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Teachers and AI: Understanding the factors influencing AI integration in K-12 education

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Abstract

This study investigates the psychological and pedagogical factors influencing K-12 teachers' readiness to integrate artificial intelligence (AI) into educational settings. An exploratory qualitative approach was employed, involving 66 teachers from 11 disciplines at a private school in Türkiye participating in a professional development program focused on AI-enhanced teaching. Data were collected through online discussion forums and AI-supported learning activity design tasks and analyzed using inductive thematic analysis. Findings reveal that teachers valued AI for its efficiency, interactivity, and adaptability, particularly in tools like ChatGPT and MagicSchool, which supported personalized learning and lesson planning. However, significant challenges emerged, including technical issues, curriculum misalignment, ethical concerns, and cultural barriers, such as difficulties adapting AI-generated content to local contexts. The study concludes that while AI offers significant potential to enhance education, successful integration requires addressing the identified barriers through targeted support, resources, and ethical guidelines. Implications for further research include exploring diverse educational settings to generalize findings, conducting longitudinal studies to assess long-term impacts, and investigating strategies to align AI tools with existing curricula and ethical standards.

Keywords Artificial intelligence in education · K-12 education · Teacher experiences · Pedagogical integration

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1 Introduction

Artificial Intelligence (AI) refers to computers that execute cognitive tasks typically attributed to human intellect, such as learning and problem-solving (Baker et al., 2019). Despite the absence of a universally accepted definition, there is a consensus that AI is profoundly transforming our world (Niemi, 2021). As AI technology evolves, it is revolutionizing communication, lifestyle, work environments, and notably, education (Chiu et al., 2021). This transformation has sparked significant interest in understanding and enhancing the integration of AI for educational purposes (Chen et al., 2020).

AI has demonstrated substantial potential in supporting students' self-learning, enhancing literacy development, and improving learning outcomes through technologies like chatbots and predictive models (Ouyang et al., 2023; Wu & Yu, 2023; Xia et al., 2023). For instance, Dai (2023) underscores the pedagogical benefits of AI, including clarifying concepts through interactive learning experiences, enhancing understanding and skill acquisition, and fostering critical thinking. Similarly, Wu et al. (2023) show that AI interventions can enhance self-regulation and knowledge construction in blended learning environments, thereby boosting student motivation and engagement.

However, the integration of AI in educational settings remains less prevalent compared to other sectors (Luckin & Cukurova, 2019). This disparity is partly due to the underutilization of AI's potential in education (Luckin et al., 2022) and the insufficient consideration of teachers' roles in integrating AI into learning environments (Seufert et al., 2021). Ayanwale et al. (2022) emphasize that the effectiveness of AI in education heavily depends on teachers' readiness and positive attitudes towards the technology. Additionally, recent studies suggest that teachers often lack the necessary understanding of AI technologies and may feel disempowered by their use, which contributes to a decline in self-efficacy and reluctance to adopt these tools in the classroom (Chiu et al., 2023). For instance, despite positive perceptions of AI's potential benefits, only a minority of primary teachers have effectively implemented AI and ChatGPT in their classrooms, often due to a lack of readiness and knowledge (Galindo-Domínguez et al., 2023).

Furthermore, global initiatives underscore the importance of integrating AI in education. For example, China's strategic policy on education modernization encourages the integration of intelligent technology into education and emphasizes teacher professional development activities related to AI (Chiu, 2021; Xia et al., 2022). Similarly, in the United States, resources and grants are being allocated to research and develop AI-driven personalized learning platforms that aim to enhance cognitive engagement and reduce educational inequalities (Boninger et al., 2020; Williamson & Eynon, 2020). Despite these efforts, research on AI's impact on education remains fragmented, with calls for more comprehensive studies that involve educators in the design, implementation, and evaluation of AI technologies (Holmes et al., 2021; Rizvi et al., 2023).

Given these insights, this study aims to investigate the experiences and reflections of K-12 teachers regarding their readiness to integrate AI in instructional settings,

focusing on psychological and pedagogical factors. Understanding these factors is essential to help teachers navigate the complexities of AI integration and foster successful collaboration between educators and AI technologies (Woodruff et al., 2023). Building on prior research, such as Galindo-Domínguez et al. (2023), which explored the adoption and functionality of AI tools like ChatGPT across educational levels in Spain, this study extends the conversation by examining underexplored dimensions such as cultural barriers, curriculum alignment, and teacher training in a Turkish context. By identifying the key challenges and opportunities that AI presents in the classroom, this study seeks to provide insights that will enhance the integration and effective use of AI in education. Ultimately, this research aims to facilitate a seamless transition to AI-enhanced educational practices, ensuring that the benefits of AI advancements are realized in the learning environment.

2 Literature review

2.1 AI in education

The use of artificial intelligence in education (AIEd) denotes the application of AI technologies, such as intelligent tutoring systems, chatbots, robots, and automated assessment tools, across various digital platforms to enhance educational performance across subjects (Chiu et al., 2023; Martin et al., 2024). For instance, ChatGPT, a chatbot created by OpenAI, simplifies the integration of AI in teaching and learning (Lo, 2023). ChatGPT employs natural language processing to generate human-like responses to user prompts, making it a valuable tool for creating exam-style questions, addressing homework assignments, drafting academic essays, and automatically generating educational content (Zhai, 2022). Distinguished from its predecessors by its optimization for dialogue, ChatGPT is particularly adept at engaging in human-like conversations, contributing to its rapid adoption, reaching over one million users within five days of its release (De Angelis et al., 2023). Since then, the evolution of large language models (LLMs) like OpenAI's GPT series, Google's PaLM, and Anthropic's Claude models, along with their APIs, has been exponential. These advancements have enabled various third-party services to offer customized solutions (Yang et al., 2024). For example, MagicSchool provides teachers with over 60 AI tools for lesson planning, content creation, and student support, powered by multiple models (MagicSchool, 2024).

Although AI has been present since the 1960s, its practical application in education, particularly with the early development of intelligent tutoring systems, has evolved into a significant area of research (Bond et al., 2024). Research in this field focuses on various aspects including assessment methods (Zawacki-Richter et al., 2019), the integration of AI into instructional processes and pedagogical strategies (Kuka et al., 2022), and the technical and ethical issues associated with using AI in educational environments (Nguyen et al., 2023). Additionally, AI offers diverse opportunities for enhancing teaching and learning, such as language learning, research and writing support, and professional development for teachers (Kasneci et al., 2023). AI also aids in the assessment and evaluation process by helping to

create and review essays, research papers, and other academic assignments (Kasneci et al., 2023). AI tools for K-12, like Intelligent Tutoring Systems, are dynamic and continuously refined to present more sophisticated problem-solving strategies and adapt content delivery methods. This evolution has the potential to enhance student engagement and learning outcomes (Touretzky et al., 2019).

2.2 The role of teachers in embracing AIEd

Several internal and external factors influence teachers' integration of AI into their teaching methods. External factors include resources, funding, ICT infrastructure, technical support, administrative regulations, and policies on AI usage (Alam, 2022). However, psychological factors play a more fundamental role in either embracing or resisting new technologies. These factors originate from teachers' inner sense, which may not be readily apparent to others or even to themselves (Kerr, 1996).

The internal factors can be divided into two main sub-groups: psychological and pedagogical. While demographic factors such as age, years of experience, and familiarity with technology can influence teachers' readiness to adopt AI, this study focuses specifically on the psychological and pedagogical aspects, as they are more directly linked to teachers' attitudes and instructional practices in K-12 education (Darayseh, 2023). Psychological constructs encompass teachers' perceptions and attitudes, self-efficacy, and perceived benefits and risks. Pedagogical constructs involve the alignment of AI with instructional goals and teaching methods, adaptability and flexibility, and ethical considerations. Preparing teachers for AI-enhanced education represents a significant challenge as it involves navigating their propensity for either embracing or resisting AI (Zhang et al., 2023). Psychological factors are particularly critical as teachers' viewpoints on AI largely determine their ability or reluctance to embrace these technologies within school environments (Chiu & Chai, 2020). Teachers' resistance often stems from negative attitudes towards innovations and a hesitancy to leave their comfort zones, thereby hindering their willingness to embrace AI in the classroom (Istenic et al., 2021; Zhang et al., 2023). Additionally, media-driven perceptions that AI may replace human roles contribute to resistance (Chan & Tsi, 2023), often obscuring the ways AI can actually enhance teaching and learning (Luckin et al., 2016). This fear, driven by uncertainty about the unknown, might dramatically heighten the perceived risks over the benefits, as highlighted by Goasduf (2019) in the context of barriers to AI adoption. Past studies on technology integration show that teachers are more likely to perceive technology as useful and accept it when they feel confident about its usage (Agarwal & Karahanna, 2000; Lee & Ryu, 2013), which may also be applicable to AI integration.

Effective integration of AI depends on its alignment with current pedagogical goals and methodologies specific to K-12 education. Common approaches in K-12 settings include project-based learning, play/game-based learning, and collaborative learning strategies (Yim & Su, 2024). For example, engaging students in hands-on activities to investigate real-world applications of artificial intelligence serves as a practical illustration of project-based learning (Fernández-Martínez et al., 2021; Han et al., 2018). When teachers recognize AI's functionality in achieving their

instructional goals within the existing educational framework, such as enhancing student engagement through adaptive learning technologies or supporting individualized learning plans (Almusaed et al., 2023), their attitudes toward AI become more positive, fostering a willingness to embrace it (Lindner et al., 2019). Adaptability is another crucial pedagogical construct, which can be considered in terms of AI's capability to adapt to existing curricula or its ability to foster adaptive learning environments. In the latter case, the goal of adaptive learning is to modify resources to meet learner needs, rather than altering the learning environment itself to fit the situation or the learner (Luckin et al., 2005). Xie et al. (2022) highlights another dimension of adaptability—social adaptability. As AI changes interactions among teachers, students, and peers, it is essential to select AI systems that promote social skills, especially among adolescents. Ethical challenges also arise in the use of AI in education, particularly regarding issues that may exacerbate existing inequalities, privacy concerns, intellectual property rights, and the inherent susceptibility of AI algorithms to bias, which may contribute to either embracing or resisting its use (Adiguzel et al., 2023). To address these challenges, Jobin et al. (2019) proposed several ethical principles, including transparency, freedom and autonomy, trust, and dignity. Since AI technologies in K-12 education are rapidly advancing due to their wide range of dynamic features, their effective implementation requires strategic particularly-programmed teacher training (Antonenko & Abramowitz, 2023).

Despite the growing body of research on AI in education, there remains a significant gap in understanding how these various factors collectively influence teachers' integration of AI into their classrooms (Yim & Su, 2024), particularly within K-12 education, where pedagogical methodologies differ significantly from other fields like English language teaching or mathematics (Darayseh, 2023). Furthermore, while adaptability and ethical challenges are well-documented, less is known about how these factors interact with teachers' practical experiences in the classroom. Thus, this study addresses a crucial gap in the literature by investigating the influence of psychological and pedagogical factors on teachers' readiness to either embrace or resist AI integration in instructional settings. Understanding these factors is paramount in helping teachers navigate the complexities of AI integration and fostering successful collaboration between educators and AI technologies. The research seeks to answer the following questions:

1. What pedagogical strategies guide teachers in the integration and implementation of AI within their teaching practices in K-12 education?
2. What psychological and pedagogical factors influence teachers' integration of AI in K-12 education?

3 Methodology

In this study, an exploratory qualitative approach was employed to examine the roles of psychological and pedagogical factors on teachers' attitudes towards embracing or resisting the integration of AIEd. Exploratory research, as characterized by its flexible and open-ended approach, allows for a deep dive into phenomena that are

not well understood or are novel (Stebbins, 2001), as is the case with AI in education. This approach is particularly suitable for our study, as it seeks to uncover new insights and understandings about teachers' experiences and perspectives, which are likely to be diverse and influenced by a multitude of factors such as personal beliefs, technological proficiency, and pedagogical philosophy.

3.1 Context and participants

In the context of the effective use of educational technologies and digital tools, a private school in Türkiye, which is among Türkiye's leading educational institutions, has implemented the DLA as one of its ongoing initiatives. The DLA has been in place for 4 years, offering a program each semester aimed at the professional development of teachers. Its primary goal is to enhance teachers' technological and pedagogical knowledge by integrating it with the latest technologies. Throughout the year, DLA Teachers, who regularly meet with academic advisors and subject area experts, share the lesson designs they have created, including high-quality digital materials and content, along with their experiences in this field, with all teachers through digital platforms and regular teacher training sessions. Since its inception in 2020, the project has sequentially organized courses on various educational methodologies and theories, including flipped learning, formative assessment, cognitive presence, self-regulated learning, active learning, and Hyflex learning.

Within the scope of this study, the artificial intelligence in education course has been added to the program. Throughout this course, participating teachers engaged in a 14-week period where they were introduced to generative AI in teaching. The course included topics such as introduction to AI in education, educational examples with AI, writing prompts and gaining experience, writing and search assistants, content scanning and summarizing, presentation creation, classroom assistant AI tools, creating fictional characters with AI, strategies for using AI in education and creating learning materials. The participants took part in video lessons and activities covering these subjects through the Moodle learning management system.

For this study, purposeful sampling was employed. This method was chosen because the aim was to include teachers who are actively involved in the DLA and have varying levels of experience with technology integration in education. Purposeful sampling allowed for the selection of participants who were directly relevant to the research objectives, as these teachers were engaged in the professional development program that focuses on integrating artificial intelligence into teaching practices. The participants were selected based on a voluntary application process, where teachers applied to participate in the program, and the final selection was made by the institution, ensuring a diverse representation of teachers. While this selection process ensured a diverse sample, it may introduce some bias as more motivated or technologically inclined teachers were likely to volunteer and be selected.

In the 2023–2024 academic year during the fall semester, 66 teachers from 11 different disciplines participated in the DLA, constituting the participants of the study. The experience levels of these teachers vary, ranging from four years to over 20 years. Before the commencement of the study, 25 of the teachers were participating

Table 1 Teachers and disciplines

Discipline	Pre-school	Primary school	High school	Total
Classroom	5 (3 new)	9 (3 new)		14
Mathematics		4 (1 new)	4 (2 new)	8
Literature		5 (2 new)	5 (2 new)	10
Foreign Languages		7 (1 new)	6 (4 new)	13
Social sciences		3 (1 new)		3
History			3 (2 new)	3
Geography			1	1
Sciences		5 (3 new)		5
Physics			2	2
Chemistry			3 (1 new)	3
Biology			4	4
Total	5 (3 new)	33 (11 new)	28 (11 new)	66 (25 new)

in the DLA for the first time, while 41 had been attending the program for at least one semester. Excluding their prior experiences, the teachers, within the scope of the DLA, have taken a course on generative artificial intelligence in education for the first time. The distribution of teachers by their disciplines and the number of teachers participating in the DLA for the first time, according to their discipline, is shown in Table 1.

3.2 Data collection tools

This study employed a multifaceted approach to data collection. The methods were designed to gather in-depth insights from educators through the following tools: online discussion forums, and AI-supported learning activity design task. As defined by Denzin (1978), using more than one method or source of data in the investigation of the research questions helps to confirm the robustness of the results.

3.2.1 Online discussion forums

Online discussion forums are instrumental within online learning environments, enabling learners to generate, collaborate on, and interact with information either synchronously or asynchronously (So, 2009). At the outset of the course, a forum was established to gather teachers' anticipations on how AI might reshape education, alongside another forum aimed at eliciting inspirational ideas pertinent to their specific fields. A total of 133 messages were exchanged across these forums. Strategically initiated in the course's early weeks yet kept open for teacher engagement throughout its duration, these forums were pivotal in fostering a continuous exchange of insights. The timing of these forums was strategically chosen to coincide with key stages in the course, aiming to capture evolving perceptions and foster a dynamic exchange of ideas.

In the final two weeks, an additional forum was launched to encourage reflection and discussion among teachers regarding their AI experiences throughout the course. Organized into five sub-forums, the topics included student feedback, student learning and ethical concerns, ideal AI tools, usage challenges, and AI tool preferences, focusing particularly on classroom applications of AI. This was in response to the teachers' eagerness to directly apply their new knowledge and experiences. Altogether, 240 messages were posted, underlining the forum's role in facilitating meaningful discourse on AI in education.

3.2.2 AI-supported learning activity design task

The aim of the AI-supported learning activity design task was to facilitate the integration of AI into instructional processes, promote responsible, ethical, and safe usage of AI tools among students, and offer hands-on and interactive learning experiences with AI. Teachers were tasked with designing a learning activity, guided by a seven-part template, to reflect applicable practices derived from their experiences throughout the course. This task yielded 63 innovative learning activity designs. In guiding teachers, the study emphasized ethical considerations, engagement, and practical application of AI tools in various educational contexts, encouraging inventive teaching methods within a responsible and ethical AI usage framework.

3.3 Data analysis

The data obtained from two sources have been subjected to inductive thematic analyses. Thematic analysis is a versatile method widely used in qualitative research to explore opinions, perceptions, and attitudes (Braun & Clarke, 2006). This approach allows for the identification of emerging themes directly from the data (Fereday & Muir-Cochrane, 2006). Initially, all qualitative data collected through online discussion forums and AI-supported learning activity design tasks were compiled and meticulously organized. During this process, the data were compiled into a single spreadsheet and anonymized. Data saturation was systematically monitored and considered reached when no new themes or insights emerged, ensuring comprehensive coverage of the research questions.

Open coding was first applied, where segments of data were labeled with codes that represented the core idea or concept they conveyed. This initial coding process was performed by one researcher to maintain consistency. Subsequently, two additional researchers reviewed the coded data to ensure trustworthiness through triangulation and peer debriefing, providing different perspectives on the interpretation of the data (Creswell & Miller, 2010). During this collaborative review process, the research team engaged in discussions to refine and agree upon the codes, resolving any discrepancies through consensus. This iterative process of coding and discussion ensured that the final set of codes was robust and reflective of the data's nuances.

Following the establishment of a finalized codebook, the research team identified patterns and relationships among the codes. Related codes were grouped into potential themes and sub-themes that captured both the underlying meanings in the

data and the theoretical constructs of interest. Credibility was further ensured by critically examining each theme and validating it against the dataset to confirm that it represented a significant aspect of the data related to the research questions.

An integrative approach was adopted to synthesize findings from the two data sources. This involved comparing themes identified from discussion forums and learning activity designs to develop a comprehensive understanding of educators' experiences with AIEd. Themes were reviewed for coherence, and overlapping themes were merged or redefined to ensure clarity and distinctiveness, further enhancing the dependability and confirmability of the findings.

3.4 Ethical considerations

After a thorough review, it was determined that the study does not require ethics committee approval. This decision was grounded in the fact that the data concerning teachers' professional development program experiences were obtained through an official contract established between the private school and the teachers. The contract explicitly included provisions for the participation of teachers in professional development activities and the use of related data for educational research purposes, ensuring that all parties were informed and had agreed to these terms beforehand.

Despite the exemption from formal ethics committee approval, the research team remained committed to upholding high ethical standards, particularly regarding anonymity, and protection of personal data. Rigorous measures were taken to ensure that all personal information of participants was anonymized in the presentation and dissemination of the study's findings. Identifying details were removed or altered, and any data potentially traceable back to individual participants were handled with the utmost care to protect their privacy and confidentiality.

4 Findings

As a required component of the course, teachers were asked to create and implement activities that leverage AI tools to enhance student learning. Below are the types of AI tools used, the various approaches taken by teachers, and teachers' desired features for AI tools and their inspiring ideas. A total of 59 designed activities were examined. First, it was found that ChatGPT is the most commonly used AI tool in the classroom, followed by MagicSchool, Canva, Gamma, and Character.ai. Figure 1 presents the tools teachers preferred for designed activities.

To explore the pedagogical integration of AI tools, teachers designed activities analyzed thematically. Table 2 presents the common themes and example AI tools with their respective use cases, illustrating how these technologies support various educational strategies and considerations.

The integration of AI tools into educational practices is guided by various pedagogical strategies that emphasize critical thinking, collaboration, creativity, and real-world applications. These tools support differentiated instruction and interactive learning, enhancing both teaching and learning experiences. The thematic analysis

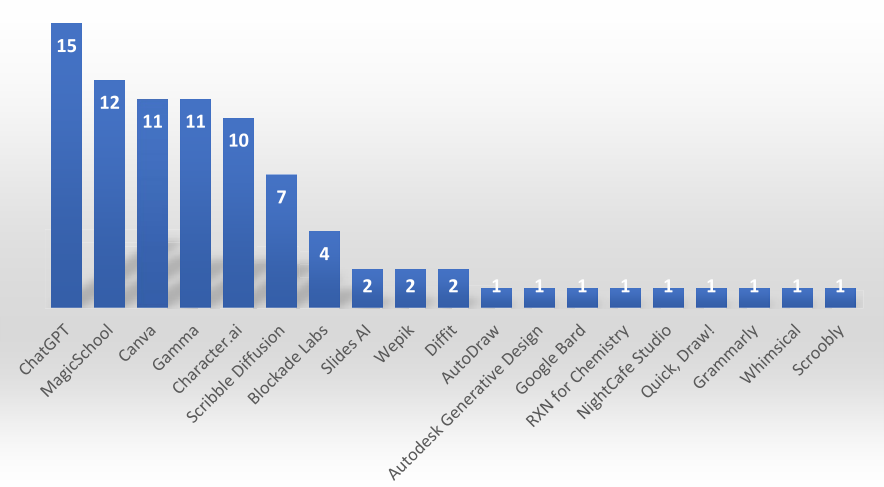

Fig. 1 AI tools preferred by teachers in designed activities

presented in Table 2 highlights the multifaceted approach teachers take in integrating AI tools, demonstrating their potential to transform educational practices.

In addition to sharing their educational practices, teachers were asked to provide inspiring ideas on how AI can be used in their disciplines and to express their preferences for different types of AI tools. Examining this is important because it not only highlights their current experiences but also identifies their perceived needs.

The analysis of teachers' preferences for AI tools and their inspiring ideas for AI use in education, as detailed in Table 3 of Appendix 1, reveals several key themes and considerations that guide their innovative practices. Teachers value AI tools capable of comprehensive curriculum design, interactive and adaptive learning, and efficient lesson planning and differentiation. These tools are highly regarded for their ability to tailor education to individual student needs and improve learning outcomes.

Support for differentiated instruction, progress tracking, and performance evaluation are also essential features that teachers look for in AI tools. Tools that facilitate progress tracking and provide timely feedback are critical for monitoring student development and gaining insights into their academic performance. Additionally, AI tools that support visual and interactive learning, such as simulations and animations, are valued for their ability to help students understand complex concepts and engage in the learning process.

Furthermore, teachers have inspiring ideas for using AI to enhance educational experiences. These ideas include using AI for mathematics and statistics simulations, visualizing scientific concepts, and creating interactive history and social studies lessons. AI tools are also envisioned to support creative writing, research and literature analysis, and grammar and language learning, demonstrating their potential to enrich educational practices through innovative, personalized, and efficient approaches. The integration of AI into education not only enhances teaching and learning but also prepares students for future challenges by developing essential skills and competencies.

Table 2 Pedagogical strategies and considerations in AI integration

Theme	Strategy/Consideration	Example AI Tools and Use Cases
Constructivist learning	Active, student-centered process, project-based learning	Character.ai: Creating characters, engaging in discussions, and reflecting on character traits
Critical thinking	Developing the ability to evaluate AI's limitations and ethical issues	Character.ai: Solving problems by asking historical characters questions
Collaborative learning	Group work, peer learning, collaborative projects	ChatGPT: Writing stories and creating quizzes in groups
Inquiry-based learning	Research, exploration, and discovery	Gamma: Creating presentations on various topics, such as breath therapy and sustainable development goals
Visual and auditory learning	Utilizing visual and auditory stimuli to enhance learning	Scribble Diffusion: Drawing and describing famous products; Magic School: Creating songs and sayings using cultural concepts
Differentiated instruction	Tailoring activities to meet individual learning needs	Canva, Scroobly: Creating visual designs, drawing and animating characters, and preparing and presenting stories
Real-world applications	Connecting learning to real-life scenarios and practical applications	ChatGPT, MagicSchool: Preparing and solving word problems related to percentages and fractions
Creative expression	Encouraging creativity through story creation, drawing, and interactive tasks	Canva, Character.ai: Reading and creating fairy tales, designing a fairy tale book
Problem solving	Teaching students to solve specific issues using AI tools	Autodesk Generative Design: Creating optimized designs for sustainability issues
Presentation skills	Developing the ability to present information clearly and effectively	Gamma, Google Bard, ChatGPT: Researching and presenting on forms of government, properties of matter, and other topics
Interactive learning	Engaging students in active participation and discussions	Scroobly: Animating sentences, discussing emotions and expressions
Feedback and improvement	Providing opportunities for self-assessment, peer review, and iterative improvements	Magic School: Enhancing writing skills through feedback, improving presentations

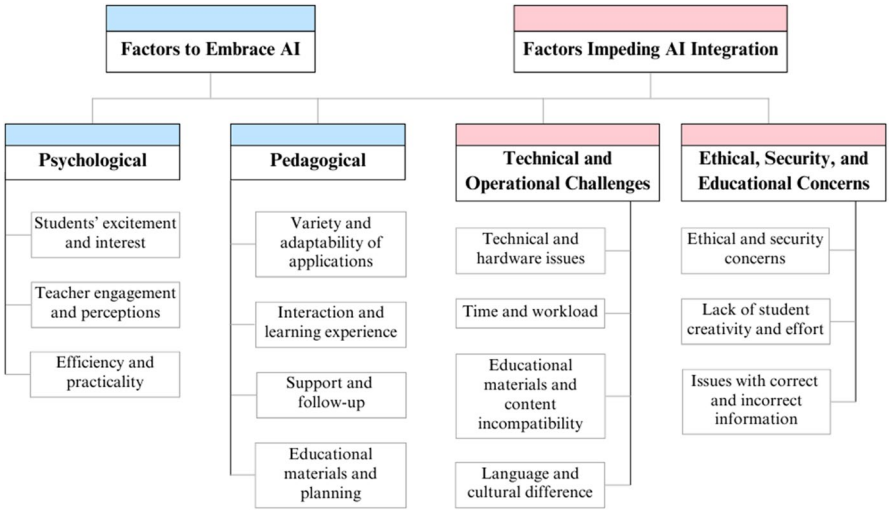

Fig. 2 Factors influencing teachers' embracement or impede AI integration

4.1 Factors influence teachers' integration of AI

The findings of this study reveal a complex interplay of factors that influence teachers' embracement or impede the integration of AIEd. Through meticulous thematic analysis, two principal categories emerged, which are detailed in Fig. 2.

As shown in Fig. 2, these categories are: Factors to Embrace AI and Factors Impeding AI Integration. Each category is supported by themes and sub-themes with direct excerpts from teachers (see Table 4 of Appendix 1), illustrating their nuanced perceptions and experiences with AI use. For example, the theme Efficiency and Practicality emerged from excerpts such as "AI can facilitate creating multi-dimensional plans for teachers and may have an impact on processing and evaluating data more quickly" and "The possibility of creating quality content in a short time will increase with AI tools". Both statements emphasize the timesaving and task-streamlining potential of AI, consistently highlighting its ability to support teachers in managing their workload more effectively. This recurring emphasis on efficiency across different teacher perspectives validated the theme. To ensure anonymity, teachers were assigned pseudonyms that were not derived from their actual names.

4.2 Psychological factors influence teachers' embracement AI integration

4.2.1 Students' excitement and interest

One of the key psychological factors driving the embracing AI in education is the excitement and interest shown by students. Teachers have observed that AI tools can capture students' attention and enthusiasm, making learning more engaging and interactive. For instance, primary school classroom teacher, Ayla noted, "I think our students are generally excited; different tools attract their attention very much." This

sentiment is echoed by pre-school classroom teacher, Melike who used the scribble diffusion application with kindergarten students and observed, "They were very excited and interested."

Additionally, the curiosity and enthusiasm for AI extend beyond the classroom. Primary school science teacher, Demet remarked, "I think they are excited. In fact, I had students who continued with the application at home." In addition, high school literature teacher, Barış highlighted the broad appeal of AI, stating, "Artificial intelligence is a serious topic of curiosity. They are more interested than we are."

4.2.2 Teacher engagement and perceptions

Teacher engagement and perceptions play a crucial role in the successful integration of AI in educational settings. For instance, teachers have observed that introducing AI through in-class activities not only enriches the course content but also makes the lessons more enjoyable for students. Primary school classroom teacher, Pınar shared, "Introducing my students to AI started with in-class activities. Since it enriches the course content, we can have more enjoyable activities." Primary school literature teacher, Filiz noted, "The activities prepared by utilizing AI in the lesson attract their attention very much."

Additionally, there is a general consensus that AI tools align well with students' ways of thinking and learning. Teachers believe that AI can complement traditional teaching methods, providing diverse and engaging materials that capture students' attention and maintain their interest. Primary school mathematic teacher, Betül remarked, "Although I haven't actively used it in class with my students, I think the idea of AI fits their way of thinking."

4.2.3 Efficiency and Practicality

Teachers appreciate how AI tools can streamline various tasks, making their work more manageable and effective. They have highlighted the potential of AI to create quality content quickly, thereby increasing the overall efficiency of educational processes. For instance, high school history teacher, Deniz mentioned, "The possibility of creating quality content in a short time will increase with AI tools. Its use will become quite widespread in all areas of education."

AI tools are also seen as beneficial for lesson planning and monitoring student performance. Teachers believe that these tools can facilitate the creation of multi-dimensional plans and improve the accuracy of performance evaluations. Primary school classroom teacher, Sevgi noted, "AI can be effectively used in lesson planning. It can facilitate creating multi-dimensional plans for teachers and may have an impact on processing and evaluating data more quickly."

Moreover, AI applications have been praised for making teachers' work easier in various situations. Primary school foreign language teacher, Kaan shared, "So far, the AI tool I liked the most is the 'gamma' application. Because it quickly prepared a presentation file on the topic and detail I wanted; it made my work easier."

4.3 Pedagogical factors shape teachers' readiness to embrace AI

4.3.1 Variety and adaptability of applications

The variety and adaptability of AI applications are highly valued by teachers, as these tools offer diverse resources that can be tailored to different teaching needs. Teachers have found applications like Magic School to be particularly useful. High school chemistry teacher, Özge mentioned, "I think the Magic School application is very useful and beneficial. With the different tools it contains, we can access many things we might need." Primary school social sciences teacher, Sibel noted, "One of my favorite tools is Magic School. Having numerous materials that we can adapt to our lessons not only makes our work easier but also helps us gain different perspectives."

4.3.2 Interaction and learning experience

AI tools provide opportunities for personalized learning experiences, which can significantly improve student engagement and outcomes. Teachers observed that AI tools significantly enhance interaction and personalize learning experiences. For example, a primary school foreign language teacher, Kaan, noted, 'AI can offer personalized learning experiences by better understanding students' individual needs and learning styles. For example, it can identify a student's weak points and provide special learning materials or exercises.' Similarly, a high school biology teacher, Ebru, emphasized AI's potential for interactivity, stating, 'I think AI will make learning materials more interactive for students. Students will be able to interact more with technologies such as virtual reality or augmented reality.

4.3.3 Support and follow-up

The support and follow-up capabilities of AI tools are also highly regarded by teachers. These tools can assist in monitoring student progress and providing additional resources. High school mathematics teacher, Selda highlighted, "AI can offer better student monitoring and evaluation tools for teachers." Pre-school classroom teacher, Ferda mentioned, "When AI is used in education, it can enrich the student experience and provide more resources and support to teachers."

4.3.4 Educational materials and planning

AI tools can significantly aid in the creation of educational materials and planning. Teachers have found these tools to be valuable in generating content and structuring lessons. For instance, primary school social science teacher, Nihal stated, "AI will be useful for teachers in lesson planning." Primary school classroom teacher, Nermin remarked, "Teachers can have difficulty finding stories or dictations suitable for each PYP concept and have to create them themselves. With detailed command systems, it is possible to obtain 3-sentence dictations and short stories with ChatGPT."

4.4 Technical and operational challenges impeding AI integration

4.4.1 Technical and hardware issues

Technical and hardware issues are significant barriers to the effective implementation of AI tools in education. Teachers often encounter problems related to the availability and functionality of necessary technology. Primary school classroom teacher, Ayla, "Since I am newly familiar with AI tools, I can't use them regularly in daily life. I sometimes experience technical problems while using them." Primary school classroom teacher, Tuna highlighted the lack of appropriate devices in primary schools: "At the primary school level, since tools like iPads and phones are not used in the classroom, we cannot benefit from interactive activities."

4.4.2 Time and workload

The time required to learn and implement AI tools, coupled with existing workload demands, poses a significant challenge for teachers. They find it difficult to allocate time for learning new technologies amidst their busy schedules. High school biology teacher, Nilay explained, "Producing materials other than the methods we know, or let's say producing materials under any circumstances, is still a topic that requires time and research. Time can be lost with the trial-and-error method." Primary school mathematic teacher, İlknur expressed concern about the intensity of the curriculum: "The intensity of the curriculum and the fact that it is not parallel with the education and examination system we are in is the biggest challenge."

4.4.3 Educational materials and content incompatibility

The compatibility of AI-generated content with existing curricula and teaching methods is another impediment to AI integration. Teachers often find that AI tools do not always align with their specific educational needs. Primary school mathematics teacher, Betül observed, "Since they have content that is not suitable for teaching mathematics or incompatible with the curriculum, I can only use them as support, especially in complex situations." High school literature teacher, Erhan mentioned, "Not every product can be adapted to every academic subject. I think this is the main problem."

4.4.4 Language and cultural differences

Language and cultural differences can also hinder the effective use of AI in education. Many AI applications are primarily designed for English-speaking users, which can create difficulties for students and teachers in non-English-speaking regions. Primary school science teacher, Demet stated, "Since most AI applications are English-based, I think students have difficulties, especially in those that require text writing." Additionally, cultural differences can affect the relevance and appropriateness of AI-generated content. Primary school foreign language teacher, Dilek shared, "Since it provides convenience in many areas, I can't say it's a difficulty, but

the only deficiency is culturally. When I give the command to prepare a humorous text in English lessons, the jokes are generally not funny in our culture."

4.5 Ethical, security, and educational concerns impeding AI integration.

4.5.1 Ethical and security concerns

Teachers are concerned about the ethical implications and security issues related to the use of AI in education. Primary school classroom teacher, Ayla expressed worries about data privacy and student information security: "I think it is essential to learn AI tools. There may be security issues regarding the use of student information ethically." High school literature teacher, Metin pointed out, "Students at a lower level of learning may make it a routine and present all their assignments to us through these tools. Despite our awareness, this situation may prevent us from grading fairly."

4.5.2 Lack of student creativity and effort

AI tools can sometimes discourage students from putting in the necessary effort and developing their creativity. Teachers have observed that reliance on AI can lead to a lack of originality in students' work. High school mathematics teacher, Orhan mentioned, "Similarly, the use of this by students bothers me a bit because it eliminates creativity and effort." Primary school classroom teacher, Nermin added, "There are scary aspects. Sometimes I wonder if it will foster creativity or create laziness."

4.5.3 Issues with correct and incorrect information

The accuracy of AI-generated content is another concern for educators. Teachers worry about students using AI tools to complete assignments without verifying the information. High school foreign language teacher, Şebnem stated, "AI use by students is directly considered plagiarism; they need to learn effective use, ethical use, and how to give references." Primary school social science teacher, Nuran shared, "I am worried that they might want to copy their assignments without researching."

In conclusion, while AI offers significant potential for enhancing education, several factors impede its integration. Technical and operational challenges, along with ethical, security, and educational concerns, present substantial obstacles. Addressing these barriers through targeted support, resources, and guidelines can help educators and developers work towards more effective and inclusive use of AI in education.

5 Discussion and conclusion

The findings of this study underscore the multifaceted dynamics shaping teachers' readiness to embrace or impede the integration of artificial intelligence in K-12 educational settings. Through an in-depth thematic analysis, two principal categories emerged: factors supporting the embrace of AI and factors impeding its integration.

5.1 Factors supporting the embrace of AI

The embrace of AI in K-12 education is driven by a range of psychological and pedagogical factors that collectively enhance teaching efficiency and student engagement. Teachers have observed that AI tools not only engage students during classroom activities but also motivate them to continue learning outside the school environment. Research has established that providing students with access to current technology leads to greater engagement and motivation in their learning processes (Pandita & Kiran, 2023). AI, as a contemporary technology, similarly evokes excitement and interest in students. Williams et al. (2023) also found that AI-generated interactive outputs significantly contribute to this enthusiasm, particularly among younger students.

Teacher engagement and perceptions are crucial for the successful integration of AI in education (Addo & Sentence, 2023). Teachers report that AI tools enrich course content, making lessons more enjoyable and engaging. AI-driven activities capture students' attention and align well with their thinking and learning styles. These findings also align with the conclusions of Xiaohong et al. (2024), who determined that perceived playfulness is a significant factor influencing teachers' adoption of artificial intelligence learning platforms. The importance of perceived playfulness in the acceptance of technologies, such as learning management systems, has been previously demonstrated (Balkaya & Akküçük, 2021). Thus, the enjoyable nature of AI tools facilitates their integration in the classroom.

Another significant factor is the efficiency and practicality of AI in streamlining tasks, creating quality content, and aiding in lesson planning. Literature indicates that teachers tend to use technologies they find beneficial (Eze et al., 2021; Younas et al., 2023). This is supported by research highlighting the importance of teachers' perception of AI's usefulness in their adoption of the technology (Chocarro et al., 2021; Darayseh, 2023; Ukoh & Nicholas, 2022). Similar to the findings of this study, Celik et al. (2022) highlight the potential benefits of AI for teachers, such as planning and streamlining tasks like automated assessment and evaluation.

Pedagogically, AI offers significant benefits through variety, adaptability, and personalized learning experiences (Hashem et al., 2023). AI applications, such as the Magic School, provide teachers with versatile resources that can be tailored to meet different teaching needs (Chiu, 2021). This adaptability allows educators to enhance their teaching methods and engage students more effectively. Teachers appreciate the range of AI tools available, which can be applied at various stages of a lesson to enrich the learning experience.

Furthermore, AI supports personalized and interactive learning, catering to individual student needs and learning styles (Zafari et al., 2022). By identifying students' weaknesses and providing tailored learning materials (Tang et al., 2021; Whalley et al., 2021), AI enhances student engagement and outcomes. Teachers have observed that AI can make learning more interactive through technologies like virtual and augmented reality, suggesting that learning will become even more engaging with the integration of AI with AR and VR. Additionally, the support and follow-up capabilities of AI tools help teachers monitor student progress and provide continuous resources and support. Studies have shown that AI plays a supportive role in enhancing teaching effectiveness (Lin, 2022). These features help teachers understand and address student needs more effectively, streamline lesson planning, and generate high-quality

educational materials, ultimately making the educational process more efficient and impactful. Additionally, it shows that the field is dynamic and open to many studies to address the ever-evolving needs of teachers and students (Chiu, 2021).

5.2 Factors impeding the AI integration

The integration of AI in education presents numerous benefits; however, several factors impede its widespread integration. A significant barrier is the lack of appropriate devices. This underscores the critical need for providing the necessary infrastructure to support AI integration. Multiple studies have identified infrastructure as a primary obstacle to technology integration in education (Akram et al., 2022; Bingimlas, 2009). Specifically, devices such as phones and tablets may be prohibited due to institutional policies, particularly at the preschool and elementary levels. Concerns about student responsibility often prevent these devices from being provided to students. In this context, schools making their hardware devices available to teachers for classroom use emerges as a viable solution.

Furthermore, in Türkiye, various studies have highlighted teachers' concerns regarding their workload (Erail et al., 2024; Kolburan Geçer & Bakar-Çörez, 2020). The excessive workload and the time-intensive process of developing materials using not only AI tools (Ahmed et al., 2022) but also general technology are significant inhibiting factors, as evidenced by Francom (2019). However, teachers in this study suggested that certain AI tools, such as MagicSchool and ChatGPT, could alleviate some of these burdens by streamlining lesson planning, automating repetitive tasks, and providing ready-to-use templates for activities. Additionally, integrating AI training into scheduled professional development sessions or offering asynchronous learning opportunities could help teachers acquire the necessary skills without adding to their workload. From a systemic perspective, reducing administrative responsibilities and prioritizing the integration of AI tools that directly address common teacher challenges can also contribute to mitigating the time constraints faced by educators. By leveraging these strategies, AI can transition from being perceived as an additional workload to a supportive resource that enhances efficiency and reduces stress.

Additionally, for AI-generated content to support seamless integration, it must be more compatible with existing curricula and adaptable to various educational contexts. Once teachers recognize the effectiveness of AI in achieving their most challenging instructional goals within their current educational paradigm, their stance towards AI is likely to become more positive (Lindner et al., 2019). While some educational AI tools already produce content aligned with specific standards (e.g., Common Core State Standards), the alignment and widespread integration of these standards with the curriculum remain insufficient. A novel finding of this study is the identification of cultural barriers, particularly in adapting AI-generated content like humor to local contexts. These challenges are rarely addressed in existing AI tools, which predominantly cater to English-speaking users and Western educational frameworks. Addressing such barriers by incorporating cultural and linguistic adaptability into AI design could enhance the relevance and equity of AI tools in diverse educational settings.

Moreover, ethical, security, and educational concerns further complicate the integration of AI in education. Issues related to data privacy, student information security, and the potential for AI tools to diminish student creativity and effort highlight the need for

robust ethical guidelines and security measures. Teachers are also concerned about the accuracy of AI-generated content and the risk of plagiarism, underscoring the importance of teaching students to use AI tools responsibly. These concerns are currently being addressed by many researchers (Akgun & Greenhow, 2022; Holmes et al., 2021; Kim et al., 2022; Su & Zhong, 2022; Yau et al., 2022). Similar to the findings in Douali et al.'s (2022) study, the current research indicates that addressing teachers' ethical, security, and educational concerns regarding AI use should be a priority.

Addressing these barriers through targeted support, resources, and clear guidelines can help educators and developers work towards more effective and inclusive use of AI in educational settings. Ensuring that the necessary infrastructure is in place, workloads are manageable, and that ethical and security concerns are adequately addressed will be essential for the successful integration of AI in education.

5.3 Overcoming challenges and enhancing pedagogical strategies for AI Integration in education

The integration of AI in education presents significant potential, as evidenced by our analysis of 59 designed activities. ChatGPT emerged as the most commonly used AI tool, followed by MagicSchool, Canva, Gamma, and Character.ai. The thematic analysis of teachers' approaches highlights various pedagogical strategies and considerations in AI integration.

Based on our data analysis, Table 2 illustrates how these specific AI tools are employed to enhance specified pedagogical strategies, demonstrating their adaptability and effectiveness in various educational contexts. Our findings show that AI tools support diverse educational strategies, including constructivist learning, critical thinking, collaborative learning, inquiry-based learning, visual and auditory learning, differentiated instruction, real-world applications, creative expression, problem-solving, presentation skills, interactive learning, and feedback and improvement.

Moreover, teachers' desired features and inspiring ideas for AI tools underscore the need for comprehensive curriculum design, interactive and adaptive learning, efficient lesson planning, and differentiation. Teachers value AI tools that support progress tracking, performance evaluation, visual and interactive learning, and tailored education to individual student needs. These tools are critical for enhancing learning outcomes and providing timely feedback.

This research provides numerous theoretical contributions by offering new insights. Firstly, it contributes to designing a comprehensive framework that identifies and classifies the supporting factors and barriers to AI integration in K-12 education. Secondly, while much of the existing literature focuses on AI for automating tasks or increasing administrative efficiency, the focal point of this study is on how AI tools proactively enhance the quality of instruction. Thus, it provides suggestions to address individual student and teacher requirements via AI integration. Thirdly, by exploring what would make a perfect AI tool, participants have added another dimension to this study, moving the discourse beyond current AI applications to consider how future innovations in hardware and immersive technologies are likely to further change educational practice through AI. Additionally, the consideration of ethical issues in this research denotes

the development of new ethical frameworks that will guide the integration of AI into K-12 education and contribute to general AI ethics. These contributions are helpful in expanding theoretical understanding and suggesting practical implications for educators, policymakers, and developers aiming to enhance K-12 education through AI.

6 Limitations and suggestions for further research

Despite the strengths of this study, several limitations should be acknowledged. First, the exploratory qualitative approach used in this study, while insightful, limits the generalizability of its findings due to its context-specific nature. Conducted within a single private school in Türkiye, the unique characteristics of this institution and its Digital Learning Academy (DLA) initiative could influence teachers' attitudes and experiences with AI in education. The homogeneity of the group, all from the same institution, may not reflect the broader educational landscape, thereby restricting the applicability of the results to other settings. The challenges and barriers identified, while relevant to the participants in this study, may vary significantly across different educational systems, cultures, and institutional practices. Therefore, caution should be exercised in generalizing these results to broader international settings. Future research should involve diverse educational contexts, including public schools and institutions across different countries, to examine how cultural, systemic, and infrastructural differences impact AI integration. Cross-national comparative studies could provide a deeper understanding of these dynamics and inform the development of globally adaptable AI tools.

Second, the data collection methods, including online discussion forums and AI-supported learning activity design tasks, have inherent limitations. Online forums, while providing a platform for diverse teacher reflections, may not capture the full depth of participants' thoughts due to their asynchronous nature and the potential for brevity in responses. Teachers may also have felt constrained by the semi-public environment, leading to self-censorship or less candid reflections. Similarly, AI-supported tasks might not fully represent the theoretical challenges teachers face or the practical barriers to AI integration in classrooms. These limitations highlight the need for complementary methods, such as interviews or focus groups, to gain richer, more nuanced insights into teachers' experiences. Additionally, the thematic analysis, despite efforts to ensure consistency and reliability, is subject to interpretive biases. The varied technological proficiency and pedagogical philosophies of the teachers, along with ethical considerations of AI use, were not deeply analyzed, necessitating further research to provide a more comprehensive understanding of AI integration in diverse educational contexts.

Moreover, longitudinal research should be conducted to track the long-term impact of AI integration on student outcomes, as the short-term nature of this study does not allow for the observation of sustained changes in student learning or teacher practices. Longitudinal studies would provide insights into how AI influences student achievement, engagement, and development over time, offering a clearer understanding of AI's lasting effects in K-12 settings. Additionally, investigating how AI-driven assessments evolve to meet students' changing needs and capabilities would be an essential area for future research.

The integration of AI in K-12 education is still an emerging field; therefore, it requires extensive research in order to unveil several emerging aspects, challenges, and

opportunities. For example, there are limited studies on how to integrate AI effectively into the K-12 curriculum. It calls for deeper investigation to support AI education frameworks for teachers and students (Anonenko & Abramowitz, 2023). Additionally, AI education programs in K-12 are growing, however, many studies depend on small sample sizes and self-reports. This shows that it is of importance to conduct research involving objective measures related to students' knowledge acquisition and learning outcomes (Yue et al., 2022). Another emerging research area pertains to NPUs, which are specialized hardware for machine learning and AI computations. Compared to CPUs, NPUs have the potential to increase the efficiency of processing AI tasks. They immensely increase the speed and energy efficiency of AI in instructional applications (Lin et al., 2023). They also enable real-time, adaptive learning environments through handling deep neural networks (Ahn et al., 2022). Altering the use of AI in K-12, NPUs may have a great impact on learning and teaching processes in K-12, which requires further research.

7 Implications for stakeholders

Addressing the challenges and enhancing the integration of AI in education involves several key considerations:

- **Technical and Operational Support:** Providing adequate technical support and hardware, such as tablets and computers, is essential. Schools need to ensure that teachers have access to necessary devices and technical assistance to overcome operational challenges. Additionally, improving infrastructure to accommodate AI-driven tools can facilitate their seamless integration into classrooms.
- **Curriculum Compatibility and Flexibility:** AI tools must be compatible with existing curricula and adaptable to various educational contexts. Collaboration between AI developers and educators can help create flexible tools that align with specific teaching needs. Moreover, addressing cultural nuances in AI-generated content, such as humor and localized examples, can enhance the relevance and equity of these tools, ensuring their effectiveness across diverse educational settings.
- **Ethical Guidelines and Security Measures**: Establishing robust ethical guidelines and security measures is vital to protect student data and ensure the responsible use of AI. Teachers and students must be trained in ethical AI usage and data privacy practices.
- **Balancing AI Use with Creativity and Critical Thinking:** It is important to balance the use of AI tools with activities that encourage creativity and critical thinking. Assignments should be designed to engage students interactively and thoughtfully, ensuring that AI enhances rather than diminishes student effort and originality. Schools can also consider integrating AI tools that promote student collaboration and problem-solving skills alongside traditional methods.
- **Teacher Training and Professional Development:** Continuous professional development and training for teachers are crucial to help them effectively integrate AI tools into their teaching practices. Providing resources and support for learning new technologies can help manage workload demands and enhance pedagogical strategies.

Appendix 1

Table 3 Teachers' preferences for AI tools and inspiring ideas

Preference or Idea	Theme	Strategy/Consideration	Example AI Tools and Use Cases
Preference	Comprehensive Curriculum Design	Tools capable of creating detailed curriculum plans	Comprehensive curriculum planning tools, The one AI
Preference	Interactive and Adaptive Learning	Tools that offer interactivity, adapt to student needs, and provide practical integration	MagicAI: Interactive, meeting student needs, creating visuals for Turkish words, digital storytelling
Preference	Lesson Planning and Differentiation	Tools that assist in lesson planning, differentiation, and providing assessment materials	Tools for creating lesson plans, differentiating instruction, and providing assessment feedback
Preference	Support for Differentiated Instruction	Tools that support differentiated learning, effective assessment, and feedback	Interactive math materials, visual aids, customized learning plans, Canva, Scroobly: Visual designs, animating characters
Preference	Progress Tracking and Performance Evaluation	Tools for tracking student progress and evaluating performance	Tools for progress tracking, student performance evaluation
Idea	Mathematics and Statistics	Tools for simulating mathematical concepts and providing interactive visualizations	Probability simulations, data usage, customized models, interactive visualizations
Idea	Science Education	Tools for simulating and visualizing scientific concepts, and supporting scientific inquiry	Simulations and interactive visualizations in science classes, explaining abstract concepts, answering student questions
Idea	History and Social Studies	Tools that help in understanding historical events and social studies concepts through visualizations	Historical event simulations, content design, visualizing historical locations and events

Table 3 (continued)

Preference or Idea	Theme	Strategy/Consideration	Example AI Tools and Use Cases
Preference	Primary Education Integration	Tools that integrate AI into primary education through personalized and interactive learning experiences	Answering PYP questions, planning lessons and activities, creating group projects, presentations with Canva
Preference	Writing and Creative Expression	Tools that support creative writing, text analysis, and visual storytelling	Creative writing, text analysis, visual illustration, comparing writing practices
Idea	Visual and Interactive Learning	Tools that support visual learning through animations, simulations, and interactive graphics	Visualizing biological processes, creating animations, interactive simulations in various subjects
Idea	Differentiated Instruction	Tools that support differentiated lesson plans and personalized learning experiences	Creating differentiated lesson plans, generating personalized content, providing feedback
Idea	Population and Resource Simulations	Tools for simulating population growth, resource management, and entrepreneurship	Simulating population growth, resource simulations, creating marketing programs
Idea	Grammar and Language Tools	Tools for teaching and enhancing grammar and language skills	Grammar rules, correct usage contexts, vocabulary development, language acquisition
Idea	Research and Literature Analysis	Tools for supporting research and analysis in literature and social studies	Literature analysis, thematic writing, style comparisons, creative text writing, virtual discussions
Idea	Data Analysis and Visualization	Tools for creating data visualizations and conducting detailed analyses	Creating graphs, charts, data simulations, visualizing statistical concepts
Preference	Administrative and Organizational Support	Tools that aid in reducing administrative tasks and organizing educational activities	Converting speech to text, organizing meeting notes, reducing email traffic, enhancing assessment processes
Idea	Engagement and Motivation	Tools that increase student engagement and curiosity through interactive and stimulating activities	Creating engaging activities, simulations, interactive content across various subjects

Table 4 Factors influencing teachers' embracement or impade AI integration

Category	Theme	Sub-theme	Excerpts from the Teachers
Factors to Embrace AI	Psychological	Students' excitement and interest	• I think our students are generally excited, different tools attract their attention very much. ***Primary school classroom teacher, Ayla***
			• We used the scribble diffusion application from AI applications with kindergarten students; I observed that they were very excited and interested. ***Pre-school classroom teacher, Melike***
			• I observe that my students are very enthusiastic and curious about artificial intelligence. They are especially interested in all the assistants that will help them prepare their homework. ***High school foreign language teacher, Figen***
			• I think they are excited. In fact, I had students who continued with the application at home. ***Primary school science teacher, Demet***
			• Artificial intelligence is a serious topic of curiosity. They are more interested than we are. ***High school literature teacher, Barış***
		Teacher engagement and perceptions	• I definitely think that the use of these tools has a positive impact on students' learning motivation. ***High school chemistry teacher, Özge***
			• Introducing my students to AI started with in-class activities. Since it enriches the course content, we can have more enjoyable activities. ***Primary school classroom teacher, Pınar***
			• The activities prepared by utilizing AI in the lesson attract their attention very much. ***Primary school literature teacher, Filiz***
			• While students are eager to learn about the use of AI, I provide limited information due to ethical reasons. ***Primary school social sciences teacher, Sibel***
			• Although I haven't actively used it in class with my students, I think the idea of AI fits their way of thinking. ***Primary school mathematic teacher, Betül***

Table 4 (continued)

Category	Theme	Sub-theme	Excerpts from the Teachers
		Efficiency and practicality	• The possibility of creating quality content in a short time will increase with AI tools. Its use will become quite widespread in all areas of education. ***High school history teacher, Deniz*** • AI can be effectively used in lesson planning. It can facilitate creating multi-dimensional plans for teachers and may have an impact on processing and evaluating data more quickly. ***Primary school classroom teacher, Sevgi*** • I think it can also make teachers' work easier in some situations. Teachers can better monitor the learning processes of students and evaluate their performance more accurately. ***High school biology teacher, Ebru*** • So far, the AI tool I liked the most is the "gamma" application. Because it quickly prepared a presentation file on the topic and detail I wanted, it made my work easier. ***Primary school foreign language teacher, Kaan*** • Although ChatGPT gets stuck at one point in adapting it for use during lessons, it is quite successful in offering effective methods aimed at the purpose. ***Primar yschool mathematic teacher, Betül*** • "Magic School" has been the most interesting AI tool I used for educational purposes. It helps in creating plans for individual and group work in many different areas and offers a variety of activities. ***Pre-school classroom teacher, Melike***

Table 4 (continued)

Category	Theme	Sub-theme	Excerpts from the Teachers
Factors to Embrace AI	Pedagogical	Variety and adaptability of applications	• I think the Magic School application is very useful and beneficial. With the different tools it contains, we can access many things we might need. ***High school chemistry teacher, Özge*** • By far, I want to say ChatGPT, as it can answer every different type of question I have or direct me to all other AI tools. ***High school mathematic teacher, Orhan*** • I find ChatGPT, character.ai, copilot, and gamma useful for preparing lesson content and offering them for students' use in classes. ***Primary school mathematic teacher, Rıza*** One of my favorite tools is Magic School. Having numerous materials that we can adapt to our lessons not only makes our work easier but also helps us gain different perspectives. ***Primary school social sciences teacher, Sibel***

Table 4 (continued)

Category	Theme	Sub-theme	Excerpts from the Teachers
		Interaction and learning experience	• AI will provide personalization in studies to be done with students. ***Primary school science teacher, Cenk*** • AI can offer personalized learning experiences by better understanding students' individual needs and learning styles. For example, it can identify a student's weak points and provide special learning materials or exercises. ***Primary school foreign language teacher, Kaan*** • I think AI applications offer the opportunity for personalized teaching. Although using these applications for kindergarten students can be a bit difficult in terms of age-appropriate content, I think it will be effective when done. ***Pre-school classroom teacher, Tuğra*** • I liked MagicSchool AI a lot, it is an interactive platform that meets students' needs. ***Primary school classroom teacher, Ayla*** I think AI will make learning materials more interactive for students. Students will be able to interact more with technologies such as virtual reality or augmented reality. ***High school biology teacher, Ebru***
		Support and follow-up	• So far, the program that I have received the most support from and liked academically is ChatGpt. It has been very useful in evaluating and questioning student writings. ***High school literature teacher, Erhan*** • AI can offer better student monitoring and evaluation tools for teachers. ***High school mathematic teacher, Selda*** • When AI is used in education, it can enrich the student experience and provide more resources and support to teachers. ***Pre-school classroom teacher, Ferda*** ChatGPT provided me with good examples on some topics. ***Primary school foreign language teacher, İnci***

Table 4 (continued)

Category	Theme	Sub-theme	Excerpts from the Teachers
		Educational materials and planning	• AI will be useful for teachers in lesson planning. ***Primary school social science teacher, Nihal*** • Teachers can have difficulty finding stories or dictations suitable for each PYP concept and have to create them themselves. With detailed command systems, it is possible to obtain 3-sentence dictations and short stories with ChatGPT. ***Primary school classroom teacher, Nermin*** • I think it can make students' research and learning processes more planned. Students have difficulties in following instructions. AI tools can break down these instructions or approach the solution step by step. ***Primary school science teacher, Okan*** • If tools like ChatGpt, Bard for text creation, and MagicSchool for rubric preparation had existed before, they would have made my planning phase easier. ***Primary school classroom teacher, Tuna*** • I find tools like ChatGpt and Bard useful for creating texts. I think MagicSchool is effective for assessment tools. It contributes to lesson planning. ***Primary school classroom teacher, Pınar***
Factors Impeding AI Integration	Technical and Operational Challenges	Technical and hardware issues	• Since I am newly familiar with AI tools, I can't use them regularly in daily life. I sometimes experience technical problems while using them. ***Primary school classroom teacher, Ayla*** • At the primary school level, since tools like iPads and phones are not used in the classroom, we cannot benefit from interactive activities. ***Primary school classroom teacher, Tuna*** • I can say that not having tablets for our students also affected our ability to apply these programs in the classroom. ***High school literature teacher, Metin***

Table 4 (continued)

Category	Theme	Sub-theme	Excerpts from the Teachers
		Time and workload	• Time allocation is necessary… ***High school literature teacher, Barış*** • Producing materials other than the methods we know, or let's say producing materials under any circumstances, is still a topic that requires time and research. Time can be lost with the trial-and-error method. Considering our workload, it is really a difficult subject. ***High school biology teacher, Nilay*** • The intensity of the curriculum and the fact that it is not parallel with the education and examination system we are in is the biggest challenge. ***Primary school mathematic teacher, İlknur*** • However, our intense curriculum causes limitations in incorporating these applications into lesson plans. ***High school literature teacher, Metin*** • There is not always time to learn the details of the applications and use them actively. ***Primary school mathematic teacher, Hümeyra***
		Educational materials and content incompatibility	• Since they have content that is not suitable for teaching mathematics or incompatible with the curriculum, I can only use them as support, especially in complex situations. ***Primary school mathematic teacher, Betül*** • I think the concepts are above the level of the classes I teach. ***Primary school classroom teacher, Sevgi*** • Not every product can be adapted to every academic subject. I think this is the main problem. ***High school literature teacher, Erhan***

Table 4 (continued)

Category	Theme	Sub-theme	Excerpts from the Teachers
		Language and cultural difference	• Since most AI applications are English-based, I think students have difficulties, especially in those that require text writing. ***Primary school science teacher, Demet*** • I think that some photos with Atatürk's image do not reflect the era and character, which can create wrong impressions about Atatürk for those who are not familiar. ***High school biology teacher, Ebru*** • Since it provides convenience in many areas, I can't say it's a difficulty, but the only deficiency is culturally. When I give the command to prepare a humorous text in English lessons, the jokes are generally not funny in our culture. ***Primary school foreign language teacher, Dilek***

Table 4 (continued)

Category	Theme	Sub-theme	Excerpts from the Teachers
	Ethical, Security, and Educational Concerns	Ethical and security concerns	• Unfortunately, our students do their writing assignments on ChatGPT and copy-paste them exactly. What kind of control mechanism can be created for this? ***Primary school foreign language teacher, Dilek*** • I think it is essential to learn AI tools. There may be security issues regarding the use of student information ethically. ***Primary school classroom teacher, Ayla*** • I am a bit worried about students absorbing incorrect information and creating wrong images to bully their friends. ***High school biology teacher, Ebru*** • However, the topics of students' personal privacy rights and data security should be emphasized ethically. ***High school physics teacher, Gülay*** • Students at a lower level of learning may make it a routine and present all their assignments to us through these tools. Despite our awareness, this situation may prevent us from grading fairly. ***High school literature teacher, Metin*** • As a Turkish teacher, participation in composition competitions concerns me. They can bring a piece written by AI as if it is their own. ***Primary school literature teacher, Mehtap***

Table 4 (continued)

Category	Theme	Sub-theme	Excerpts from the Teachers
		Lack of student creativity and effort	• Similarly, the use of this by students bothers me a bit because it eliminates creativity and effort. ***High school mathematic teacher, Orhan***
			• There are scary aspects. Sometimes I wonder if it will foster creativity or create laziness. ***Primary school classroom teacher, Nermin***
			• I support students using AI tools, but I think there should be a limit because unfortunately, I believe some creativity-requiring work can be open to abuse. ***High school foreign language teacher, Figen***
			• The loss of originality in students' work and the uniformity created by the ChatGPT language do concern me. ***High school foreign language teacher, Pelin***
			• They can have AI do the questions or tasks without making any effort. At this point, it may cause students to think they can achieve success without challenging themselves. ***Primary school literature teacher, Filiz***
		Issues with correct and incorrect information	• AI use by students is directly considered plagiarism; they need to learn effective use, ethical use, and how to give references. ***High school foreign language teacher, Şebnem***
			• I am worried that they might want to copy their assignments without researching. ***Primary school social science teacher, Nuran***
			• It is inevitable for our students to follow what is current; it is important for them to learn to use these tools ethically and to question the information. ***High school foreign language teacher, Zuhal***
			• They need time to scan and sort out the appropriate information they obtain. ***Primary school classroom teacher, Lale***

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Declarations

Ethical approval This study does not require ethics committee approval as the data were obtained through an official contract established between the private school and the teachers.

Consent to participate All authors have provided full consent for the article's publication.

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