Participants are informed about the purpose of the technique and the steps of the application.
2. Distribute Colored Papers: Each participant is given papers in six different colors.
3. Write Initial Responses: Participants write the most important information about the subject on the papers.
4. Fold Papers and Place in Jar: After completing the writing process, participants fold the papers and place them in the glass jar.
5. Change Papers and Write New Responses: Each participant selects another colored paper from the jar, reads it silently, and writes a third important piece of information.
6. Evaluate and Analyze Responses: All papers are taken out of the jar one by one, read aloud for group discussion, categorized, and analyzed to create a collective product.

Data analysis

In this study, content analysis was used to analyze data collected using the Storage Technique. Due to the nature of this technique, the initial analysis and grouping were conducted by 14 participating academics with academic expertise in AI who played an active role in the data collection phase. This collaborative, preliminary analysis phase allowed participants to categorize core competencies and concepts without being influenced by one another, which aligned with the methodological foundations of the storage technique. The colored paper system incorporated into the technique facilitated participants' independent reflection, while the anonymous and iterative exchange of ideas allowed organic themes to emerge based on the participants' perspectives.

Following the initial grouping during the application of the technique, the research team conducted a more in-depth content analysis. The dataset was meticulously examined to identify recurring concepts, key phrases, and semantic patterns. Each meaningful unit was assigned a specific code reflecting its content and its relevance to the research question. These codes were then clustered into overarching themes through a process of comparison and categorization.

Initial thematic grouping was conducted by the participants as part of the Storage Technique process, while subsequent in-depth coding and thematic synthesis were conducted independently by the researcher to ensure methodological rigor.

The theme generation process followed several steps to ensure transparency and validity:

Theme Generation Process: Codes were first examined for semantic similarity and grouped into candidate subthemes. These subthemes were then synthesized into six main categories by identifying their conceptual overlap and alignment with the research objectives. Themes such as Instructional Planning, AI Use and Integration, and Student-Centered Personalization emerged directly from patterns repeatedly emphasized by multiple participants.

Coding Challenges: One of the main challenges encountered during the coding process was distinguishing between overlapping concepts, such as technology use and AI integration, which often appeared together within the same responses. To address this, codes were iteratively refined, and definitions for each theme were developed to avoid thematic ambiguity.

Illustrative Quotations: Identified themes were supplemented by anonymized yet illustrative participant statements representing broader perspectives. For example, a Romanian academic supported both the Assessment and Decision-Making and Student-Centered Strategies themes by stating, "AI should not only support assessment but also offer dynamic personalization based on students' backgrounds."

Inter-Coder Reliability: The entire coding process was conducted independently by two researchers. Each researcher coded the entire dataset separately, and then a reconciliation session was held to compare and align the codes. Any discrepancies were discussed and resolved through consensus. This process increased inter-coder agreement and contributed to the reliability and robustness of the thematic structure.

Data analysis was conducted manually, without the use of qualitative data analysis software. However, to ensure reliability, criteria such as descriptive competence, congruence between codes and data, and internal consistency among categories were rigorously applied. As a result of this multi-layered analytical framework, a structured and meaningful thematic map was developed that reflects the detailed competencies teachers need for the integration of AI into education. This analytical approach, combining participant-led initial categorization and researcher-led rigorous thematic synthesis, added depth, transparency, and interpretative richness to the study's findings. This technique not only preserved participant autonomy but also enhanced the richness of the data by allowing diverse and unbiased themes to emerge naturally.

Findings

This research, which focuses on teachers' AI competencies and analyzes the perspectives of scientists conducting scientific studies in this field in depth, sought to determine the competencies required for teachers to use AI effectively in educational processes. The data obtained categorized the core competencies that teachers should have under six main categories. These categories and related themes revealed how teachers can use AI in education and what specific skills they will need. Table 1 showed the competencies and the details of these competencies required for teachers to use various aspects of AI in education. The table includes themes and specific skills related to these themes, grouped under the main categories of instructional planning and content development, AI use and integration, assessment and decision-making, learner strategies and personalization, technology and resource use, collaboration and teamwork.

Table 1. Competencies and themes required for teachers' use of AI.

Category	Themes	Specific Competencies
Education Planning and Content Development	- Inquiry skills	- Creating and planning syllabus
	- Creating interactive lessons	- Using online education platforms interactively and collaboratively
	- Using tools throughout education	
AI use and integration	- Promoting creativity with AI	- Promoting innovative and critical thinking with AI
	- Integrating results into general information	- Asking the right question to use chatbot properly
Assessment and Decision Making	- Assessment and evaluation	- Deciding child's ability

	- Interpreting results - Reasoning	- Ability to analyze
Student-Centered Strategies and Personalization	- Considering child's academic history	- Developing personalized learning strategies
Technology and Resource Usage	- Organizing data resources for autonomous learning - Using another device	- Developing lifelong learning competencies - Proper use of PC and the Internet
Collaboration and Teamwork	- Finding new resources and information - Team activity	- Organizing data resources for autonomous learning - Facilitating teamwork among students - Encouraging collaborative learning environments - Developing team-based projects

As presented in Table 1, the competencies were grouped under six key categories. These encompass essential teaching skills such as instructional planning, AI integration, assessment, personalization, digital resource usage, and collaboration. Together, they outline a holistic framework for AI-related teacher competencies. Table 1 shows that teachers' competencies related to AI are multifaceted and span a wide range of areas such as training, technology use, personalization, assessment and collaboration. These competencies are critical for teachers to both improve themselves and provide more effective education to students.

Results and Discussion

This study was conducted to understand the effects of AI in education and teachers' competencies related to these technologies. The findings revealed that there is a wide range of competencies required for teachers to use AI effectively. The data obtained from the participants were grouped under six main categories using content analysis method: Instructional Planning and Content Development, AI Use and Integration, Assessment and Decision Making, Student Strategies and Personalization, Technology and Resource Use, Collaboration and Teamwork. The results address various aspects of the role of AI in education and teachers' ability to adapt to these technologies.

Education planning and content development

The category of Education Planning and Content Development emphasizes teachers' ability to create interactive lessons and use digital platforms effectively. In modern educational approaches, the effective use of digital technologies makes lessons more student-centered and engaging (Pedro et al., 2019). These findings suggest that teachers' ability to use digital tools and platforms plays a critical role in improving the quality of education.

AI use and integration

In the Use and Integration of AI category, the potential of AI to foster creative thinking and problem-solving abilities stands out. The integration of AI into educational processes can help students develop innovative thinking skills (Onesi-Ozigagun et al., 2024). These findings revealed how AI can transform teaching strategies and offer more interactive and personalized experiences in education.

Assessment and decision making

In the Assessment and Decision-Making category, teachers' ability to assess student performance and analyze results plays a central role. AI can reduce teachers' workload by enabling more accurate and faster assessments in these processes (Chen et al., 2020). This supports teachers to make more data-driven and effective decisions.

Student-centered strategies and personalization

In the Learner-Directed Strategies and Personalization category, the competencies of developing personalized learning strategies and organizing data sources for autonomous learning are highlighted. AI can help create educational programs tailored to students' individual learning needs (Kaswan et al., 2024; Polak et al., 2022; Tapalova & Zhiyenbayeva, 2022). These findings revealed the importance of personalized approaches in education and the contributions of AI in this field. As emphasized by Karacaoğlu et al. (2025), the application of AI tools in education not only improves knowledge acquisition but also prepares individuals for high-risk contexts such as disaster response. Therefore, teacher competencies in AI should include the ability to design, interpret, and deploy such applications responsibly and effectively.

Technology and resource utilization

The Technology and Resource Use category highlights teachers' ability to use technology and the internet effectively. Appropriate use of technology makes lessons richer and more accessible (Gökdaş et al., 2024; Yau et al., 2023). This allows teachers to improve their educational processes by using digital tools and resources. Karacaoğlu (2025) considers the ability to use technology and the Internet effectively within the scope of digital literacy that a 21st century teacher should have.

Collaboration and teamwork

In the Collaboration and Teamwork category, the skills of participating in team activities and fostering collaborative learning environments stand out. These skills contribute to the development of students' social and academic skills (Lameras & Arnab, 2021). AI can help create collaborative learning environments and increase students' interactions within the group. This research showed that teachers' competencies related to the use of AI are important in various areas and how these competencies can affect various processes in education. The effective use of AI in education can significantly improve the educational experiences of teachers and students (Onesi-Ozigagun et al., 2024). However, these competencies need to be developed and teacher education programs need to be restructured to include AI integration (Chen et al., 2020; Pedro et al., 2019).

Future research may provide more insights into how these competencies can be applied in different educational contexts and how they can support teacher professional development. Furthermore, it is clear that to maximize the potential benefits of AI in education, educational policies and strategies need to be redesigned to account for this technology (Owoc et al., 2019; Popenici & Kerr, 2017; Schiff, 2022). This is an important step towards reducing digital and social gaps in education and ensuring more equitable and quality education for all students (Polak et al., 2022; Pratama et al., 2023). The systematic review study by Zawacki-Richter et al. (2019) highlighted the weak connection with theoretical pedagogical perspectives due to the almost complete absence of critical reflection on the challenges and risks of using AI in education and the need for further exploration of ethical and educational approaches in the application of AI in education. These findings suggest that teachers' competencies in the use of AI are multifaceted and play important roles in various fields. Developing these competencies will improve both their own and their students' educational experiences. Furthermore, this study suggests that educational institutions and policymakers should restructure teacher education programs and professional development opportunities to include AI integration. As a result, developing teachers' AI-related competencies is critical to improving quality in education. Future research can investigate how competencies differ across countries, disciplines or educational levels.

Conclusions

This study identified six core categories of teacher competencies related to artificial intelligence through a qualitative analysis of expert perspectives. The findings highlight the need to equip teachers not only with technical knowledge but also with pedagogical strategies to effectively integrate AI into educational environments. These competencies are critical for developing more personalized, data-driven, and innovative teaching practices. In this context, the results highlight the need to redesign teacher education curricula, expand access to AI-based tools, and promote the ethical and responsible use of AI in education.

Furthermore, these AI-related competencies significantly contribute to lifelong learning by encouraging teachers to continuously adapt to technological advancements and changing educational demands. Equipping educators with such competencies not only enhance individual professional development but also fosters educational leadership by empowering teachers to lead innovation and drive transformative

change within their institutions. Future research could investigate how these competencies are applied in various educational contexts, how teachers perceive themselves in relation to these competencies, and how they can be more systematically embedded in teacher development frameworks.

Recommendations

Based on the findings of this study, several suggestions were made to improve teachers' competencies in the use and integration of AI. Faculties of education and teacher training programs should offer comprehensive courses and practical training modules on the use of AI technologies in education. The curriculum should allow prospective teachers to learn how to use AI to foster creative and critical thinking. Continuous professional development opportunities should be provided for existing teachers and these programs should demonstrate how AI can be used effectively in the classroom. Seminars, workshops and trainings should be organized at regular intervals so that teachers can keep up with technological innovations. Schools should ensure that teachers and students can easily access AI-based digital tools and resources. By increasing investments in technological infrastructure and hardware, teachers should be supported to use digital platforms effectively. Teachers should develop personalized learning strategies using AI technologies, taking into account students' individual learning needs and academic backgrounds. AI should be used to identify students' strengths and weaknesses and provide appropriate learning materials accordingly. Schools should develop team-based projects and activities to foster collaborative learning environments. Teachers should encourage teamwork among students to ensure the integration of AI into collaborative learning processes. Teachers should be able to analyze students' academic performance in a more objective and detailed way by using AI-supported assessment tools. These tools should allow teachers to monitor student performance and reorganize educational strategies when necessary. Education policy makers should provide the necessary regulations and incentives to support the integration of AI into the education system. Guidance and standards for the ethical and safe use of AI technologies in education should be developed. These recommendations provide feasible strategies to increase teachers' competencies related to AI and to improve the quality of education. Future research and applications should evaluate the effects of these recommendations and contribute to the development of more effective teaching methods.

AUTHOR STATEMENT

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

The author solely contributed to all stages of the manuscript.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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