

DESIGN AND IMPLEMENTATION OF AN AI COMPETENCY MODULE
FOR PROSPECTIVE TEACHERS: A MIXED-METHODS STUDY



BERSU ANSEN

BOĞAZİÇİ UNIVERSITY

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Bersu Ansen

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Design and Implementation of an AI Competency Module for Prospective Teachers:
A Mixed-Methods Study

The thesis of Bersu Ansen
has been approved by:

Assist. Prof. Mutlu Şen Akbulut
(Thesis Advisor)

Prof. Diler Öner

Assoc. Prof. Elif Polat Hopcan
(External Member)

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DECLARATION OF ORIGINALITY

I, Bersu Ansen, certify that

- I am the sole author of this thesis and that I have fully acknowledged and documented in my thesis all sources of ideas and words, including digital resources, which have been produced or published by another person or institution;
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Signature

Date

ABSTRACT

Design and Implementation of an AI Competency Module for Prospective Teachers:

A Mixed-Methods Study

This study explores how a learning module grounded in the AI competency instructional model (Ng et al., 2023) facilitates prospective teachers' AI competencies and their AI literacy. Adopting a complementarity parallel mixed-methods design, the research was conducted over nine weeks with eleven undergraduate prospective teachers enrolled in an Instructional Technologies and Material Development course at a university in Türkiye. Quantitative data were collected via the Meta AI Literacy Scale (MAILS), and qualitative data included pre- and post-opinion forms and AI-integrated final projects. The findings revealed a statistically significant improvement in participants' AI literacy levels, particularly in the sub-domains of understanding, detecting, and creating AI. Although there was no significant change in the domains of AI ethics and apply AI, qualitative data indicated a notable shift in ethical awareness and reflections on AI's societal implications. Lesson plan analysis showed that participants successfully integrated AI into diverse subject areas, aligning the Five Big Ideas in AI and UNESCO's AI competency framework. However, assessment strategies for AI concepts remained limited. This study contributes to the literature by providing empirical evidence on how pedagogically informed modules can build AI competencies and guide meaningful integration of AI into instructional design. Implications for teacher education and recommendations for future research are discussed.

ÖZET

Öğretmen Adayları İçin Yapay Zeka Yetkinlik Modülünün Tasarımı ve Uygulanması: Karma Yöntemli Bir Çalışma

Bu çalışma, yapay zekâ yeterlilik öğretim modeline (Ng et al., 2023) dayalı olarak tasarlanan bir öğrenme modülünün öğretmen adaylarının yapay zekâ yeterliklerini ve yapay zekâ okuryazarlıklarını nasıl geliştirdiğini incelemeyi amaçlamaktadır.

Tamamlayıcılık işleviyle yapılandırılmış paralel karma yöntem desenine dayanan araştırma, Türkiye'deki bir üniversitede Öğretim Teknolojileri ve Materyal Tasarımı dersine kayıtlı on bir öğretmen adayıyla dokuz hafta boyunca yürütülmüştür. Nicel veriler Meta Yapay Zekâ Okuryazarlığı Ölçeği (MAILS) aracılığıyla toplanmış; nitel veriler ise ön-son görüş formu ve yapay zekâ entegrasyonlu dönem projelerinden toplanmıştır. Bulgular, katılımcıların özellikle yapay zekâyı anlama, algılama ve üretme alt boyutlarında anlamlı düzeyde gelişim gösterdiğini ortaya koymuştur.

Yapay zekâ etiği ve uygulama boyutlarında anlamlı nicel fark gözlemlenmemesine rağmen, nitel veriler etik farkındalıkta ve yapay zekânın toplumsal etkilerine yönelik belirgin bir artış olduğunu göstermiştir. Ders planı analizleri, katılımcıların yapay zekâyı farklı disiplinlere entegre ettiğini ve öğretim tasarımlarını Yapay Zekâda Beş Büyük Fikir ile UNESCO'nun öğrenci yeterlik çerçevesine göre yapılandırıldığını ortaya koymuştur. Yapay zekâyı yönelik ölçme ve değerlendirme stratejilerinin sınırlı olduğu görülmüştür. Bu çalışma, pedagojik olarak temellendirilmiş modüllerin öğretmen adaylarının yapay zekâ yeterliklerini geliştirme potansiyeline dair ampirik kanıtlar sunmakta ve öğretmen eğitimi için önemli çıkarımlar önermektedir.

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ABBREVIATIONS

AI: Artificial Intelligence

AIED: AI in Education

AI-LOs: The AI4K12 Learning Objectives

CKAI: Content Knowledge of AI

FDR: False Discovery Rate

GenAI: Generative AI

HRM: Human Resources Management

ITSs: Intelligent Tutoring Systems

LLM: Large Language Model

LOs: Learning Objectives

MAILS: Meta AI Literacy Scale

MIT-AI: MIT App Inventor

P21 Framework: Partnership for 21st Century Learning Framework

PCKAI: Pedagogical Content Knowledge of AI

PCK: Pedagogical Content Knowledge

SOBETIK: The Ethics Committee in Social Sciences and Humanities

TCKAI: Technological Content Knowledge of AI

TPACK: Technological Pedagogical Content Knowledge

TPACKAI: Technological Pedagogical Content Knowledge of AI

TPKAI: Technological Pedagogical Knowledge of AI

UNESCO: The United Nations Educational, Scientific and Cultural Organization

CHAPTER 1

INTRODUCTION

1.1 Significance of the study

Rapid advancements in technology usually require changes in various fields with a small or worldwide effect. One of the technologies that has seen the most worldwide impact and rapidly affects almost all fields (e.g., education or industries) is artificial intelligence (AI).

Definitions of the term intelligence are found in various dictionaries, in psychological literature, and within the field of AI, yet there is no agreed one. However, for machines, intelligence can be described as “an agent’s ability to achieve goals in a wide range of environments” (Legg & Hutter, 2007, p. 402).

AI refers to “the science and engineering of making intelligent machines, especially intelligent computer programs” (McCarthy, 2007, p.2). The science component focuses on theories (e.g., learning or rule-based systems) in order to explain different types of intelligence, whereas the engineering component focuses on enhancing the abilities of AI to solve real-life problems (Chowdhary, 2020).

While the concept of AI gained widespread public attention with the release of ChatGPT in 2022, AI technologies have been in use across various sectors for decades. For example, one of the earliest AI systems, which is ELIZA, was developed in the 1960s to simulate a psychotherapist by engaging in natural language conversations with users (Weizenbaum, 1966). These efforts introduce new AI applications to society to address people’s needs.

For instance, IBM Watson is a cognitive system that answers questions in a confidence-based manner developed with machine learning (High, 2012). This

cognitive system has been used by various industries, such as in the medical field, aiming to make clinical decisions such as effectively diagnosing cancer (Tian et al., 2019; Qi & Lyu, 2018). Textio is an augmented writing system (Kreutzer & Sirrenberg, 2019) based on a large language model (LLM) that facilitates human resources management (HRM) processes like talent acquisition and unbiased employee performance feedback.

As AI continues to evolve, its integration into education has become increasingly prominent and offers diverse applications to support teaching and learning. Various types of AI applications are also used in the field of education. For example, Connected Papers facilitates both higher education students and researchers to explore literature reviews visually (Behera et al., 2023); ChatGPT allows learners to receive study support and create personalized learning paths (Ifelebuegu et al., 2023); intelligent tutoring systems (ITSs) provide learners with personalized learning and automatic feedback (Fitria, 2021); Teachable Machine allows students to learn and perform classification in machine learning (Carney et al., 2020) and this tool can be used in education for different purposes.

The widespread adoption of AI tools in educational settings has been met with approval from both students and teachers, and with the advancements in AI and its applications, both teachers and students have started or are willing to start to use these tools in their learning environments. Based on a survey held by Impact Research for the Watson Family Foundation in the United States, 79% out of 1000 students ages between 12 to 17 agree that ChatGPT has a positive impact on their learning, and 88% out of 1002 teachers agree that ChatGPT has a positive impact on teaching (*Teachers and Students Embrace ChatGPT for Education*, 2023). Moreover, researchers also argue that young students who were born after 2010

perceive AI as a part of their lives (Krašna & Bratina, 2024; Lipovec et al., 2024).

Given this reality and the rising popularity of AI among students, it can be concluded that AI is likely to have a transformative presence in education.

As technology develops and becomes more integrated into everyday life, young learners who are adapted to interacting with AI and its tools may expect these technologies to play a role in their educational experiences. Researchers have started to develop AI-based frameworks to fulfill these needs. For higher education, there are proposed frameworks for integrating AI in medical education (Paranjape et al., 2019) and engineering education (Balart & Shryock, 2024).

In contrast to integrating AI as a tool to support curriculum delivery, frameworks have been developed for teaching AI. Five Big Ideas in AI (Touretzky et al., 2019) and the United Nations Educational, Scientific and Cultural Organization's (UNESCO) education policy (Duggan & Knyazeva, 2020) are frameworks for educators to show a path to teach AI to their K-12 students.

While students have already begun engaging with AI tools in their daily lives, possessing AI literacy or competencies requires much more than simply using such technologies. It demands participation in meaningfully designed learning experiences that foster a deeper understanding of AI concepts and implications. To support students in this process, it is essential for prospective teachers to develop AI competencies to improve their technological, pedagogical, and content knowledge and effectively integrate AI into their classrooms (Ng et al., 2021). To conclude, there is a need for teacher education programs to prepare AI-competent graduates to meet both their and their students' needs (Luckin et al., 2022).

1.2 Purpose of the study

The purpose of the study is to explore how a learning module based on the AI competency instructional model (Ng et al., 2023) facilitates prospective teachers' AI competencies and their AI literacy.

1.3 Research questions

Overarching Research Question: How does the designed AI module facilitate prospective teachers' AI competencies?

1. How does prospective teachers' AI literacy evolve after participating in the module?
 - 1.1. Is there a significant difference between prospective teachers' pre- and post-AI literacy scores after participating in the module?
 - 1.2. What are the prospective teachers' perceptions of AI before and after participating in the module?
2. How do prospective teachers' AI competencies evolve after participating in the module?
 - 2.1. To what extent do prospective teachers integrate AI into their learning, teaching, and assessment practices, as evident in their final projects after participating in the module?
 - 2.2. What are the prospective teachers' perceptions of AI regarding learning, teaching, and assessment practices before and after participating in the module?

1.4 Research hypotheses

H: There will be a significant difference between prospective teachers' pre- and post-AI literacy scores after participating in the module.

1.5 Organizations of the sections

Chapter 2 covers a literature review of AI in education (AIED), AI literacy and competency, AI in teacher education, frameworks and initiatives for developing teachers' AI competency, and the conceptual framework for the study. Chapter 3 consists of the research methods, research design, the context and participants, data collection instruments, data collection procedures, data analysis, and trustworthiness. In Chapter 4, the findings of the research were presented. Chapter 5 includes discussion of the findings, recommendations and implications for future studies, and limitation of the study.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the role of AI in education has been explored through a review of the relevant literature. The literature review began with an overview of AI in education, followed by the definitions and importance of AI literacy and competency. The chapter also examined the integration of AI in teacher education and various frameworks and initiatives for developing teachers' AI competencies. Finally, the conceptual framework guiding this study was explained.

2.1 AI in education

AI in education (AIED) is a fast-growing research area (Bai et al., 2024) that aims to improve teaching, learning, and assessment by integrating AI technologies into these practices. AIED includes applications that have been designed to improve teaching and learning experiences, such as ITSs, adaptive learning environments, and automated grading. These AI-based applications aim to personalize learning by customizing educational content and assessment to students' needs, which is more effective in addressing learning gaps than traditional methods (Luckin et al., 2016).

For instance, ITSs allow students to get instant feedback depending on their performance. Personalized interventions have increased student engagement, increased educational outcomes, and decreased the achievement gap among students with different abilities (Kulik & Fletcher, 2016). Furthermore, AI can facilitate lifelong learning by offering recommendations for courses, resources, and skill development based on students' backgrounds, which is especially useful in higher

education and professional training, where learners are often interested in updating their skills due to the fast job market changes (Zawacki-Richter et al., 2019).

AI-based adaptive learning platforms analyze students' information to modify the curriculum to ensure that every student receives teaching that aligns with their comprehension levels (Demartini et al., 2024). In these applications, platforms have supported data analytics and predictive modeling to uncover learning trends and theories about potential future successes, which enables teachers to modify their teaching strategies (Salas-Pilco et al., 2022). For example, Knewton and DreamBox Learning are adaptive learning platforms that process extensive amounts of data to develop personal learning paths for every student (Kulik & Fletcher, 2016). This adaptability improves students' interests and motivations and supports mastery learning because students know basic ideas before proceeding to complicated ones (Pane et al., 2014).

Furthermore, the literature support that students tend to integrate AI in their daily life activities and learning because they stated that AI enhances the efficiency of tasks, facilitates to search for information and translation, and quickly solves complex problems (Adeshola & Adepoju, 2023; Fošner, 2024; Folmeg et al., 2024). Research has also shown that students are aware of the implications of using AI in their daily lives and they generally considered generative AI (GenAI) tools as a source of unreliable and inaccurate information as well as with false references (Kasneci et al., 2023; Ngo, 2023) and AI has negative consequences, such as challenges in transparency and accuracy, privacy, and human values (Chan & Hu, 2023).

Beyond supporting students, AIED also offers essential benefits for teachers. AI-based applications can support teachers' daily activities like scheduling, monitoring attendance, and managing resources enabling teachers to spend more time teaching and engaging with their students (Chen et al., 2020).

The successful use of AI in education also emphasizes the need to develop AI literacy and skills among teachers and students (Ding et al., 2024). Teachers need basic knowledge about AI technologies to use them effectively in their teaching practices and analyze their effects on learning outcomes (Long & Magerko, 2020). Professional development programs that focus on building teachers' AI competencies can equip them with the tools they need to incorporate AI applications into their classrooms. This knowledge can lead to more effective and innovative teaching methods that enhancing the learning experience of students (Uzumcu & Acilmis, 2024). In the same way, promoting AI literacy among students prepares them for a future workforce increasingly shaped by AI. Hence, teachers should support their students in critically and responsibly engaging with AI (Chiu & Sanusi, 2024; Touretzky et al., 2019).

2.2 Defining AI literacy and AI competency

Literacy involves specific methods of reading and writing to understand or convey ideas within a certain context (Keefe & Copeland, 2011; Chiu et al., 2024). In contrast, competency is a set of skills and behaviors that people need to develop in order to successfully complete their tasks (Woodruffe, 1993). In other words, while literacy is about knowing and directly related to skills, competency is about effectively applying that knowledge (Chiu et al., 2024). Table 1 explains the relationship between skill, literacy, and competency.

Table 1. Differentiation Between Skill, Literacy, and Competency

Skill	Literacy	Competency
“Knowing how” (Stanley & Williamson, 2017, p.714)	Understanding concepts which are knowledge and skills (Chiu et al., 2024).	Applying literacy and skills to solve real-life problems (Woodruffe, 1993).

AI Literacy is a novice term in the field, and there is no agreed definition of AI literacy in the literature. The research has shown that AI literacy refers to “a set of competencies that enables individuals to critically evaluate AI technologies; communicate and collaborate effectively with AI; and use AI as a tool online, at home, and in the workplace” (Long & Magerko, 2020, p.2).

On the other hand, research has shown that AI literacy can be described as the cognitive processes involved in AI learning at various levels according to the Bloom’s Taxonomy (Ng et al., 2021). Based on the framework, in order to develop AI literacy, people should foster four domains of AI literacy: (1) know and understand AI, (2) use and apply AI, (3) evaluate and create AI, and (4) AI ethics. This AI literacy framework supports AI competencies (Ng et al., 2023).

The first domain includes knowing the foundations of AI and how to use its applications, such as machine learning, neural networks, and k-means clustering as core concepts of AI (Ng et al., 2021). The second domain covers knowing and understanding AI to apply it to real-world scenarios by practicing and adopting AI perspectives (Ng et al., 2021). Training an AI model and considering AI as a problem-solving tool can be examples of this domain. The third domain covers higher-order thinking skills to design and build AI models (Ng et al., 2021). The last domain includes human-centered considerations such as transparency, ethics, environmental effects, and privacy concerns related to AI (Ng et al., 2021).

Although AI competency and AI literacy are conceptually distinct, they remain closely interrelated (Zhou et al., 2025). AI competency refers to an individual's ability to understand, explain, and responsibly use AI technologies (Ng et al., 2021). Simply, AI competencies are necessary knowledge, skills, and attitudes to understand and use AI (Cukurova et al., 2024). According to Chiu et al. (2024), these competencies include using AI to communicate and collaborate effectively in various types of settings, practicing ethical decisions-making, and consistently enhancing one's knowledge of AI through learning and self-reflection. Figure 1 shows the relation between AI competency and AI literacy.

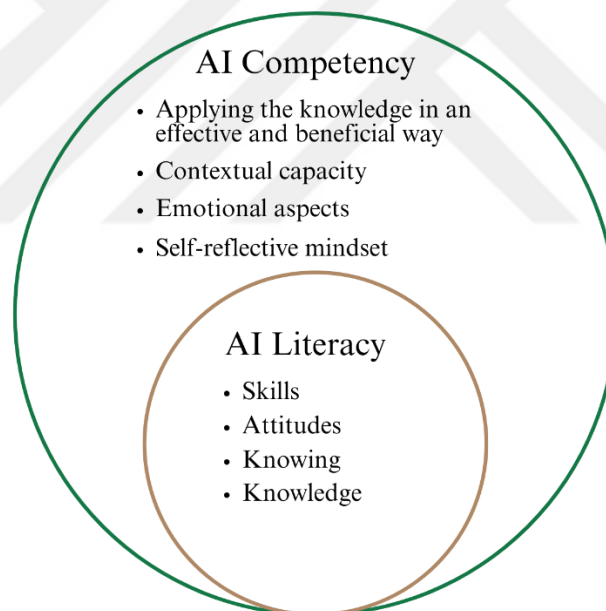


Figure 1. The relation between AI competency and AI literacy

Note. Adapted from Zhou, X., Li, Y., Chai, C. S., & Chiu, T. K. (2025). Defining, enhancing, and assessing artificial intelligence literacy and competency in K-12 education from a systematic review. *Interactive Learning Environments*, 1-23, p.3

Therefore, it is crucial for prospective teachers to develop AI literacy and competency in today's educational landscape. AI literacy equips them with the skills to critically evaluate AI technologies, effectively communicate with AI, and use it as a tool in various contexts, including online environments, at home, and in the workplace (Long & Magerko, 2020). These skills allow educators to present AI applications in the classroom, teach students the fundamentals of AI, and apply AI in scenarios involving problem-solving.

Furthermore, AI competency ensures that educators are able to utilize AI responsibly, make ethical decisions, and improve their knowledge and skills of the technology continuously. Therefore, gaining AI literacy and competency is essential for prospective teachers to advance their professional development and support their students in succeeding in the AI-driven world.

2.3 AI in teacher education

To foster students' AI competencies and increase their AI literacies by integrating AI curriculums in schools, teachers need to acquire the necessary knowledge and competencies for their teaching and learning practices (Velandar et al., 2024). Although there is an extensive amount of research and initiatives about developing AI literacy and competencies for K-16 students to become AI-ready, the literature lacks research about teacher education about developing their AI literacy and competencies (Ng et al., 2023).

Most of the studies between 2000 and March 2023 were related to AI literacy in teacher education, primarily focusing on AI literacy frameworks, teacher attitudes about adopting AI in classrooms, curriculum development to foster students' AI literacy, increasing teachers' AI literacy through professional development, how to

adapt AI applications for teaching, and AI ethics regarding education (Sperling et al., 2024).

Similar to AI literacy in teacher education studies, there are few initiatives and frameworks to foster teachers' AI competencies. Kim et al. (2021) adopted the Technological Pedagogical Content Knowledge (TPACK) framework to assess the teacher competencies related to K-12 AI education available globally; Kim and Kwon (2023) identified the 22 AI competencies of elementary school teachers in South Korea by adopting TPACK framework; Kitcharoen et al. (2024) proposed a professional AI development training to enhance teachers' AI competencies; Sun et al. (2023) designed a professional development program by utilizing the TPACK framework to enhance K-12 computer science teachers' AI teaching competencies; and Ng et al. (2023) developed an AI competency instructional design model to promote teachers' teaching, learning, and assessment practices by adopting DigCompEdu, Ng et al.'s (2021) revised TPACK model for AI literacy and Partnership for 21st Century Learning (P21) framework.

2.4 Frameworks and initiatives for developing teachers' AI competencies

Although the literature lacks studies or initiatives about developing prospective teachers' AI competencies, frameworks and initiatives exist regarding developing prospective teachers' AI competencies in K-12 education.

There exists an initiative that adopted the TPACK framework to design a program aimed at developing prospective teachers' expertise in AI convergence education (Kim, 2024). The program consists of five phases. Firstly, in the analysis phase, teachers identify classroom challenges to set the foundations. Secondly, the exploration phase covers studying TPACK theory, curriculum, teaching methods,

and AI, focusing on how technology can address these challenges. In the design phase, which is the third phase, teachers create AI-focused lesson plans that integrate technological, pedagogical, and content knowledge. Fourthly, the application phase allows them to implement these plans through microteaching to gain practical experience using AI in education. Lastly, the evaluation phase involves reflecting on and refining their lessons based on the outcomes, enhancing their TPACK skills. The study concluded that this program effectively improves teachers' pedagogical content knowledge (PCK) and TPACK.

Another initiative was developed aiming to improve the AI teaching competency of K-12 in-service computer science teachers (Sun et al., 2023). The main purposes of the TPACK-based professional development program for K-12 in-service computer science teachers were (1) promoting the AI teaching competency of CS teachers by focusing on the integration of AI knowledge into their teaching practice, (2) developing in-service teachers' AI teaching competencies, including their ability to create effective AI lesson plans and enhance their AI programming skills, and (3) improving teachers' AI teaching self-efficacy, which includes both AI teaching efficacy beliefs and AI teaching outcome expectancy. The program was developed with the TPACK framework. Content knowledge of AI (CKAI) ensures that teachers have a deep understanding of AI concepts, including the Five Big Ideas in AI (Touretzky et al., 2023). Technological content knowledge of AI (TCKAI) covers proficiency in AI programming and the use of digital software and hardware for AI learning. PCK of AI (PCKAI) includes effective teaching strategies and instructional design for AI education. Technological pedagogical knowledge of AI (TPKAI) aims to understand the utilization of tools and resources for teaching AI.

Lastly, TPACK of AI (TPACKAI) includes the integration of programming, technologies, and pedagogy for teaching AI.

Since 2024, there has been an increase in attention to AI literacy frameworks and initiatives across educational contexts. This includes efforts at the K–12 level to integrate foundational AI literacy into curricula, as well as broader frameworks designed to support AI literacy for learners of all ages. Additionally, initiatives aimed at developing the AI competencies of teachers and prospective teachers have started to develop.

A framework was developed by UNESCO to promote teachers' AI competencies (Cukurova & Miao, 2024). This framework highlights the importance of knowledge, values, and skills that teachers should gain in the era of AI. The framework encompasses 15 competencies through five aspects which are humans-centered mindset, AI foundations and applications, ethics of AI, AI for professional learning, and AI pedagogy. Moreover, these competencies fall under three stages of progression, namely, acquire, deepen, and create. The initiative aims to support all educators in developing a high level of experience in AI and competency by mastering all levels (Cukurova & Miao, 2024).

Another framework was developed by UNESCO to promote students' AI competencies (Miao & Shiohira, 2024). The framework promotes critical evaluation of AI, understand students' own civic responsibilities, and gain essential knowledge for lifelong learning (Miao & Shiohira, 2024). The framework highlights 12 competencies across four aspects which are human-centered mindset, ethics of AI, AI techniques and applications, and AI system design. Similar to the UNESCO's AI competency framework for teachers (Cukurova & Miao, 2024), these competencies fall under three stages of progression, namely, understand, apply, and create.

Mills and colleagues (2024) also developed an AI literacy framework which focuses on equipping educators with the necessary knowledge and practice to design and implement effective instructional approaches for promoting AI literacy among diverse learner groups (e.g., K-12 students, in-service teachers, or professionals). The framework consists of four essential components to support AI literacy which are core values, AI literacy practices, types of use, and modes of engagement. This framework provides educators with five different strategies to support AI literacy in K-12 education (Mills et al., 2024).

Moreover, Tenório et al. (2025) introduced core AI competencies for non-computer science learners in undergraduate education aiming to ensure these learners can engage with AI technologies effectively and responsibly in their future workplaces. The study resulted in 27 AI competencies considered essential for non-computer science students by interviewing with the 19 multidisciplinary higher education educators.

In summary, the development of AI competencies among prospective and in-service teachers is crucial for preparing students for the future. While the literature may lack specific frameworks for prospective teachers, existing initiatives for both prospective and in-service educators offer valuable insights. These initiatives emphasize the importance of integrating AI knowledge into teaching practices, developing effective lesson plans, and improving teachers' confidence in delivering AI education. By emphasizing pedagogical and content knowledge, these initiatives substantially contribute to advancing AI education in K-12 settings. Moreover, these initiatives foster teachers to better prepare their students for an increasingly AI-driven world. However, these frameworks and initiative mostly emphasizes AI literacy and there are few initiatives and frameworks to foster AI competencies.

2.5 Conceptual framework for the proposed research

The study was guided by the AI competency instructional design model (Ng et al., 2023) as a conceptual framework. This framework addresses the critical role of teachers in integrating AI into the educational landscape, particularly in the aftermath of the COVID-19 pandemic. Ng et al. (2023) highlight the need for teachers to go beyond technical proficiency to encompass a broader range of skills, including life and career skills, multidisciplinary competencies, learning and innovation abilities, and ethical considerations.

The framework is developed based on three models, namely DigCompEdu, Ng et al.'s (2021) revised TPACK model for AI literacy, and the P21's framework for twenty-first-century learning and offers four key processes for AI competency instructional design: (1) teacher professional engagement, (2) instructional design, (3) content choices, (4) students' learning outcomes.

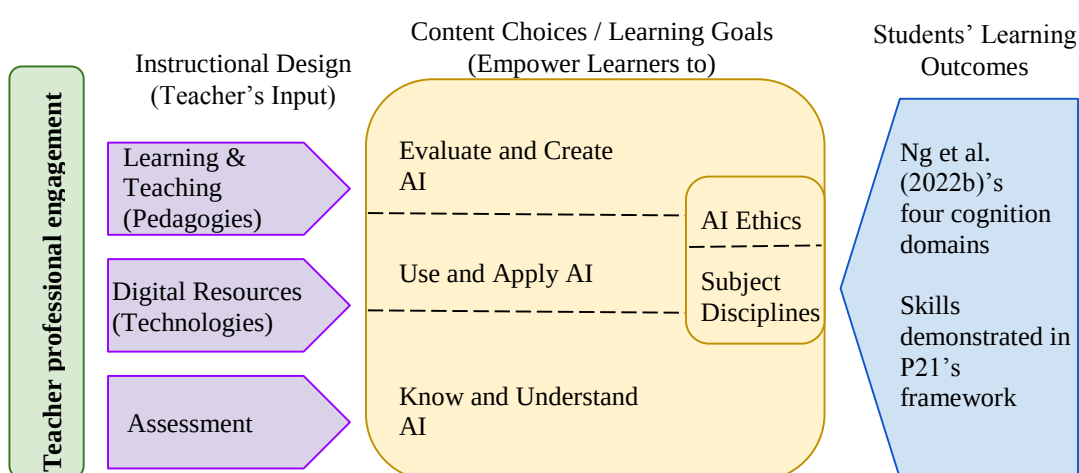


Figure 2. AI competency instructional design model (Ng et al., 2023)

Note. Adapted from Ng, D. T. K., Leung, J. K. L., Su, J., Ng, R. C. W., & Chu, S. K. W. (2023). Teachers' AI digital competencies and twenty-first century skills in the post-pandemic world. *Educational Technology Research and Development*, 71(1), 137–161.

2.6.1 The first domain: Teacher professional engagement

The first key process implies the competencies that increase the effectiveness of teaching activities and promote professional communication with stakeholders (Ng et al., 2023). Teacher professional engagement includes organizational communication for developing and enhancing teaching practices and ongoing innovation in their organization, professional collaboration for innovative pedagogy, reflective practice for digital pedagogical practice, and continuous digital professional development (Redecker, 2017).

To empower the effective and responsible use of AI, teacher professional development should focus especially on enhancing the general digital competencies of teachers with an emphasis on ethics and humanity through an understanding of digital pedagogy (Cukurova et al., 2024).

2.6.2 The second domain: Instructional design (teachers' input)

The second key process comprises the crucial teaching activities needed to achieve the formal knowledge necessary for developing appropriate and efficient teaching practices, technologies, and assessment tools for students' learning outcomes (Ng et al., 2023).

The learning and teaching sub-domain highlights AI pedagogy is important in terms of evaluating when and how to use AI in an ethical and human-centered manner, ensuring that its application supports effective teaching and learning practices (Cukurova et al., 2024). The revised TPACK model (Ng et al., 2021) supports educators' instructional design in terms of technological knowledge (e.g., AI-related agents, unplugged artifacts), content knowledge (e.g., AI awareness, five big ideas about AI (Touretzky et al., 2019) and pedagogical knowledge (e.g.,

collaborative learning, storytelling) (Ng et al., 2023; Ng et al., 2021). Teachers need to restructure lessons, activities, and learning content to support learning objectives effectively.

For the digital resources sub-domain, research has shown that AI applications can take place in education as an intelligent tutoring system, can be used for assessment and feedback, coaching and counseling, large school systems (e.g., planning and forecasting tasks), and predicting outcomes (Gillani et al., 2023). Educators should incorporate AI in order to design their teaching and learning practices while being aware of how to manage, utilize, and innovate with existing AI applications (Ng et al., 2023). Teachers should identify, select, modify, and build upon these resources to fit specific learning goals, environments, pedagogies, and learner groups.

For the assessment sub-domain, the conceptual framework includes both lower and higher-order thinking skills, especially the content choices domain. Educators should know how to assess students' different cognitive domains, such as their basic understanding of AI as a lower-level thinking skill or higher-order thinking skill, such as designing and building AI models facilitating AI concepts (Ng et al., 2023). Research has shown that educators prioritize assessing students' critical thinking about the ethical considerations of AI rather than focusing solely on technical proficiency (Cukurova et al., 2024).

2.6.3 The third domain: Content choices / learning goals (empower learners to)

The third key process represents Ng et al.'s (2021) AI literacy model expanded with Bloom Taxonomy to engage learners in lower- and higher-order thinking activities (Ng et al., 2021). The model includes four cognitive domains, which are know and understand AI, use and apply AI, evaluate and create AI, and AI ethics. These domains are designed to support AI competencies (Ng et al., 2023).

2.6.4 The fourth domain: learning competencies (students' learning outcomes)

The last key process includes a range of learners' outcomes which are skills, values, and attitudes for developing a broad range of AI competencies (Ng et al., 2023). One of the students' expected learning outcomes is P21's skills (e.g., technological skills, life and career skills for success in a competitive and complex world (Tight, 2021).

The purpose of the study was to explore how a learning module based on the AI competency instructional model (Ng et al., 2023) facilitates prospective teachers' AI competencies and their AI literacy. The following research questions guided the study:

Overarching Research Question: How does the designed AI module facilitate prospective teachers' AI competencies?

1. How does prospective teachers' AI literacy evolve after participating in the module?
 - 1.1. Is there a significant difference between prospective teachers' pre- and post-AI literacy scores after participating in the module?
 - 1.2. What are the prospective teachers' perceptions of AI before and after participating in the module?

2. How do prospective teachers' AI competencies evolve after participating in the module?
 - 2.1. To what extent do prospective teachers integrate AI into their learning, teaching, and assessment practices, as evident in their final projects after participating in the module?
 - 2.2. What are the prospective teachers' perceptions of AI regarding learning, teaching, and assessment practices before and after participating in the module?

Depending on the presented literature, it was expected that prospective teachers' AI literacy scores will significantly increase after attending the specifically designed AI module, and their perceptions of AI literacy will evolve in alignment with the study's conceptual framework. Moreover, it was expected that prospective teachers' AI competencies regarding AI teaching, learning, and assessment will evolve at the end of the study and will be evident in their final projects. Lastly, prospective teachers' perceptions of AI regarding learning, teaching, and assessment practices evolve at the end of the study.

CHAPTER 3

METHODS

The purpose of the study is to explore how a learning module based on the AI competency instructional model (Ng et al., 2023) facilitates prospective teachers' AI competencies and their AI literacy. This chapter covers (1) the research design, (2) the context of the study and participants, (3) data sources, (4) the data collection procedure of the study, (5) data analysis, (6) trustworthiness of the study, and (7) the researcher's position.

3.1 Research design

This study was guided by the complementarity parallel mixed-methods design (Tashakkori et al., 2021). Parallel mixed-methods design allows the simultaneous collection of quantitative and qualitative data and analysis by integrating their results to conclude meta-inferences that are findings obtained by the integration of both data sets. The function of complementarity helps to enhance findings through the exploration of the interactions between the methods to offer a more comprehensive and deeper understanding (Tashakkori & Teddlie, 2010).

The complex and multifaceted nature of this research and relying solely on either quantitative or qualitative methods would not have provided a complete understanding of prospective teachers' AI competencies. Quantitative data offered evidence of their AI literacy development, while qualitative data captured the nuanced perceptions and experiences behind their AI competencies.

By integrating both approaches through a mixed-methods design, the study was able to present a more comprehensive understanding. For this purpose, in this research, qualitative findings were expanded through quantitative findings, and the quantitative dataset was used as complementarity.

Therefore, the purpose of using the selected research design was to develop meta-inferences by integrating both methods' findings and enhancing qualitative results with quantitative data for in-depth understanding (Creswell & Plano Clark, 2018). The quantitative data confirmed whether the AI module improves AI literacy, while the qualitative data explained how these improvements translate into changes in teaching, learning, and assessment practices.

The quantitative data was collected from the Meta AI literacy scale (MAILS) (Carolus et al., 2023, see Appendix A), and qualitative data was collected from pre- and post-opinion forms regarding AI teaching, learning, and assessment practices (see Appendix B) and students' final projects.

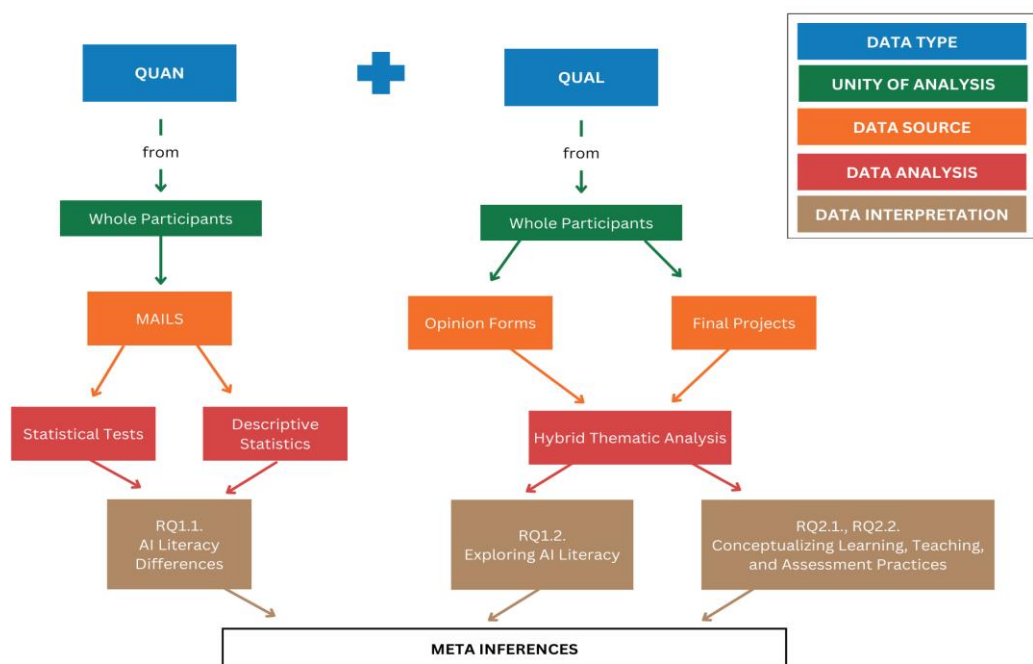


Figure 3. Graphical design of the study's parallel-mixed methods design

3.2 The context and participants

The participants of the study were selected using the purposeful sampling method (Creswell, 2013). The criteria for participating in the study were being a prospective teacher in higher education and taking the Instructional Technologies and Material Development course (hereinafter referred to as the course) at a university in Turkey. The research involved twelve undergraduate students from the Faculty of Education who were currently taking the Instructional Technologies and Material Development course. The participants were in the age range of 22 to 24, and they took the course face-to-face in the fall semester of 2024-2025. The data included eleven participants (see Table 2) because one participant dropped out of the course in the middle of the semester.

Table 2. Demographic Information of Participants

Pseudonym	Department	Gender
P1	Guidance and psychological counseling	Female
P2	Secondary school mathematics education	Female
P3	Primary school mathematics education	Female
P4	Primary school mathematics education	Female
P5	Science education	Female
P6	Primary school mathematics education	Female
P7	Foreign language education	Male
P8	Guidance and psychological counseling	Female
P9	Foreign language education	Male
P10	Chemistry education	Male
P11	Primary school mathematics education	Female

The course integrates the concepts and principles of educational technology as a fundamental component of the teaching and learning process. It covers a range of essential skills and tools, including the selection, development, implementation, and evaluation of media informed by learning theories. Additionally, the course had two sessions on Tuesdays and Thursdays each week. Each session was a hundred minutes long.

The study was conducted in one section of the course over a period of nine weeks. In this section, the participants engaged in various learning activities to develop their AI competencies as well as their AI literacy levels.

3.2.1 Course activities

Nine weeks of the course aimed to cover the activities related to the conceptual framework's domains (see the full course schedule in Appendix F). These course sessions of the AI module focused on enhancing teachers' professional engagement, instructional design knowledge (pedagogies, digital resources, and assessment), and content choices in terms of knowing, understanding, using, applying, evaluating, and creating AI, as well as AI ethics, through term projects, lectures, assignments, discussions, and product development using MIT App Inventor (MIT-AI). Table 3 and Table 4 present the details of the course activities and their relations to the framework.

Table 3. Course Activities' Relations to the Framework

Session #	Name of the Activity	Description	Domains							
			Teacher Professional Engagement	Instructional Design			Content Choices			
				Pedagogies	Digital Resources	Assessment	Know and Understand AI	Use and Apply AI	Evaluate and Create AI	AI Ethics
Session 1 (50X2 minutes)	Foundations of AI	This class session covers the technical and conceptual understanding of basic AI concepts.					X			
Session 2 (50X2 minutes)	Activities for Foundations of the AI (Teachable Machine, Code.org activities, GenAI tools	This class session covers how to apply the AI concepts they have learned through various scenarios.	X		X			X		
Session 3 (50X2 minutes)	Pedagogies for AI - Conceptualizing AI Literacy & DigiCompEdu & UNESCO Frameworks	This class session covers the pedagogies that can be used in AI instruction.		X	X	X				
Session 4 (50X2 minutes)	Pedagogies for AI - AI4K12	This class session covers the pedagogies that can be used in AI instruction.		X	X	X				

Table 4. Course Activities' Relations to the Framework Cont'd

Session #	Name of the Activity	Description	Domains							
			Teacher Professional Engagement	Instructional Design			Content Choices			
				Pedagogies	Digital Resources	Assessment	Know and Understand AI	Use and Apply AI	Evaluate and Create AI	AI Ethics
Session 5 (50X2 minutes)	AI Ethics & Issues related to AI & Creation of a detailed lesson plan via GenAI	This class session covers the human-centered considerations of AI. Additionally, issues around AI (e.g., environmental impacts) will be delivered.			X					X
Sessions 6, 8, 10, 12, and 14 (50X2 minutes each)	MIT-AI Activities	These class sessions cover developing higher-order thinking skills through designing and building AI applications.			X		X	X	X	X
Sessions 7, 9, 11, and 13 (50X2 minutes each)	Collaboratively Work on Term Projects	These class sessions facilitate prospective teachers' professional engagement (e.g., effective teaching strategies and professional communication) through working collaboratively.	X							

Table 5 provides a brief overview of each session. Then, a detailed explanation of each session is provided under the following subsections.

Table 5. Overview of the Sessions

Session	General overview of the session (50X2 minutes each)
Introductory	Introduction to the course and the study, pre-data collection for the study (consent forms, pre-MAILS, and pre-opinion forms).
1	A warm-up discussion on AI, a presentation of AI and related concepts, a group activity for AI-powered mobile apps, and a final class discussion to wrap the session up.
2	A brief discussion about the last session, AI-tools exploration (Teachable Machine, Google AI Studio, Code.org), demo activities, AI model training in pairs.
3	A discussion on AI literacy, a presentation about the pedagogies that can be used in AI instruction (e.g., AI literacy frameworks and DigCompEdu), a group discussion about the key ideas of the session.
4	A brief discussion about the last session, a presentation about the AI4K12 initiative, engaging with the AI4K12 activities as a group to explore AI concepts through real-world scenarios.
5	A brief discussion about the last session, a presentation about AI ethics and issues related to AI, a lesson plan generation via a GenAI tool and an evaluation of the lesson plan regarding appropriateness for their teaching fields (as pairs).
6	A question-and-answer session about MIT-AI, followed by learning how to use the platform via different projects, and concluded with an overall discussion.
7	Prospective teachers collaboratively worked on their final projects in this session.
8	A question-and-answer session about MIT-AI, followed by learning how to use the platform via different projects, and concluded with an overall discussion.
9	Prospective teachers collaboratively worked on their final projects in this session.
10	A question-and-answer session about MIT-AI, followed by learning how to build an AI-based model (training an image dataset and adding the AI model to the app in the platform), and concluded with an overall discussion.
11	Prospective teachers collaboratively worked on their final projects in this session.
12	A question-and-answer session about MIT-AI, followed by learning how to build an AI-based model (making ChatGPT chatbot and voice calculator), and concluded with an overall discussion.
13	Prospective teachers collaboratively worked on their final projects in this session.
14	A question-and-answer session about MIT-AI, followed by learning how to build an AI-based model (making a quiz with prospective teachers' own datasets), and concluded with an overall discussion.
Final	Presentation of the final projects and post-data collection for the study (post-MAILS, and post-opinion forms).

3.2.1.1 The introductory session: Introduction to AIED

The introductory session started with a brief explanation of both the course and the study, followed by a detailed explanation of the research and collecting the consent forms, followed by the implementation of the pre-MAILS and filling out the pre-opinion forms regarding AI teaching, learning, and assessment practices, and concluded with an overall discussion. The session took approximately a hundred minutes.

In the first ten minutes, the researcher explained the objective of the research and presented the AI module to the participants. After presenting the AI module, the researcher informed participants that participating in the study is voluntary and there will not be any drawbacks if a participant decides to participate in the study or not. After informing the participants, the researcher collected consent forms from voluntary participants.

For the next seventy-five, voluntary participants filled out the pre-MAILS (fifteen minutes) and pre-opinion forms (sixty minutes) regarding AI teaching, learning, and assessment practices via Google Forms. In the following ten minutes, there was an overall discussion about whether participants wanted to ask about the research or the course. Before finishing the session, the researcher told participants that the resources to be used in the next lesson would be uploaded to the Learning Management System (Moodle) used by the university and that they should read these resources before coming to class.

3.2.1.2 Session 1: Foundations of AI

Session 1 started with a discussion of AI, followed by a presentation about the foundations of AI, and concluded with an overall discussion. The session covered the technical and conceptual understanding of AI concepts. The session took approximately a hundred minutes.

For the first ten minutes, a discussion was held for a warm-up activity. The researcher asked, “What is the definition of AI?” and “Do you know any concepts related to AI? Can you explain them?”. Participants were expected to answer these questions in their own words as they were required to read the session’s materials before coming to class.

For the next fifty minutes, the researcher presented the foundations of AI and AI concepts with the help of a presentation. During the presentation, the researcher played short videos about AI concepts (e.g., machine learning, deep learning, and neural networks) from IBM Technology, Google Cloud Tech, and Simplilearn. It was expected to contribute to the presentation from the participants. The researcher guided them with questions such as “Can you give me an example of machine learning?”.

For the next twenty minutes, participants divided into pairs. They explored their mobile apps and chose an AI-powdered app that they use. They were asked to investigate the app about how AI facilitates the app. All groups presented their tools and explained which AI concept facilitates the app during the class. There was an overall discussion about the session for the last ten minutes.

3.2.1.3 Session 2: Activities for the foundations of the AI

Session 2 started with a discussion of the last session, followed by an exploration of selected AI tools for understanding AI concepts, and concluding with an overall discussion. The session covered how to use and apply AI concepts through various activities. The session took approximately a hundred minutes.

For the first five minutes, the researcher asked the participants what they remembered about AI concepts (e.g., unsupervised learning and deep learning) they taught in Session 1 and guided the discussion.

For the next five minutes, the researcher introduced Teachable Machine, Google AI Studio, and Code.org to the participants and explained the purpose of these AI tools. For the next twenty minutes, the participants were divided into pairs to explore these tools. They tried to understand how to use them. The researcher also encouraged participants to engage with other groups to help each other. The researcher was a facilitator in this phase and helped students if they had any questions.

For the next twenty minutes, the researcher demonstrated short demo activities for these tools. The participants performed these demo activities with the researcher on their computers.

For the next thirty minutes, the participants trained their own AI models via Teachable Machine with their pairs. They chose a project type (image, audio, or pose) and trained their model. The researcher encouraged participants to engage with other groups to consult or help each other. With this activity, participants gained insights about how to use and apply AI.

For the next ten minutes, participants exported their models and submitted them via Moodle, writing a short reflection about their journey.

3.2.1.4 Session 3: Pedagogies for AI: Conceptualizing AI literacy & DigCompEdu

Session 3 started with a discussion, followed by a presentation about AI literacy and DigCompEdu, and concluded with an overall discussion. The session covered the pedagogies that can be used in AI instruction. The session took approximately a hundred minutes.

For the first ten minutes, the researcher asked, “Have you ever heard of AI literacy? What is it?”, “How is TPACK related to AI literacy?”, “Can you give examples from DigCompEdu?” and “Why is it important to learn these approaches as a prospective teacher?”. It was expected to read the session’s materials by the participants before coming to the class.

For the next sixty minutes, the researcher explained Ng et al.’s (2021) conceptualizing AI literacy research and DigCompEdu with a presentation. During the presentation, the researcher gave participants brainstorming questions (e.g., What is the difference between AI literacy and development, How is AI literacy related to Bloom’s Taxonomy? and how to assess students' AI literacy development?) to increase the engagement of the participants.

For the next fifteen minutes, participants were divided into groups of three and discussed the key ideas of the session. The participants also shared their key points via the Padlet board with the class. For the last ten minutes, the researcher informed the participants about their assignment.

3.2.1.5 Session 4: Pedagogies for AI

Session 4 started with a discussion, followed by a presentation about AI4K12, and concluded with an overall discussion. The session covered the pedagogies that can be used in AI instruction. The session took approximately a hundred minutes.

For the first ten minutes, the researcher asked, “What do you remember from the last session?” and “Have you ever heard of the AI4K12 initiative? What is it?”. It was expected to read the session’s materials by the participants before coming to the class.

For the next sixty minutes, the researcher explained AI4K12 with a presentation. During the presentation, the researcher showed the official website (<https://ai4k12.org/>) to explore Big Ideas’ posters, progression charts, and resources that are useful for AI-based instruction. The researcher gave participants brainstorming questions (e.g., How can we differentiate human perception vs machine perception?) to increase the engagement of the participants during the presentation.

For the next twenty minutes, the participants were divided into groups of three and selected an activity from <https://ai4k12.org/activities/>. This activity aimed to engage participants with two of the five Big Ideas (natural interaction and perception activities are available) and explore AI concepts through real-world scenarios. There was an overall discussion about the session for the last ten minutes.

3.2.1.6 Session 5: AI Ethics & Issues related to AI & Creation of a detailed lesson plan via GenAI

Session 5 started with a discussion, followed by a presentation about AI ethics and issues related to AI, and concluded with an overall discussion. The session covered the human-centered considerations of AI (e.g., fairness, ethics, safety) and issues around AI (e.g., environmental impacts). The session took approximately a hundred minutes.

For the first fifteen minutes, there was a short discussion about AI ethics and related issues. The researcher asked, “What does AI ethics mean?”, “How can we use AI in an ethical manner?”, “What do human-centered considerations mean?”, “Does AI have an impact on society?” and “Does AI have an impact on environment?”

For the next thirty-five minutes, the researcher explained AI ethics and issues around AI via short videos from IBM Technology and with a short presentation that included examples of issues around AI. During the presentation, participants brainstormed about the examples (e.g., images produced by AI versus by humans) and tried to explain human-centered considerations (e.g., fairness).

For the next thirty minutes, participants were divided into groups of three and generated a detailed lesson plan via a GenAI tool (e.g., ChatGPT). They examined their lesson plans and assessments in terms of grade level, learning objectives, instructions, main activities, misconceptions and learning difficulties, accuracy of the questions, and accuracy of the references.

For ten minutes, groups shared their findings with the class. There was an overall discussion about the session for the last ten minutes.

3.2.1.7 MIT-AI sessions

Five sessions (see Table 3, Table 4, and Table 5 for details) included hands-on MIT-AI activities and were guided by the researcher. All sessions started with a question-and-answer session about MIT-AI, followed by learning how to build an AI-based model in the platform, and concluded with an overall discussion. The sessions took approximately a hundred minutes.

Session 6 and 8: Introducing and exploring the tool. In this session, the researcher introduced the platform and demonstrated how to use the platform via demo projects. Participants completed the project on their computers, simultaneously with the researcher. At the end of the session, the researcher announced to the participants their assignment related to Session 8. Moreover, prospective teachers filled out their AI literacy diaries.

Session 10: Training an image dataset and adding the AI model to the app. In this session, the researcher showed how to train an image dataset and how to integrate it into MIT-AI. Participants completed the project on their computers, simultaneously with the researcher. At the end of the session, the researcher announced to the participants their assignment related to Session 8. Moreover, prospective teachers filled out their AI literacy diaries.

Session 12: Making ChatGPT chatbot and voice calculator. In this session, the researcher showed how to make a ChatGPT chatbot and a voice calculator in MIT-AI. Participants completed the project on their computers, simultaneously with the researcher. At the end of the session, the researcher announced to the participants their assignment related to Session 10.

Session 14: Make a Quiz with your own dataset. In this session, the researcher showed how to create and integrate their dataset into MIT-AI to make a quiz. Participants completed the project on their computers, simultaneously with the researcher. At the end of the session, the researcher announced to the participants their assignment related to Session 12.

3.2.1.8 Sessions 7, 9, 11, and 13: Collaboratively work on term projects

These sessions did not have lesson plans because the participants collaboratively worked on their term projects. However, sessions 7, 9, 11, and 13 contributed to the conceptual framework, especially in the domain of teacher professional engagement.

Term projects were significant in this module because project-based learning experiences positively affect the development of prospective teachers' technology competencies (Şen-Akbulut & Öner, 2021), and it is a useful pedagogy in AI literacy education for non-engineering undergraduates (Ng et al., 2022).

3.2.1.9 The final session

The final session started with presentations of the final projects, followed by the implementation of the post-MAILS, filling out the post-opinion forms regarding AI teaching, learning, and assessment practices, and concluding with an overall discussion.

Participants presented their final projects for the first fifty minutes and got feedback from the course instructor and their peers. For forty minutes, voluntary participants filled out the post-MAILS and post-opinion forms regarding AI teaching, learning, and assessment practices via Google Forms. For the last ten minutes, there

was an overall discussion about whether participants wanted to ask questions related to their projects and the course.

3.2.2 MIT-AI

MIT-AI is a web-based and block-based platform that enables students to produce mobile applications to solve real-world problems and fosters problem-solving, collaboration, and creativity (Patton et al., 2019). Research has shown that MIT-AI can be used as an educational mobile application development tool because it is perceived as user-friendly, enjoyable, and useful by teachers (Polat & Hopcan, 2019).

Teachers and students agree that the tool positively contributes to pedagogical designs to enhance students' understanding of fundamental programming concepts (Chatzinikolakis & Papadakis, 2014), and it can be used to enhance TPACK (Rezaei & Mohseni, 2024). Moreover, MIT-AI enables users to work with AI extensions to build their own AI models, learn reinforcement learning, design chatbots, and other facilities.

3.2.3 Final projects and lesson plans

Final projects and lesson plans aimed to (1) develop prospective teachers' professional engagement abilities (e.g., effective teaching strategies, professional communication, engagement) in AI instruction by working collaboratively and (2) promoting their higher-order thinking skills via producing their mobile app by utilizing instructional design and content choices domains.

The final project artifacts were its reports and lesson plans (see Appendix D). Participants filled out their final reports for their lesson plans. Final reports include two phases: (1) project proposal and development phase and (2) project reporting phase.

The first phase included the learning materials' area of interest/need, unit/topic description, learning objectives from the AI4K12 framework and related objectives from the Ministry of National Education (MoNE) curriculum, the rationale behind the choice, and AI's role in the project. Moreover, participants shared their lesson/unit plans and reported their collaboration strategies about how to support each other during the production. Lastly, in the second phase, participants explained how they utilize universal design for learning, multimedia design, ISTE standards, AI pedagogies, AI ethics, assessment techniques, and limitations of their lesson plans.

3.3 Data sources

The study's quantitative data was collected through the MAILES (Carolus et al., 2023), and the study's qualitative data was collected through opinion forms and participants' final projects. Table 6 shows the data sources and related research questions.

Table 6. Data Matrix of the Study

Research Question	Data Source			Data Analysis
	MAILS	Pre- and Post-Opinion Forms	Final Projects	
1.1. Is there a significant difference between prospective teachers' pre- and post-AI literacy scores after participating in the module?	X			Inferential and Descriptive Statistics
1.2. What are the prospective teachers' perceptions of AI before and after participating in the module?		Q1, Q2, Q3, Q4, Q5		Hybrid Thematic Analysis
2.1. To what extent do prospective teachers integrate AI into their learning, teaching, and assessment practices, as evident in their final projects after participating in the module?			X	Hybrid Thematic Analysis
2.2. What are the prospective teachers' perceptions of AI regarding learning, teaching, and assessment practices before and after participating in the module?		Q8, Q10, Q11, Q12		Hybrid Thematic Analysis

3.3.1 MAILS

MAILS is a 34-item self-reported questionnaire and a ten-point Likert scale from hardly or not at all pronounced (0) to very well or almost perfectly pronounced (10) for measuring students' AI literacy development in three main domains: (1) AI literacy, (2) AI self-efficacy, and (3) AI self-competency (Carolus et al., 2023, Appendix A). Each domain includes different facets (see Table 7).

Table 7. MAILS Domains and Their Facets

Domain	Facets
AI literacy (22 Items)	Apply AI
	Understand AI
	Detect AI
	AI Ethics
	Create AI
AI self-efficacy (6 Items)	AI problem solving
	Learning
AI self-competency (6 Items)	AI persuasion literacy
	AI emotion regulation

Since the conceptual framework of the study is developed based on three models, namely DigCompEdu (Redecker, 2017), Ng et al. (2021)'s revised TPACK model for AI literacy, and the P21's framework for twenty-first-century learning (Ng et al., 2023), this questionnaire is suitable for the study. The AI literacy domain especially matches the AI competency instructional design model. Moreover, the cognitive domains of AI literacy, which are in the AI literacy facet, are considered as the core domains of AI literacy (Ayanwale et al., 2024; Lumanlan et al., 2025; Long and Magerko, 2020; Ng et al., 2021).

The data was collected from 300 German-speaking adults, and confirmatory factor analysis was performed. The confirmatory factor analysis supported a measurement model with 34 observed items representing AI literacy and related psychological constructs. All items were significantly loaded onto their respective factors ($p < .001$), and first-order factors were significantly loaded onto second-order factors ($p < .001$). The second-order factors were also significantly correlated ($p < .01$), with AI self-efficacy and AI self-competency showing particularly strong associations with AI literacy.

Regarding to the AI literacy domain, it has been reported that Cronbach's α values for the facets of apply AI, understand AI, detect AI, AI ethics, and create AI are 0.93, 0.87, 0.77, 0.75, and 0.92 respectively.

3.3.2 Opinion forms regarding AI teaching, learning, and assessment

Students filled out pre- and post-opinion forms regarding AI teaching, learning, and assessment (see Appendix B) in the first week and the last week of the research. Both forms have 13 questions. Opinion form questions were developed based on the conceptual framework of the research (Ng et al., 2023). These questions aimed to understand how participants' perceptions of AI teaching, learning, and assessment practices will change and were counted as qualitative data for the research. Those data contributed to understanding the effectiveness of the AI module and potential areas for enhancement.

After the opinion forms were initially drafted, an expert interview was conducted to evaluate their relevance, clarity, and alignment with the research objectives. The expert consulted for this purpose is an academic specializing in the field of educational technology and has ongoing research in AIED.

The review session lasted approximately 45 minutes and involved a comprehensive evaluation of both the pre-opinion and post-opinion forms, each of which originally consisted of 12 questions. During the session, each item was discussed in terms of its alignment with the study's conceptual framework, its intended purpose, and the linguistic structure used. The discussion addressed not only opinion forms' questions clarity, but also in terms of appropriateness of terminology and consistency of expression.

As a result of this iterative review and discussion process, several items were refined for improved clarity and conceptual alignment. Additionally, one new question was added to each form based on the expert's recommendations, bringing the total number of finalized questions to 13 per form.

3.4 Data collection procedure

Before conducting the research, the ethics approval was taken from the Ethics Committee in Social Sciences and Humanities (SOBETIK) of Boğaziçi University (see Appendix E). Before collecting data, the purpose of the research was explained at the beginning of the semester, and a consent form was sent to participants who wanted to participate in the study (see Appendix C).

The consent form includes the purpose of the research, the period of the study, and an explanation of which materials will be counted as data. The consent form also underlies that the participation is voluntary, there will be no penalty for non-participation or stopping participation, no incentives or awards, and all the data will be stored anonymously by the researcher.

At the beginning and at the end of the study, the MAELS (Carolus et al., 2023) and opinion forms regarding AI teaching, learning, and assessment practices were collected simultaneously. Prospective teachers filled out the MAELS in approximately 20 minutes and completed opinion forms in approximately 60 minutes, both at the beginning and end of the study.

Throughout nine weeks, participants engaged with different topics regarding AI learning, teaching, and assessment for their lecture course sessions and explored MIT-AI to enhance their technological skills and AI competencies. At the same time, they produced several course artifacts, such as assignments regarding theoretical course sessions, laboratory assignments, lesson plans, and final projects (see Appendix D), filled opinion forms, and the MAELS. Table 8 provides details of the study's data collection procedure.

Table 8. The Data Collection Procedure of the Study

Overarching Research Question	Sub-Research Question	Data Source	Period
How does the designed AI module facilitate prospective teachers' AI competencies?	1.1. Is there a significant difference between prospective teachers' pre- and post-AI literacy scores after participating in the module?	MAILS (Carolus et al., 2023; Appendix A)	Before and after the intervention (2nd and 13th weeks of the semester)
	1.2. What are the prospective teachers' perceptions of AI before and after participating in the module?	Pre- and post-opinion forms regarding AI teaching, learning, and assessment (Appendix B)	Before and after the intervention (2nd and 13th weeks of the semester)
	2.1. To what extent do prospective teachers integrate AI into their learning, teaching, and assessment practices, as evident in their final projects after participating in the module?	Final projects (Appendix D)	During the intervention (From 6th to 13th weeks of the semester)
	1.1. Is there a significant difference between prospective teachers' pre- and post-AI literacy scores after participating in the module?	Pre- and post-opinion forms regarding AI teaching, learning, and assessment (Appendix B)	Before and after the intervention (2nd and 13th weeks of the semester)

3.5 Data analysis

3.5.1 Quantitative analysis

To address the overarching research question (How does the designed AI module facilitate prospective teachers' AI competencies?) was explored through research question 1's (How does prospective teachers' AI literacy evolve after participating in the module?) sub question of 1.1. (Is there a significant difference between prospective teachers' pre- and post-AI literacy scores after participating in the module?) by using the MAILS.

Participants' answers on the pre and post-MAILS were collected and scored by the Likert scale from hardly or not at all pronounced (0) to very well or almost perfectly pronounced (10) with rating three domains: (1) AI literacy questions from 1 to 22, (2) AI self-efficacy questions from 23 to 28, and (3) AI self-competency questions from 29 to 34.

Quantitative data were analyzed using descriptive statistics and inferential tests to examine changes in prospective teachers' MAILS scores. The IBM SPSS statistical software (Statistical Package for Social Sciences - Version 29) was used for the analysis. Due to the small sample of the study ($N = 11$), the Shapiro-Wilk test was used to determine whether the pre- and post-survey scores followed a normal distribution. The Skewness and Kurtosis values were also calculated to detect outliers and extreme values of the scores.

The outliers were not excluded from the dataset because the sample size was small ($N = 11$). Even though the test scores were normally distributed, a nonparametric test was conducted due to the potential influence of extreme values on parametric tests, as nonparametric tests offer a more reliable approach by reducing the impacts of outliers while maintaining the validity of the analysis (Zimmerman,

1994). Moreover, the Wilcoxon Signed-Rank test was used to determine whether there was a difference in the median of the MAILS' pre- and post-scores.

For the quantitative analysis of the sub-domains of AI literacy domain, Benjamini-Hochberg procedure performed for the false discovery rate (FDR) (Benjamini & Hochberg, 1995) in addition to Wilcoxon Signed-Rank test. Conducting multiple statistical tests on multiple comparisons increased the Type I error which occurs when a true null hypothesis is incorrectly rejected (Creswell, 2008). The Benjamini-Hochberg procedure controls the FDR which refers to the expected proportion of false positives among the rejected hypotheses (Benjamini & Hochberg, 1995). In this procedure, the significance threshold for each individual p-value is calculated by multiplying the p-value's rank order (i) by the alpha level (α) which refers to the FDR and equals to 0.05 and dividing the result by the total number of independent comparisons (m), which equals to 5 in this quantitative analysis.

3.5.2 Qualitative analysis for opinion forms

In order to answer the sub-research questions 1.2. (What are the prospective teachers' perceptions of AI before and after participating in the module?) and 2.2. (What are the prospective teachers' perceptions of AI regarding learning, teaching, and assessment practices before and after participating in the module?), the data collected from the opinion forms on AI teaching, learning, and assessment practices were initially organized using Microsoft Word (Version 16). After organizing the responses, the documents were imported into MAXQDA Analytics Pro 24 for qualitative analysis.

To explore prospective teachers' perceptions of AI literacy, these opinions were analyzed through hybrid thematic analysis (Fereday & Muir-Cochrane, 2006; Swain, 2018). Firstly, deductive thematic analysis was applied to organize the qualitative data in the deductive categories based on the AI Competency Instructional Design Model (Ng et al., 2023)'s third key domain. This key domain includes four cognitive aspects to foster AI literacy (Ng et al., 2021). Secondly, inductive thematic analysis was performed by doing in vivo and line-by-line coding. Thirdly, emerging concepts were identified from inductive coding. Qualitative analysis yielded 97 codes to answer this research question. The codes were initially categorized under the cognitive aspects of AI literacy, and these clusters were grouped under categories as emerging categories to explore the shifts in prospective teachers' AI literacy perceptions (see Table 9 and Table 10).

Moreover, Braun and Clarke's (2006) six steps for thematic analysis were followed. Firstly, transcribed and organized opinion forms were read multiple times to ensure familiarization with the data and for initial ideas. Secondly, deductive thematic analysis was performed based on the cognitive domains of AI literacy. Initial codes were generated systematically across the dataset, identifying meaningful features related to prospective teachers' perceptions of AI literacy. Thirdly, in order to identify patterns in the responses, related codes were grouped into relevant themes. In the fourth stage, these themes were examined and improved upon by comparing their relevance to the coded extracts and the complete dataset. During the fifth phase, each theme was defined and named according to the participants' perspectives. The sixth step concluded with the selection of representative data segments for constructing an in-depth analytical narrative (Braun & Clarke, 2006).

Table 9. Overview of Coding Process for Pre-Opinion Forms

Deductive coding: Aspects of AI literacy (Ng et al., 2023)		
	Definitions of the Aspects	Inductive coding samples (Pre)
Know and understand AI	Definition of AI	A software, a coded program, an autonomous system, an assisting agent, a technology-based brain, an intelligence for machines, an interactive search engine, a human-made program, AI is a tool
	Types of AI and its examples	ChatGPT, GenAI
	How AI operates	AI is trained, AI has algorithms, AI has data repertoire, AI performs autonomous data processing, AI can retrieve data, AI performs rapid data processing, AI performs data processing, AI has continuous autonomous learning, AI can perform digital knowledge manipulation
	What does AI do	AI can context-aware adaptation, AI can generate goal-oriented output, performs human tasks
	Understanding AI	Assessing the advantages and disadvantages of AI
		How to use AI, using AI in a way it can understand, filtering AI outputs based on relevance, identifying and eliminating misinformation, giving step-by-step explanation
Use and apply AI	Using AI effectively	
	AI in daily life	How to integrate AI into daily life
Evaluate and create AI	Evaluation of AI systems	Critical evaluation of AI tools,
	Creating AI applications	Ability to develop AI
AI Ethics	Data privacy and security	How does AI store data?, protection of personal data, AI use sources without control, unlimited access to information is a problem
	Ethical use	Transparency, explainable AI, responsible AI, knowing AI ethics
	Integrity in AI	Humans should take responsibility when using AI, scientific integrity is needed, plagiarism from AI
	AI risks and societal impacts	Plagiarism from AI, violation of academic integrity, devaluation of human effort, malicious use, safety, human rights
	AI development and governance	Set of rules to train AI
	Issues around AI	Knowing the consequences of AI

Table 10. Overview of Coding Process for Post-Opinion Forms

Deductive coding: Aspects of AI literacy (Ng et al., 2023)		
	Definitions of the Aspects	Inductive coding samples (Post)
Know and understand AI	Definition of AI	A software, a coded program, an information system, an assisting agent, a technology-based program, an intelligence for machines, a developed search engine, a human-made program, a mechanism
	Types of AI and its examples	GenAI, AI has types
	How AI operates	AI has algorithms, AI recognizes patterns, AI has data repertoire, AI is trained, AI can retrieve data, AI performs rapid data processing
	What AI does	AI can adapt to various situations, AI mimics human intelligence, AI can goal-oriented problem solving, AI produces human-like responses, performs human tasks, AI can context-aware adaptation, AI perform rapid output generation, AI transmits data to humans, AI can real-time support, AI can execute instructions
	Understanding AI	Assessing advantages and disadvantages of AI, knowledge of AI applications, knowing the foundations of AI, knowing when to use AI
	AI concepts	Machine learning, deep learning, AI has reasoning, AI has perception, AI performs question answering (QA), big data, AI decision-making
	GenAI capabilities	Content generation, image generation, video generation,
	Use and apply AI	How to use AI, how to use AI in a proper way, using AI in a way it can understand, using AI in a goal-oriented manner, giving right orders
Evaluate and create AI	Using AI effectively	
	Evaluate AI	Ability to evaluate AI, analyze AI, critically evaluate AI outputs
AI Ethics	Data privacy and security	Protection of personal data,
	Ethical use	Transparency, explainability, knowing the source of the information
	AI risks and societal impacts	Bias, biased data, misuse, unintended negative consequences, questionable design, hallucinations, fairness, devaluation of human effort, safety, malicious use, human agency
	Issues around AI	Environmental issues, water consumption,
	Bias types	Gender bias, race bias, algorithmic bias

3.5.3 Qualitative analysis of the AI-integrated final projects

During the study, prospective teachers collaborated in groups to develop AI-integrated final projects based mostly on their subject areas. They were allowed to choose one or two subject areas, consequently two different units and topics. The projects consisted of two main phases: (1) project proposal and development phase, and (2) project reporting phase. During the first phase, each group created four lesson plans as part of a developing AI-integrated unit plan. The participants were divided into four groups, with three prospective teachers in each. However, one group had four members due to the total number of participants.

Participants were encouraged to collaborate with both their group members and the other groups as suggested as the conceptual framework of the study. In order to develop AI pedagogy, collaborative learning is an essential component of the pedagogical knowledge that prospective teachers acquire.

AI-integrated unit plans (including four lesson plans each) were introduced to prospective teachers in the sixth week of the study as a final project. Participants developed their lesson plans based on the Five Big Ideas in AI (Touretzky et al., 2023). While they attempted to integrate all five ideas into their projects, it was not a mandatory requirement. The groups submitted their first drafts in the tenth week of the module, the second drafts in the last week, and their final versions one week after the module ended. After submitting their first and second drafts, the groups presented their draft lesson plans in the classroom and got feedback from both their peers and instructors.

Each lesson plan (n = 16) was analyzed with content analysis, deductive approach (Crabtree & Miller, 1999) was used to identify themes with the conceptual framework of the study and the UNESCO framework for students (Miao & Shiohira, 2024). The rubric used to analyze the lesson plans is presented in the Table 11.

Table 11. The Rubric for Analyzing the Lesson Plans

Aspect	Component
Descriptives	Area of learning
	Grade level
	Selected topic
Learning Objectives	Instructional learning objectives that aligned with MoNE, ISTE, CCSS, CC, or PRIMM
	The AI4K12 learning objectives related to instructional learning objectives
Learning Activities	Materials (e.g., activity sheets, infographics, or simulations) that were designed/utilized for learning objectives
Competencies	Aligned with the selected UNESCO competencies for students
Assessment	The assessment techniques that were used to evaluate AI literacy skills

The aspects were selected based on the relevant literature and the conceptual framework of the study. Moreover, at the beginning of the study, the lesson plan template (see Appendix D) was constructed around some of the essential components, which were learning objectives, learning activities, and assessment strategies (Brown & Lee, 2015; Savage, 2014). The aspects of descriptives and competencies were integrated in order to provide an overview of the designed

lessons and to perform deductive analysis to align with the conceptual framework of the study.

The descriptive aspect aimed to provide an overview of the areas of learning, selected topics, and grade-level lesson plans. This aspect was chosen for descriptive purposes and was not supported by a specific study. However, it was important to present how prospective teachers utilized AI across disciplines and levels of education in context.

Learning objectives (LOs) are considered the most significant part of a lesson plan. LOs define learning and determine the other components of lesson plans, including instructional materials, activities, and assessments (Savage, 2014). In this study, the learning objectives aspect includes the instructional learning objectives that are aligned with the Ministry of National Education (MoNE) or other relevant curriculums (e.g., ISTE, CCSS, or PRIMM) and the AI4K12 learning objectives (Touretzky et al., 2023). This aspect was chosen for descriptive purposes and deductively analyzed based on the Five Big Ideas in AI (Touretzky et al., 2023).

Learning activities include materials (e.g., activity sheets, infographics, or simulations) that were designed or utilized for learning objectives. Lesson plans that were developed by prospective teachers cover a variety of activities regarding the topics that were chosen from their subject field and the AI4K12 domains. Firstly, all activities were analyzed, and the activities related to the AI4K12 domains were detected. Secondly, deductive analysis was performed to match these activities with relevant AI4K12 domains, their specific learning contents (e.g., commonsense reasoning), and their cognitive level of AI literacy.

Moreover, learning activities that are relevant to the AI4K12 were deductively analyzed to detect the UNESCO competencies for students (Miao &

Shiohira, 2024). The activities matched with corresponding competencies, their progression levels, and their aspects. These findings were represented with their frequency charts (see Chapter 4).

Lastly, the assessment aspect includes the techniques that were appropriate to evaluate the students' AI literacy skills in terms of lower-order and higher-order thinking skills. Assessment strategies were analyzed in terms of their content which was concerned with identifying assessment strategies and their aims.

3.6 Trustworthiness

Parallel mixed-methods design (Tashakkori et al., 2021) allows the simultaneous collection of quantitative and qualitative data and analysis by integrating their results to conclude meta-inferences that are findings obtained by the integration of both data sets. While the quantitative results are based on statistical evidence, the qualitative strand offers an in-depth understanding of participants' experiences.

Lincoln and Guba (1985) defined trustworthiness as the degree to which researchers can convince their audience that the findings are “worth paying attention to” (p. 290). According to Lincoln and Guba (1985), there are four criteria to increase trustworthiness in qualitative findings: credibility, transferability, dependability, and confirmability.

Credibility refers to how trustworthy and believable the outcomes are according to the perspective of the participants (Guba & Lincoln, 1989). Similar to internal validity in quantitative research, it examines whether the results accurately reflect the participants constructed realities rather than whether they correspond to an objective reality. A variety of techniques exist to enhance the credibility of the study, and one of them is peer debriefing (Guba & Lincoln, 1989; Lincoln & Guba, 1985).

Peer debriefing refers to one's engagement in discussions with an objective perspective to critically examine the study's interpretations. Peer debriefing was employed to increase the credibility of the study. This process was conducted with two graduate students who are currently enrolled in Educational Technology master's program at Boğaziçi University as the researcher.

The first peer is conducting research on learning in metaverse environments, with particular attention to differences in cognitive load across various platforms such as 2D and 3D learning spaces. In addition to the researcher's work on immersive technologies, this researcher is also engaged in studies related to AIED. These areas of expertise positioned the researcher to offer objective and meaningful feedback on the interpretation of the study's data, especially from the technological perspectives.

The second peer conducts studies on computational thinking and has a strong foundation in qualitative research design. The researcher's experience in analyzing and interpreting qualitative data allowed them to provide well-informed, methodologically sound feedback on the qualitative dimensions of the study.

The second criterion, dependability, is associated with "the stability of the data over time" (Guba & Lincoln, 1989, p. 242), and dependability is an inevitable part of credibility (Guba, 1981). In this study, a dependability audit was established to increase the overall dependability of the research by clearly explaining the research design, data collection instruments, the steps followed during data collection, and the detailed procedures applied in data analysis.

Throughout the research process, careful documentation was maintained to allow for external scrutiny. A comprehensive audit trail was developed, recording all critical decisions made during the research design, data collection, and analysis

phases. This systematic documentation enables other researchers to trace the logic and methodological procedures implemented in the study, thereby supporting the transparency and consistency of the findings.

The third criterion, transferability, can be described as the extent to which qualitative research findings can be applied to other settings (Guba & Lincoln, 1989; Lincoln & Guba, 1985). In qualitative research, transferability can be provided through thick descriptions. The thick description technique involves “understanding the intentions/meanings of the individuals” (Tashakkori et al., 2021, p. 202). In this study, detailed information about the participants and the setting was provided in order to increase the transferability of the study into different settings.

The last criterion, confirmability, refers to concerns about the study's data, interpretations, and conclusions are grounded in the real experiences of the participants and the research setting rather than being influenced by the researcher's preconceptions or prejudices (Guba & Lincoln, 1989).

To enhance confirmability in this study, all findings were grounded in the prospective teachers' actual statements. A clear audit trail was maintained throughout the research process, including detailed documentation of coding decisions, theme development, and data interpretation. Direct quotes from participants were included to support each theme to show how interpretations were formed. Additionally, a deductive coding approach based on pre-determined AI literacy domains helped to reduce bias and ensured that the analysis remained closely aligned with the study's research questions and the data itself.

3.7 Researcher's position

The researcher's position is regarded as a unique and influential component of the study, as it can affect various aspects of the research process (Holmes, 2020). I hold a Bachelor of Science degree in Physics Education from Boğaziçi University. During and after my undergraduate studies, I worked as a physics and mathematics teacher, which allowed me to develop a strong foundation in my subject area. While continuing my professional work, I began my graduate studies in Educational Technology master's program at the same university. In the second year of the program, I started working as a research assistant at the Robotics and Artificial Intelligence Education laboratory under the supervision of my thesis advisor.

In this study, I took on dual responsibilities as both the researcher and the teaching assistant for the course where the research was carried out. I designed the instructional module and created the materials used in the course. My previous professional experience, particularly my work as a learning experience designer in the private sector, significantly contributed to the development of this module. My role as a research assistant contributed to the development of the instructional module by helping me ground the design process in relevant literature and research-based practices. As a teaching assistant, under the supervision of my advisor, I implemented the course sessions and delivered both the theoretical content and the MIT App Inventor activities.

Moreover, while implementing the module, I also had the opportunity to closely observe the participants, which helped me better interpret the data collected throughout the study. I was also responsible for grading all course-related assignments, including the final projects. This active involvement in the assessment process allowed me to become highly familiar with the data collected.

As I was both delivering the content and collecting the data for research purposes, I may have unintentionally provided more detailed explanations of certain concepts, especially when learners needed further clarification. This extended instructional support could have positively influenced the quality of the data by helping learners engage more deeply with the content.

Given my dual role in both delivering the instructional content and collecting the research data, I made a conscious effort to remain neutral during classroom interactions. I was particularly attentive to avoiding any tendency to guide learners toward specific answers that aligned with the module content. Instead, I encouraged participants to express their own perspectives freely and offered clarifications only when necessary to support comprehension. This intentional stance was aimed at preserving the authenticity of participant responses and minimizing potential bias introduced by my teaching assistant role.

However, I was aware that these observations could introduce potential biases during data analysis. To minimize this risk, I kept detailed observation notes for each session. When analyzing the qualitative data, I strictly adhered to the participants' own responses without adding personal interpretation. In order to ensure the trustworthiness of the findings, I conducted peer debriefing by sharing my analyses with two graduate students who were not involved in the study. This process is explained in detail in section 3.6 which is trustworthiness (see Chapter 3).

CHAPTER 4

RESULTS

The purpose of this complementarity parallel mixed-methods design study was to explore how a learning module based on the AI competency instructional model (Ng et al., 2023) facilitates prospective teachers' AI competencies and their AI literacy. At the beginning of the specifically designed AI module, MAILS was conducted to measure prospective teachers' AI literacy before participating in the module. Moreover, the participants were asked to fill out the opinion form regarding the use of AI for teaching, learning, and assessment practices. During the study, the participants engaged in a nine-week AI module and produced several course artifacts (e.g., lesson plans, AI-supported activities based on MIT-AI, etc.). At the end of the study, the participants were asked to fill out the MAILS and the opinion form regarding AI teaching, learning, and assessment practices. Pre- and post-MAILS scores were analyzed to examine the difference between prospective teachers' AI literacy scores and used as complementarity quantitative data. Pre- and post-opinion forms and course artifacts were collected as qualitative data to explore how the participants' learning, teaching, and assessment practices evolved after engaging with the AI module. Qualitative data was analyzed using a hybrid thematic analysis approach. In this chapter, the results of the data analysis to explore how the designed AI module facilitates prospective teachers' AI competencies in depth are presented in detail.

4.1 Research question 1: How does prospective teachers' AI literacy evolve after participating in the module?

In order to answer the first research question, several data sources were analyzed. First, prospective teachers' initial and final AI literacy scores were collected through the MAELS (Carolus et al., 2023, see Appendix A) and analyzed using both descriptive and inferential statistics. Second, prospective teachers' perceptions regarding AI before and after participating in the module were collected via open-ended questions in opinion forms (see Appendix B) were analyzed using a hybrid thematic analysis approach. The following subsections present findings regarding the first research question.

4.1.1 Research question 1.1: Is there a significant difference between prospective teachers' pre- and post-AI literacy scores after participating in the module?

Since there was a small sample size in the study, the Shapiro-Wilk's test was conducted for normality to check the normal distribution of data in order to analyze pre- and post-AI literacy scores. The distribution of pre-test scores demonstrated a skewness of -0.174 (SE = 0.661) and kurtosis of -1.311 (SE = 1.279), whereas the post-test scores exhibited a skewness of -0.658 (SE = 0.661) and kurtosis of 1.974 (SE = 1.279) (see Table 12). The results showed that pre and post-test scores were normally distributed ($p > .05$), as shown in Table 13.

High or positive kurtosis values typically indicate the presence of outliers in the data (Hatem et al., 2022). In line with this, two outliers were identified in the post-test results. However, the outliers were not excluded from the data set because the sample size was small ($N = 11$). Even though the test scores were normally distributed, a nonparametric test was conducted due to the potential influence of

extreme values on parametric tests (Zimmerman, 1994). Nonparametric tests offer a more reliable approach by reducing the impacts of outliers while maintaining the validity of the analysis (Zimmerman, 1994).

Table 12. Descriptive Statistics of Pre- and Post-MAILS Scores

	N	Min	Max	Mean	Median	SD	Skewness	Kurtosis
Pre-MAILS	11	109	254	178.91	196.000	48.589	-.174	-1.311
Post-MAILS	11	165	297	239.00	243.00	33.761	-.658	1.974

Table 13. Shapiro-Wilk Results of Pre- and Post-MAILS Scores

	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-MAILS	.930	11	.412*
Post-MAILS	.920	11	.317*

* $p > .05$

A Wilcoxon signed-rank test showed that the specifically designed AI module elicited a statistically significant change in the MAILS $Z = -2.756$ and $p = 0.006$ (see Table 14 and Table 15), with a large effect size ($r = .83$) (Cohen, 1992).

Table 14. Wilcoxon Signed-Rank Test for Pre- and Post-MAILS

		N	Mean Rank	Sum of Ranks
Post-MAILS - Pre-MAILS	Negative Ranks	1 ^a	2.00	2.00
	Positive Ranks	10 ^b	6.40	64.00
	Ties	0 ^c		
	Total	11		

a. Post-MAILS < Pre-MAILS

b. Post-MAILS > Pre-MAILS

c. Post-MAILS = Pre-MAILS

Table 15. Wilcoxon Signed-Rank Test Result

	Post-MAILS - Pre-MAILS
Z	-2.756 ^b
Asymp. Sig. (2-tailed)	.006
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

In order to analyze the significant differences in the domain of AI literacy, prospective teachers' scores were calculated. The descriptive statistics results indicated that the mean of the AI literacy scores increased from 113.45 to 157.82 at the end of the study (see Table 16). However, mean calculation is not sufficient to demonstrate a significant difference.

Since there was a small sample size, Shapiro-Wilk's test was conducted for normality to check the normal distribution of data in order to analyze pre- and post-domain scores of MAILS. The results showed that pre and post-test scores were normally distributed ($p > .05$), as shown in Table 17. The distribution of pre-AI literacy scores demonstrated a skewness of -0.327 (SE = 0.661) and kurtosis of -0.535 (SE = 1.279), whereas the post-test scores exhibited a skewness of -1.068 (SE = 0.661) and kurtosis of 2.814 (SE = 1.279). These statistical values are presented in Table 16.

High or positive kurtosis values typically indicate the presence of outliers in the data (Hatem et al., 2022). In line with this, two outliers were identified in the post-AI literacy scores. However, the outliers were not excluded from the data set because the sample size was small ($N = 11$). Even though the test scores were normally distributed, a nonparametric test was conducted due to the potential influence of extreme values on parametric tests (Zimmerman, 1994).

Nonparametric tests offer a more reliable approach by reducing the impacts of outliers while maintaining the validity of the analysis (Zimmerman, 1994).

Table 16. Descriptive Statistics of the AI Literacy Domain of MAILS

	N	Min	Max	Mean	Median	SD	Skewness	Kurtosis
Pre-AI literacy	11	69	160	113.45	123.00	28.058	-.327	-.535
Post-AI literacy	11	111	190	157.82	159.00	19.444	-1.068	2.814

Table 17. Shapiro-Wilk Results of Pre- and Post-AI Literacy Domain Scores

	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-AI literacy	.924	11	.356*
Post-AI literacy	.912	11	.259*

* $p > .05$

A Wilcoxon signed-rank test showed that the specifically designed AI module elicited a statistically significant change in the domain of AI literacy scores $Z = -2.847$ and $p = 0.004$ (see Table 18 and Table 19), with a large effect size ($r = .86$) (Cohen, 1992).

Table 18. Wilcoxon Signed-Rank Test for Pre- and Post-Scores of AI Literacy Domain

		N	Mean Rank	Sum of Ranks
Post-AI literacy - Pre-AI literacy	Negative Ranks	1 ^a	1.00	1.00
	Positive Ranks	10 ^b	6.50	65.00
	Ties	0 ^c		
	Total	11		

a. Post-AI literacy < Pre-AI literacy

b. Post-AI literacy > Pre-AI literacy

c. Post-AI literacy = Pre-AI literacy

Table 19. Wilcoxon Signed-Rank Test Result of AI Literacy Domain

	Post-AI literacy - Pre-AI literacy
Z	-2.847 ^b
Asymp. Sig. (2-tailed)	.004

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Lastly, participants' scores were calculated to analyze the domain of AI literacy's sub-domains, namely, apply AI, understand AI, detect AI, AI ethics, and create AI. The descriptive statistics results indicated that the means of AI literacy domain's sub-domain scores increased. Respectively, the apply AI sub-domain increased from 37.73 to 44.73, the understand AI sub-domain increased from 31.55 to 42.45, the detect AI sub-domain increased from 19.09 to 23.73, the AI ethics sub-domain increased from 18.73 to 21.82, and, lastly, the create AI sub-domain increased from 6.36 to 25.09 at the end of the study (see Table 20). Since there was a small sample size, Shapiro-Wilk's test was conducted for normality to check the normal distribution of data in order to analyze pre- and post-AI literacy's sub-domain scores. The results showed that pre and post-test scores were normally distributed ($p > .05$) except for the pre-create AI scores, as shown in Table 21.

The distribution of pre-test scores for apply AI demonstrated a skewness of -0.054 (SE = 0.661) and a kurtosis of -0.634 (SE = 1.279), whereas the post-test scores exhibited a skewness of -1.366 (SE = 0.661) and a kurtosis of 2.134 (SE = 1.279). Moreover, the distribution of pre-test scores for understand AI exhibited a skewness of 0.377 (SE = 0.661) and a kurtosis of -0.763 (SE = 1.279), while the post-test scores demonstrated a skewness of 0.524 (SE = 0.661) and a kurtosis of -0.046 (SE = 1.279). For detect AI, the pre-test scores displayed a skewness of -0.711 (SE = 0.661) and a kurtosis of 0.072 (SE = 1.279), whereas the post-test scores

exhibited a skewness of -0.296 (SE = 0.661) and a kurtosis of 0.226 (SE = 1.279). The distribution of pre-test scores for AI ethics demonstrated a skewness of 0.167 (SE = 0.661) and a kurtosis of -0.591 (SE = 1.279), while the post-test scores exhibited a skewness of -0.188 (SE = 0.661) and a kurtosis of 0.044 (SE = 1.279). As the final subdomain, the distribution of pre-test scores for create AI showed a skewness of 1.116 (SE = 0.661) and a kurtosis of 0.218 (SE = 1.279), whereas the post-test scores exhibited a skewness of -1.113 (SE = 0.661) and a kurtosis of 2.297 (SE = 1.279). These statistical values are presented in Table 20.

High or positive kurtosis values typically indicate the presence of outliers in the data (Hatem et al., 2022). In line with this argument, one outlier was identified in the post-Apply AI results, and one outlier was identified in the post-create AI results. In addition to these outliers, one outlier was identified in the pre-create AI domain, even though the kurtosis value (0.218) is in the acceptable range. On the other hand, the skewness value (1.116) is greater than 1, which confirms that the data are highly skewed (Hatem et al., 2022). The outliers can be explained with the median absolute deviation (MAD) approach, which offers a more robust and reliable method to detect outliers, particularly those with skewed or small sample size datasets (Leys et al., 2013). Based on the MAD formulation, the MAD was found to be 5, where the median was 6. The formula of “the median minus or plus 2.5 times the MAD” (Leys et al., 2013) was applied to calculate the outlier thresholds. The lower bound was detected as -6.5, whereas the upper bound was calculated as 18.5. The maximum value, which is 20, of the data set was found as the outlier.

However, the outliers were not excluded from the data set because the sample size was small ($N = 11$). Even though the test scores were normally distributed, a nonparametric test was conducted due to the potential influence of extreme values on

parametric tests (Zimmerman, 1994). Nonparametric tests offer a more reliable approach by reducing the impacts of outliers while maintaining the validity of the analysis (Zimmerman, 1994).

Table 20. Descriptive Statistics of Pre- and Post-AI Literacy's Sub-Domains Scores

	N	Min	Max	Mean	Median	SD	Skewness	Kurtosis
Pre-Apply AI	11	21	55	37.73	39.00	10.219	-.054	-.634
Post-Apply AI	11	31	51	44.73	46.00	5.850	-1.366	2.134
Pre-Understand AI	11	21	45	31.55	31.00	7.581	.377	-.763
Post-Understand AI	11	32	57	42.45	40.00	7.515	.524	-.046
Pre-Detect AI	11	8	26	19.09	20.00	5.467	-.711	.072
Post-Detect AI	11	16	30	23.73	24.00	4.027	-.296	.226
Pre-AI Ethics	11	8	30	18.73	18.00	6.650	.167	-.591
Post-AI Ethics	11	14	29	21.82	23.00	4.215	-.188	.044
Pre-Create AI	11	0	20	6.36	6.00	7.047	1.116	.218
Post-Create AI	11	8	36	25.09	26.00	7.382	-1.113	2.297

Table 21. Shapiro-Wilk Results of Pre- and Post-AI Literacy's Sub-Domains Scores

	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-Apply AI	.975	11	.930*
Post-Apply AI	.872	11	.082*
Pre-Understand AI	.963	11	.811*
Post-Understand AI	.947	11	.611*
Pre-Detect AI	.949	11	.632*
Post-Detect AI	.958	11	.750*
Pre-AI Ethics	.983	11	.979*
Post-AI Ethics	.981	11	.974*
Pre-Create AI	.834	11	.027
Post-Create AI	.915	11	.282*

* $p > .05$

Table 22. Wilcoxon Signed-Rank Test Result of Sub-Domains Scores

	Post-Apply AI - Pre- Apply AI	Post-Understand AI - Pre- Understand AI	Post-Detect AI - Pre- Detect AI	Post-AI Ethics - Pre-AI Ethics	Post-Create AI - Pre- Create AI
Z	-1.424 ^b	-2.403 ^b	-2.185 ^b	-.936 ^b	-2.938 ^b
Asymp. Sig. (2-tailed)	.154	.016	.029	.349	.003

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

A Wilcoxon signed-rank test showed that the specifically designed AI module showed a statistically significant change in almost every sub-domain of the AI literacy domain (see Table 21 and Table 22). Significant changes were obtained in the sub-domain of understand AI with $Z = -2.403$ and $p = 0.016$, in the sub-domain of detect AI with $Z = -2.185$ and $p = 0.029$, and in the sub-domain of Create AI with $Z = -2.938$ and $p = 0.003$. There was no significant statistical difference between the sub-domains of apply AI and AI ethics between their pre and post-test scores.

In addition to the Wilcoxon-Signed Rank test, Benjamini-Hochberg procedure performed for the FDR (Benjamini & Hochberg, 1995). Table 23 shows the Benjamini-Hochberg correction for adjusted p-values to determining the significance.

Table 23. The Benjamini-Hochberg Correction for the Sub-Domains of AI Literacy

Rank	Sub-Domain	p-value	Adjusted p-value
1	Create AI	0.003	0.01
2	Understand AI	0.016	0.02
3	Detect AI	0.029	0.03
4	Apply AI	0.154	0.04
5	AI Ethics	0.349	0.05

The analysis indicated that significant changes were obtained in the sub-domain of create AI, understand AI, and detect AI whereas there was no significant statistical difference between the sub-domains of apply AI and AI ethics. This analysis supports the Wilcoxon-Signed Rank results.

4.1.2 Research question 1.2: What are the prospective teachers' perceptions of AI before and after participating in the module?

After participating in the AI module, prospective teachers' cognitive levels of AI literacy developed in terms of the understanding of the foundational principles of AI, how AI operates, how to use and apply AI, and AI ethics. In parallel with the increase in AI literacy scores, a clear shift was observed in prospective teachers' perceptions of AI before and after participating in the module.

The analysis of pre- and post-opinion forms revealed that participants developed both a broader and deeper understanding of AI. While initial reflections were mostly limited to daily life use cases and focused heavily on generative tools like ChatGPT, post-module responses showed that participants began to describe AI as a complex system that imitates human intelligence, raises ethical concerns, and has the potential to transform learning processes. In particular, participants started to engage more critically with the ethical and societal aspects of AI, recognizing issues such as misinformation, environmental impact, and data privacy. This transformation in perception suggests that the module not only supported participants in developing their technical understanding of AI but also encouraged them to reflect more deeply on its role and implications in educational settings. The analysis of pre- and post-opinion forms to explore prospective teachers' perceptions of AI literacy yielded different themes (see Table 24).

Table 24. Pre- and Post-Themes Regarding Perceptions of AI Literacy

Data Source	Pre-Opinion Forms (Before the Module)	Post-Opinion Forms (After the Module)
Themes	AI as a tool for quick solutions	AI is a complex system that imitates humans
	AI as a reliable source of information	Using and applying AI to facilitate daily life and learning
	AI's potential drawbacks	AI ethics and the societal impact of AI

4.1.2.1 Participants' perceptions of AI before the module

The findings indicated that before participating in the AI module, prospective teachers exhibited limited understanding of AI, primarily perceiving AI as a tool.

Accordingly, three key themes emerged regarding their perceptions of AI: (a) AI as merely a tool, (b) AI as a reliable source of knowledge, and (c) AI's potential drawbacks.

Theme 1: AI as a tool for quick solutions

The data analysis revealed that prospective teachers perceived AI as just a tool before participating in the AI module. Pre-opinion forms highlighted that their knowledge about AI was primarily about recognizing AI as software that provides people with anything they ask based on its own database. Moreover, the data revealed that their perception of AI was limited to GenAI, and its purpose was to facilitate people's daily lives. One of the participants stated that "Artificial intelligence is the result of human-made programming that is established through software and generally emerges to make daily life easier" (P5, pre-opinion form). Another prospective teacher shared initial opinions as follows:

I got to know artificial intelligence through ChatGPT. Later, I got involved in the concept [of AI] with sounds, images, and videos created with artificial intelligence on social media. For this reason, the definition I will make will not be a research I did but rather an inference I made from my experiences. I can say that artificial intelligence is software created with certain codes and various formulas that respond to instant human requests and needs without the intervention of another human (thanks to the software created). With the data in its repertoire, they can quickly create things that people can do with their own skills or research thanks to their software. At least, this is how the artificial intelligence programs I have experienced work (P1, pre-opinion form).

Moreover, the participants perceived AI as a daily life assistant in terms of generative production, writing, searching, language translation, and even city guidance. For instance, participants shared their initial ideas as “I think the use of artificial intelligence can benefit people in every field, from drawing pictures to creating an imaginary video . . . ” (P9, pre-opinion form), “. . . Or when you want to design a poster, you can come across good examples. In this way, you can have many ideas in your mind while designing a poster” (P1, pre-opinion form) and “. . . or it can help us with potentially dangerous areas in a city we don't know at all, or give us information about fun places” (P10, pre-opinion form).

Furthermore, the data analysis revealed that participants’ understanding of AI was limited to its advantages and disadvantages as a tool. Participants majorly focused AI's ability to save time. One of the prospective teachers stated, “In the fast-paced world we live in, turning to artificial intelligence to save time and finding answers to most of our questions makes our job much easier. . . ” (P4, pre-opinion form), whereas another prospective teacher shared an opinion as “All steps to access information are completed within seconds . . . ” (P11, pre-opinion form).

To conclude, prospective teachers primarily perceived AI as a tool designed to ease daily life, with their understanding largely shaped by experiences with

GenAI. Their knowledge was limited to viewing AI as software that quickly responds to human needs using its internal database.

Participants commonly associated AI with functions like writing, searching, translation, and creative design, emphasizing its time-saving benefits. Overall, their initial perceptions centered on the practical uses and advantages of AI, rather than a deeper or critical understanding of its broader implications.

Theme 2: AI as a reliable source of information

The data analysis indicated that participants perceived AI as a reliable source of information. For example, one of the participants shared that “. . . [AI] can help us form a general opinion on a subject we have no idea about . . .” (P10, pre-opinion form) whereas another prospective teacher shared an initial idea as “. . . artificial intelligence is a system that assists me in my homework and the questions I am curious about in my daily life by quickly using and comparing various data . . .” (P3, pre-opinion form). In addition, participants argued that AI can be used to divide complex problems into small pieces. For instance, a prospective teacher stated that “It explains in detail the stages that we cannot understand in solving the problem . . .” (P8, pre-opinion form). However, relying on AI as a trustworthy source in areas where one has no prior knowledge may be problematic, and indicates a lack of understanding regarding responsible use of AI.

Prospective teacher 2 shared as “. . . [AI’s] information is more reliable,” highlighting the idea that AI can provide accurate information by easily accessing it and saving time. In addition to providing accurate information, prospective teachers saw AI as capable of making rational and unbiased decisions. A participant stated “. . .

. . to be able to make realistic and logical decisions without being affected by emotions . . . ” (P6, pre-opinion form) as an advantage of AI.

These qualitative findings did not coincide with the notions of AI literacy the prospective teachers declared at the study's beginning via the MAILS survey, which will be further discussed in the integration of findings subsection.

Theme 3: AI's potential drawbacks

Before the module, participants were concerned about the ethical issues related to AI, particularly its potential use in deepfake technology, which decreases the credibility of AI. A participant stated that “ . . . in addition, its ability to imitate sound and image is at a very frightening point. Everything seen on social media is no longer credible. It undermines trust processes” (P1, pre-opinion form). In addition to deepfake technology, malicious use was also a concern that prospective teachers underlined. One of the prospective teachers stated that “It could be misuse of artificial intelligence to leak people's personal information or make them appear to have done things they never did or said” (P11, pre-opinion form).

Moreover, participants also stated that AI could be used to spread misinformation, which could lead to serious consequences. One of the participants indicated that “ . . . apart from that, I think the biggest harm is what could happen if the information received from artificial intelligence is wrong” (P9, pre-opinion form), whereas the other participant indicated “assuming false information to be true” (P8, pre-opinion form) when identifying disadvantages of AI. Prospective teachers also mentioned that AI has some ethical issues, but none of them explicitly explain what it means. Lastly, with the development of technology, AI's incredible

development and being solely rather than dependent on humans was also considered a concern.

A prospective teacher stated that “. . .with the development of technology, the ability of artificial intelligence to get out of control may increase” (P5, pre-opinion form).

Furthermore, participants argued the importance of data privacy and safety by highlighting the protection of personal information. Prospective teacher 4 shared an idea as “When using artificial intelligence, be conscious of issues such as transparency, human rights, and protection of personal data, and not misuse them.” In addition, prospective teacher 7 highlighted the importance of transparency in AI systems as “I know that AI should be transparent and non-directive in its knowledge transfer and that its code should be publicly available to be more trustworthy.” However, he did not further elaborate on the issue.

To conclude, prospective teachers expressed significant ethical concerns about AI, particularly its potential misuse through deepfake technology, misinformation, and threats to personal data privacy. They were worried about AI decreasing trust in digital content, spreading false information, and being used maliciously. Although participants recognized AI's ethical implications, they often lacked clarity or depth in explaining these concerns.

Overall, before participating in the AI module, prospective teachers viewed AI through an instrumental lens, primarily as a software-based tool that serves immediate, practical needs. Their understanding centered around GenAI tools like ChatGPT, which they associated with tasks such as writing, searching, and visual production. This perspective reflected a surface-level engagement with AI, focusing

on its convenience and efficiency rather than its underlying mechanisms, ethical dimensions, or potential for transformative use in education.

In addition to seeing AI as a tool for efficiency, prospective teachers also regarded it as a trustworthy source of information. They tended to trust AI outputs when completing academic tasks or exploring unfamiliar topics, believing that AI could help them form general opinions, divide complex problems into smaller parts, and access information quickly. Their responses often emphasized AI's speed and rationality, framing it as an objective system. However, this trust seemed to stem more from personal experience than critical awareness, as they rarely questioned the accuracy of AI-generated content or discussed the risks of overreliance. This indicated a limited understanding of responsible AI use and highlighted a gap between perceived usefulness and actual digital literacy.

Alongside these positive perceptions, participants also stated concerns about the risks and ethical issues surrounding AI. Their reflections focused on topics such as deepfake technologies, misinformation, data privacy, and the potential for AI to be misused for harmful purposes. Some participants pointed out the dangers of assuming false information to be true, while others mentioned the importance of transparency and data protection, although these points were generally not elaborated in detail. A few participants also raised concerns about AI becoming increasingly independent and difficult to control. Overall, while their ethical awareness was present, it remained limited in scope and depth, reflecting the need for more structured guidance on AI's broader implications.

4.1.2.2 Participants' perceptions of AI after the module

Three themes emerged regarding perceptions of AI after participating in the module:

(a) AI is a complex system that imitates humans, (b) using and applying AI to facilitate daily life and learning, and (c) AI ethics and issues around AI.

Theme 1: AI is a complex system that imitates humans

After participating in the module, participants began to perceive AI as not only a generative tool but also a complex system that is based on foundational principles and mechanisms to imitate humans. They also highlighted the human-agency aspect of AI during its programming.

Prospective teacher 8 defined AI as “[AI] is a type of software that humans program that tries to mimic the human brain [with] machine learning, self-learning, deep learning,” and prospective teacher 7 explained as “Artificial programs that can run algorithms by recognizing patterns and, depending on the type of AI, that can provide generative productions.” In addition, prospective teacher 1 shared an initial idea as “Artificial intelligence is a program model with technological content. It creates its own data and content thanks to the data processed by humans. In this way, it can answer questions or follow given instructions.”

Moreover, in the beginning, participants viewed AI as a system that executes tasks, processes data, and performs human tasks. For instance, one of the participants viewed AI as a writing facilitator and shared that “It can do a good job of creating a roadmap for certain topics. For example, when I want to write an article, it can give me good ideas for creating an outline . . . ” (P1, pre-opinion form).

However, post-opinions revealed a more enhanced understanding of AI's adaptive, interactive, and cognitive capabilities. The participants recognized AI as a useful tool capable of assisting people in various aspects of life by drawing from its

own database, performing tasks, offering real-time support, and even providing practical solutions like recipe suggestions. For example, a participant shared an idea as follows:

I think artificial intelligence is a software that has the capacity to help people in every aspect by using its own database. It is a versatile technology with different areas of use, from drawing pictures to creating videos or from live support to getting cake recipes. I think artificial intelligence is a step further developed than search engines because it gives us the information we want quickly and directly without wasting time (P9, post-opinion form).

By exchanging ideas with artificial intelligence, we can carry out our responsibilities more quickly and effectively. Additionally, being able to do this whenever and wherever we want is a nice feature in terms of getting instant feedback (P4, post-opinion form).

After completing the AI module, prospective teachers developed a deeper and more nuanced understanding of AI. They began to see it not just as a generative tool but as a complex system that mimics human cognition through mechanisms. Participants acknowledged the human role in programming AI and recognized its adaptive, interactive, and cognitive capabilities. Post-module reflections emphasized AI's usefulness, real-time responsiveness, and practical support in everyday tasks, marking a shift from viewing AI as merely a tool to understanding it as an intelligent, supportive, and dynamic system.

Theme 2: Using and applying AI to facilitate daily life and learning

Before participating in the study, prospective teachers did not explicitly mention any ideas related to the cognitive domain of use and apply AI. However, after participation, they criticized where and how to integrate AI. Based on Ng et al. (2021), the use and apply AI level is about applying AI concepts and applications in different scenarios in daily life.

Prospective teachers acknowledged that learning could occur with AI in a more engaging and interactive way as “ . . . it offers us different platforms to plan learning objectives within the education system in a more active and attractive way” (P3, post-opinion form). AI was also considered a useful tool for visualization in learning, helping students better understand complex concepts through visual aids. Prospective teacher 10 mentioned that “ . . . as a teacher, it can be used to visualize some parts of the topics that remain conceptual.”

Moreover, prospective teachers also evaluated AI as a tool for enhancing thoughts, helping individuals develop ideas, and providing new perspectives. Prospective teacher 9 stated that “ . . . or, by asking its opinions on a subject and using them, we can use the information we already have in our minds more effectively.”

Overall, participants began to explore how AI can be used in daily life and education, especially in lesson planning, visualizing, and supporting learning. They acknowledged AI’s potential to make learning more interactive and enhance students’ understanding of abstract concepts. AI was also valued for generating ideas and offering new perspectives in both educational and personal contexts.

Theme 3: AI ethics and the societal impact of AI

The qualitative analysis indicated that participants developed a critical perspective on AI ethics and its societal impacts. This critical perspective had not existed in their initial opinions before engaging with the module. This outcome is not surprising, as participants' initial understanding of AI ethics was limited. The module had intensive learning experiences that addressed ethical issues and were rated as meaningful and effective by participants. Classroom discussions were also crucial by presenting the

opportunity to dive into the complex concepts in AI ethics that are generally difficult to comprehend. The classroom discussions facilitated having a better and more nuanced appreciation of the moral implications of AI.

Prospective teachers highlighted concerns about the environmental issues caused by AI, such as its high-water consumption. Participants also mentioned AI's negative impact on climate change. Prospective teacher 11 mentioned, “. . . in addition, due to the use of artificial intelligence, water consumption is also increasing”, whereas prospective teacher 1 stated that:

. . . At the same time, the answer that artificial intelligence gives to every question is wasting drinking water. In a time when the climate crisis is severe, I think that asking artificial intelligence questions that we can learn, even through Google, is a negative for us who do research and in the field of education . . . (P1, post-opinion form).

Moreover, ethical concerns about AI's potential for spreading misinformation and behaving unethically were discussed, with prospective teachers highlighting that AI sometimes provides information without credible sources, further diminishing its reliability.

AI misuse was a major concern due to its potential to negatively impact societies. Prospective teacher 11 stated that “. . . if artificial intelligence is used in a behavior that does not serve its purpose, this can be a disadvantage for society. In the hands of malicious people, many harmful designs can be realized”. Additionally, there was a concern about AI's ability to manipulate individuals who lack AI literacy due to biased data. Prospective teacher 7 explained as “People who are AI-illiterate might be easily influenced by biased data.”

In addition, prospective teacher 5 highlighted the importance of fairness, equity, and questionable design of AI as follows:

The ethical views of the people who create artificial intelligence can also be transferred to the created artificial intelligence unless they are objective. For example, these views may not reflect equality between men and women or may reflect racial differences (P5, post-opinion form).

Moreover, prospective teachers argued AI's adverse effect on people's cognitive abilities. For instance, they claimed that AI might make people impatient due to the easy access to information. Prospective teacher 6 stated that "... since people can handle everything in a very short time using artificial intelligence, people's patience levels may also decrease". The use of AI to solve tasks quickly could reduce patience levels, as people no longer need to search or struggle for answers.

Additionally, AI was seen as making people dependent on readily available answers, which might cause laziness. Prospective teacher 2 explained as "It accustoms people to ready-made knowledge and increases laziness, making effort or labor meaningless". This explanation also supports the perception of AI devaluing human effort and hard work. AI's ability to produce instant results could undermine the value of human labor.

Lastly, prospective teachers stated that AI could cause people to lose their research skills as they became more reliant on AI for quick answers and solutions. Prospective teacher 9 stated that "I think using artificial intelligence to save time is extremely logical, but I think it is very critical that users take control and use it without losing their research skills".

4.2 Research question 2: How do prospective teachers' AI competencies evolve after participating in the module?

In order to answer the second research, several data sources were analyzed. First, prospective teachers' final projects were analyzed through the lesson plan rubric that was specifically developed based on theories and selected conceptual frameworks.

Second, prospective teachers' perceptions regarding AI teaching, learning, and assessment before and after participating in the module were collected via opinion forms (see Appendix B) and thematically analyzed. The following subsections present findings regarding the second question.

4.2.1 Research question 2.1: To what extent do prospective teachers integrate AI into their learning, teaching, and assessment practices, as evident in their final projects after participating in the module?

4.2.1.1 Findings from the analysis of the lesson plans

According to the descriptives obtained from the lesson plan analysis, there are four disciplines that prospective teachers chose to develop AI-integrated lesson plans, namely science, English, geography, and mathematics. The descriptive analysis showed that the lesson plans were evenly distributed across these four subject areas, with four lesson plans for each (see Table 25). For instance, Group 1 and Group 4 developed science lesson plans focusing on science topics such as mixtures, solutions, dissolution, and techniques for separation of mixtures. Group 2 developed geography lesson plans covering the formation process of landforms, groundwater and its resources, soil types, and climate change in Turkey. Meanwhile, Group 3 and Group 4 also designed mathematics lesson plans addressing topics like regular

polygons, creating and interpreting line graphs, classifying triangles, and quadrilaterals. Lastly, Groups 1 and 3 developed English lesson plans with focusing on writing and spoken interaction and production.

When the target groups of the lesson plans were analyzed, the descriptives indicated that 10 lesson plans were designed for seventh and eighth graders (i.e., middle school students), while the other six lesson plans for tenth and twelfth graders (i.e., high school students) (see Table 25). The descriptives revealed that prospective teachers chose their expertise area or the closest subject field to develop AI-integrated lesson plans.

Table 25. The Descriptive Table for the Lesson Plans (LPs)

	Grade Level				Area of Learning and the Topic			
	LP1	LP2	LP3	LP4	LP1	LP2	LP3	LP4
Group 1	7	7	8	8	Science - Mixtures and solutions	Science - Mixtures and dissolution	English - Writing	English - Spoken interaction and production
Group 2	10	10	10	10	Geography - Effects of external forces on the formation process of landforms in Turkey	Geography - Groundwater and its resources in Turkey	Geography - Soil types in Turkey	Geography - Climate change in Turkey
Group 3	7	7	12	12	Mathematics - Creating and interpreting line graphs	Mathematics - Classifying triangles	English - Creative writing	English - Creative writing
Group 4	7	7	7	7	Mathematics - Regular polygons and their angles	Mathematics - Quadrilaterals and area solutions	Science - Mixtures and dissolution	Science - Techniques for separating mixtures

The analysis revealed that there were 25 instructional learning objectives (LOs) based on the national curriculum. Some of these LOs were associated with multiple cognitive levels based on Bloom's Taxonomy, resulting in 31 levels. The results showed that the understanding level had the highest frequency with 11 objectives, followed by six objectives at the apply level, five at the evaluate level, four at the create level, and two at the remember level (see Figure 4). These findings indicate a strong emphasis on lower-order thinking skills, especially in the understanding domain, whereas a considerable number of learning objectives also indicate higher-order thinking skills. For instance, Group 3's data visualization lesson required students to interpret line graphs and examine the impact of visual manipulation, aiming at understanding and evaluation level objectives. Similarly, Group 4's use of Python and OpenCV for edge detection involved applying and creating skills aligned with Bloom's Taxonomy. The instructional learning objectives of the lesson plans are presented in Appendix G.

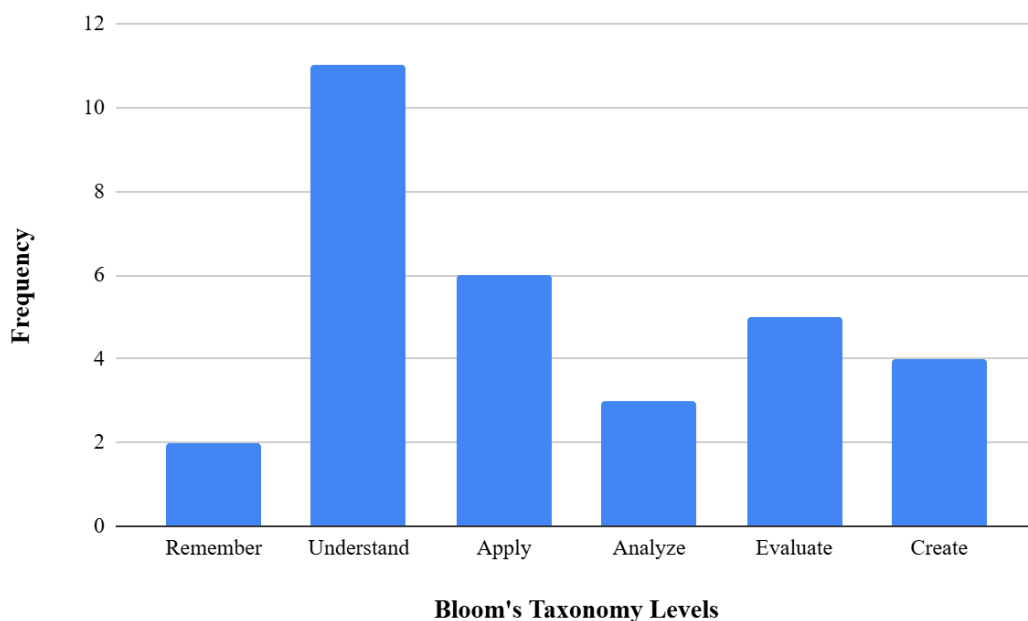


Figure 4. The frequency of Bloom's Taxonomy levels of instructional learning objectives in participants' lesson plans

In addition to the instructional learning objectives, prospective teachers also integrated the Five Big Ideas in AI (Touretzky et al., 2023) in their lesson plans to promote AI teaching and learning. There were 24 AI4K12 learning objectives (AI-LOs) in total, and they were adapted from the progression charts of the framework. The AI-LOs indicated that prospective teachers mainly took objectives from the big idea of learning with eight objectives, followed by six objectives for the societal impact idea, five objectives for the perception idea, three objectives for the representation and reasoning, and lastly, two objectives for the natural interaction (see Figure 5). For instance, one of the lesson plans of Group 1 was related to the training of an AI model in Teachable Machine to classify mixtures and examining bias in the training data which belongs the big idea of learning and the big idea of societal impact. Group 3's activity which was examining bias in AI-generated narratives and discussing ethical concerns about them covers the big idea of societal impact. Group 4's activity about using Python and the Canny Edge Detection method to process images of quadrilaterals and extract their geometric properties was related to feature extraction which is a topic of the big idea of perception. Related to Group 4's another lesson plan, the activity which was modeling how a computer would solve a physics-related problem using quadrilateral geometry is related to the big idea of natural interaction. Group 1's activity which was about organizing dissolution process data using multimodal (photos and measurements) inputs to create a visual graph was related to data structures and visualization which are related to the big idea of representation and reasoning.

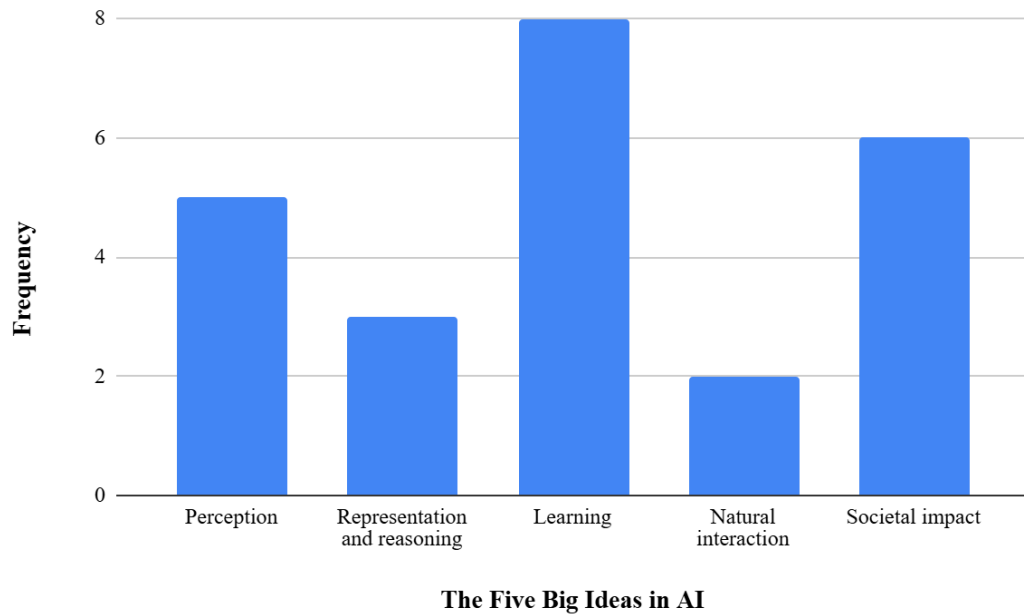


Figure 5. The frequency of the Five Big Ideas used in the lesson plans

Secondly, these AI-LOs were categorized under the cognitive domains of AI literacy framework. This categorization showed that prospective teachers mainly focused on the use and apply AI cognitive domain with nine objectives, followed by eight objectives for the AI ethics, four for know and understand AI, and three for evaluate and create AI cognitive domain (see Figure 6). In particular, Group 1's Teachable Machine activity for classifying mixtures reflects an emphasis on the cognitive domain of use and apply AI. Group 2's activity which was about exploring the landforms that formed by wind erosion is related to recognizing patterns and indicating the cognitive domain of know and understand AI. Group 3's discussion on AI systems' ethical considerations such as their transparency during AI-generated comic book activity is related to the cognitive domain of evaluate and create AI and AI ethics. Similar to Group 1, Group 4's classification activity with an AI tool for mixtures indicates the cognitive domain of use and apply AI. The AI4K12 learning objectives of the lesson plans were presented in Appendix H.

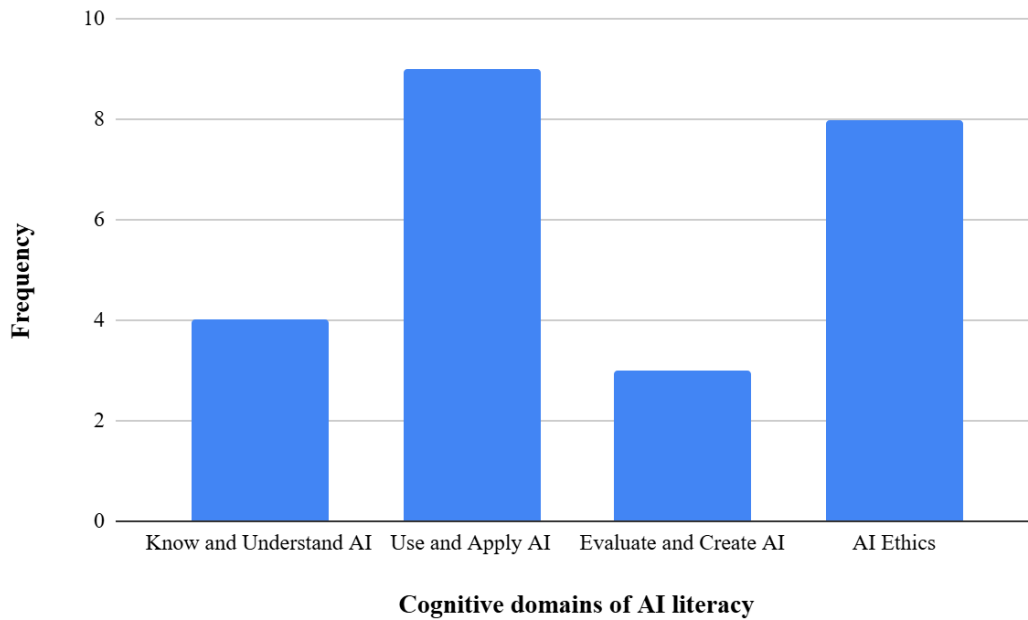


Figure 6. The frequency of the cognitive domain of AI literacy of the AI4K12 learning objectives in the final projects

All of the lesson plans ($n = 16$) that were produced by the prospective teachers had at least one main learning activity. The analysis revealed that two lesson plans out of 16 did not have a main activity related to one of the five big ideas of AI. The remaining 14 lesson plans had 21 activities regarding one of the five big ideas of AI. However, it was concluded that three of the activities did not aim to teach AI concepts but rather used AI tools to support learning, whereas the remaining 18 activities were directly related to teaching and learning about AI. For instance, Group 1's activity using Teachable Machine to classify mixtures visually engaged students in learning about classification. On the other hand, Group 2 used an unplugged activity on AI water usage, which supported learning indirectly by raising awareness rather than explicitly teaching a technical concept.

The related key AI concepts of these 18 activities were examined, and the analysis showed that these activities had 14 different key AI concepts (see Figure 7). The data revealed that prospective teachers develop these activities primarily to teach

classification and ethical considerations (e.g., transparency, safety, and privacy) of AI. Bias was the second key AI concept that prospective teachers focused on while designing their AI activities. Group 1 and Group 3 explicitly addressed the concept of AI bias through distinct yet complementary instructional strategies. Group 1 incorporated AI image generation activities, prompting students to compare AI-generated visuals with their own drawings to examine potential biases. Group 3 focused on ethical storytelling by engaging students in creative writing and peer review processes that fostered critical reflection on the ethical dimensions of AI-generated narratives. In contrast, Group 4 reinforced technical AI concepts such as classification and supervised learning through activities involving the categorization of polygons and mixtures.

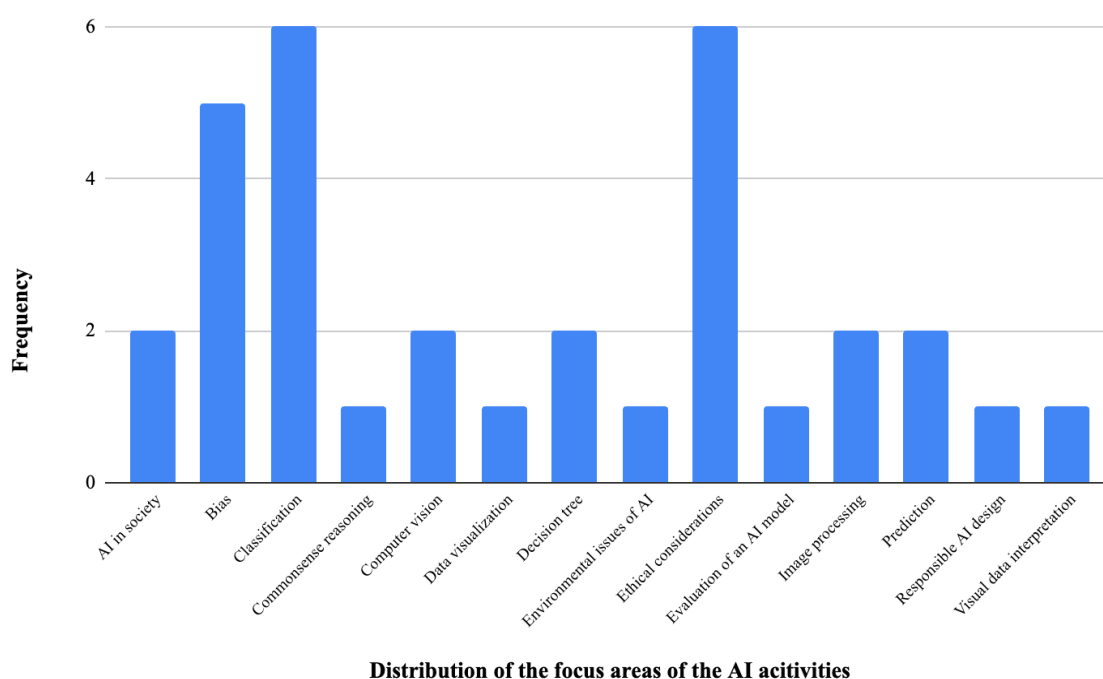


Figure 7. Distribution of the focus areas of the AI activities developed by the prospective teachers

Moreover, the activities were also analyzed in relation to UNESCO's AI competency framework for students (Miao & Shiohira, 2024). The analysis identified 18 activities that addressed four key aspects and seven different competencies. These aspects were examined to assess the extent to which prospective teachers incorporated each dimension of UNESCO's student competencies into their activity designs (see Figure 8). The findings indicate that the AI techniques and application aspect was the most frequently addressed, appearing in 10 activities. This was followed by the ethics of AI aspect, represented in nine activities, the AI system design aspect in two activities, and the human-centered mindset aspect appeared in one activity. Group 4's use of decision trees in geometry and Group 2's climate prediction activity using national data platforms illustrate a focus on AI techniques and applications. Ethics of AI was a core element in Group 3's storytelling unit and Group 1's argumentative text planning. Moreover, Group 1's redesigning an AI-driven system by identifying stakeholders and their values activity emphasis human-centered mindset aspect. Lastly, Group 4's activity which was modeling how a computer would solve a physics-related problem using quadrilateral geometry emphasis both AI techniques and applications and AI system design aspects.

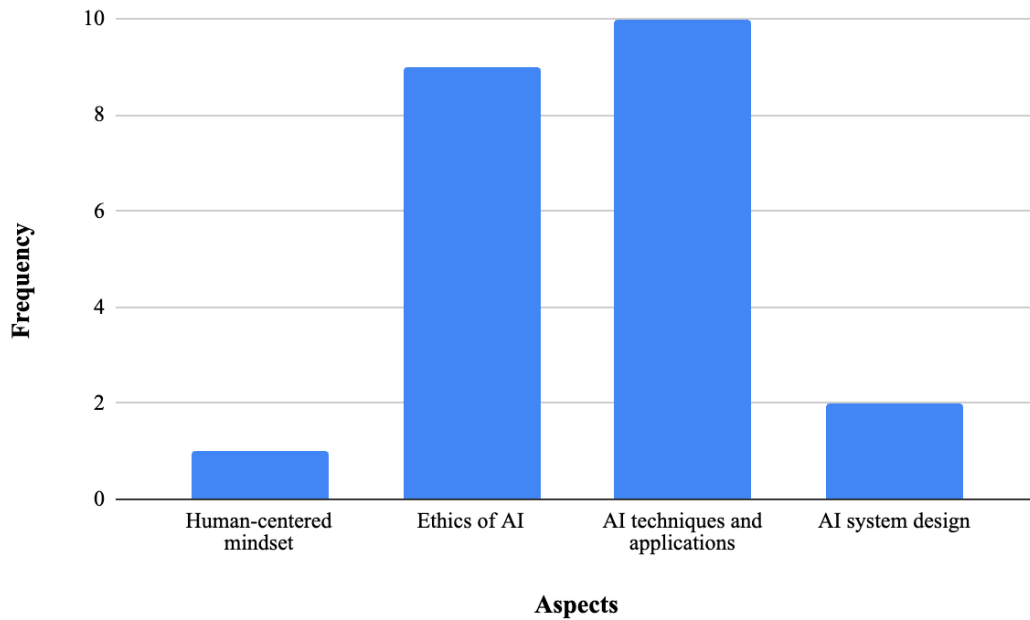


Figure 8. The frequency of the aspects of the UNESCO AI competencies framework for students

Furthermore, the activities were analyzed in terms of their alignment with UNESCO's student competencies (see Figure 9). The analysis revealed that prospective teachers selected seven different competencies for their activities. The application skills competency had a frequency of eight, followed by embodied ethics with a frequency of six, ethics by design with a frequency of three, and problem scoping with a frequency of two, the competencies of AI foundations, citizenship in the AI era, and creating AI tools with a frequency of one.

For example, Group 1's use of Teachable Machine to classify mixtures and examine bias addressed both AI foundations and embodied ethics at the understanding level. Similarly, their activities on image bias and redesigning AI systems reflected ethics by design and citizenship in the AI era at the apply and create levels, respectively. Group 2 incorporated application skills and embodied ethics through lessons on AI's environmental impact and machine learning-based climate prediction, the latter also representing creating AI tools.

Group 3 emphasized ethical storytelling, bias detection, and classification using MIT-AI, aligning with competencies such as embodied ethics and ethics by design. Group 4’s lessons on decision trees, edge detection, and AI-based classification highlighted application skills and problem scoping through both computational and ethical reflection activities.

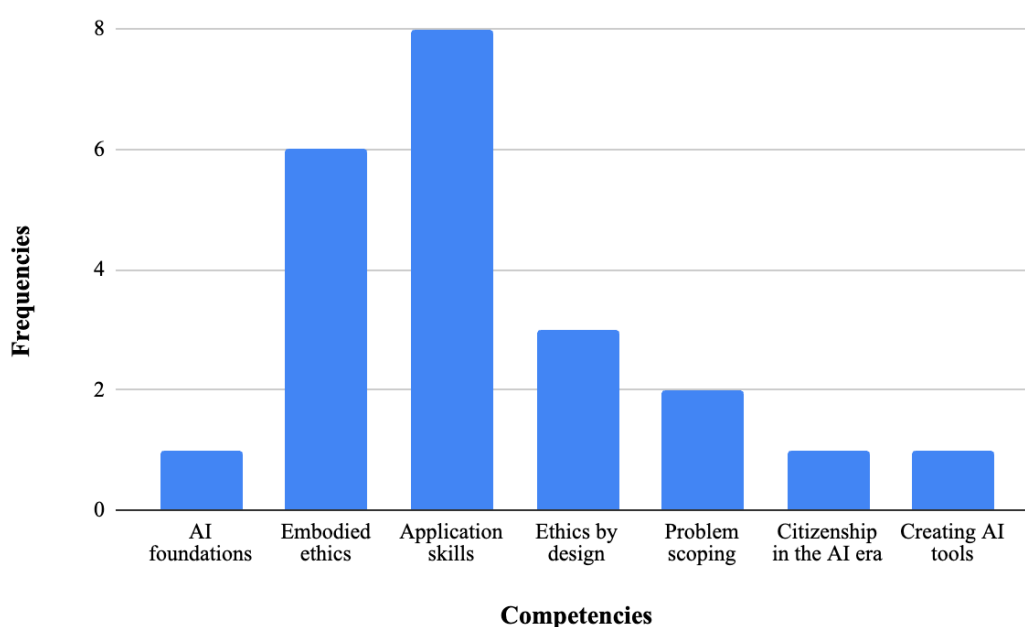


Figure 9. The frequency of the competencies of the UNESCO AI competencies framework for students

The analysis also revealed that the competencies identified in the activities covered all three progression levels defined by UNESCO’s framework: understand, apply, and create (see Figure 10). The understanding level, which includes AI foundations, embodied ethics, and problem-scoping competencies, had a frequency of nine, followed by the apply level, which had a frequency of eight, and the create level, which includes ethics by design, citizenship in the AI era, and creating AI tools, with a frequency of 2.

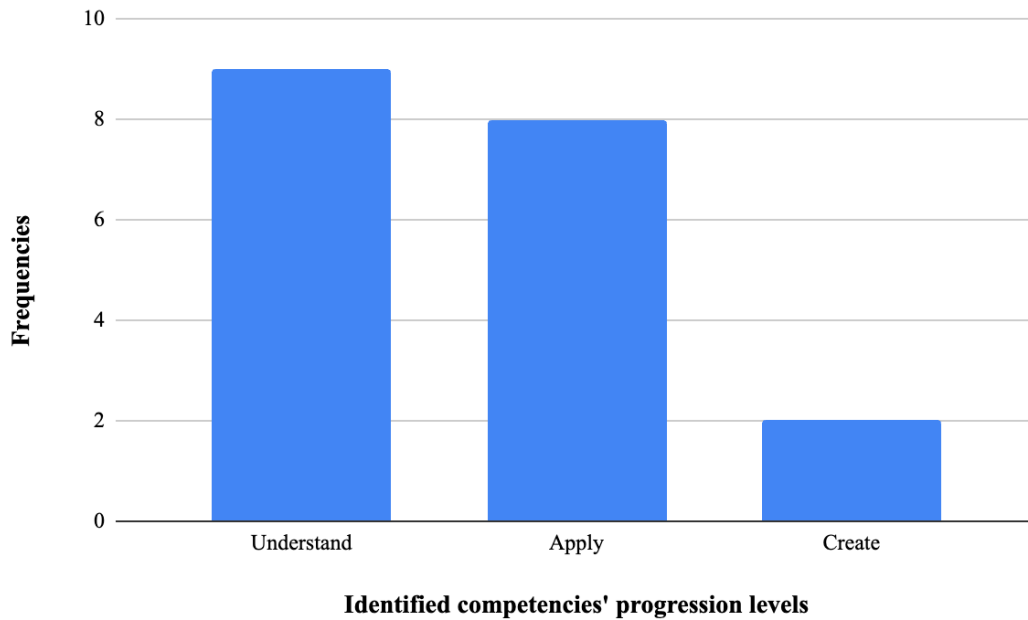


Figure 10. The frequency of the competencies' progression levels based on the UNESCO competency framework for students

Furthermore, the analysis revealed that out of 16 lesson plans, only 11 of them had an assessment strategy. Particularly, three of 11 lesson plans had two different assessments and eight of them had one assessment. To conclude, prospective teachers developed 14 different assessment techniques for these lesson plans (see Table 26). The assessments' aims indicated that three of the assessment techniques were designed to assess the content knowledge without relation to AI concepts. Eight of the assessments were developed for both the content and AI concepts (e.g., supervised learning, bias, and algorithms) at the same time, but they were not only focused on AI concepts.

For instance, Group 3 included self-assessment essays and peer feedback activities in their creative writing and comic lessons, which assessed both ethical storytelling and AI tool use. Group 4 used concept maps and AI quizzes to evaluate understanding of mixture separation and classification, tying assessments to both content and AI.

In contrast to assessing AI concepts, three assessment techniques were designed to raise awareness of AI's water consumption, writing experience with AI, and assessing the AI tool used in the classroom, respectively. These were designed as an activity, not as an assessment strategy. This is aligned with Group 2's unplugged activity simulating water use in AI queries, an awareness-raising initiative rather than a formal assessment strategy.



Table 26. The Lesson Plans' Assessment Strategies and Their Aims

Lesson Plan	Assessment Tool	Aim
#1	Quiz on MIT-AI	To assess the content, no relation between AI concepts
#2	Mindmapping	To assess both the content and AI concepts
#3	An argumentative essay	To assess both the content and AI concepts
#4	No assessment was provided	No assessment was provided
#5	No assessment was provided	No assessment was provided
#6	Linden chart	To raise awareness for the content and AI's water consumption
#7	Reflection	To assess both the content and AI concepts
#8	No assessment was provided	No assessment was provided
#9	No assessment was provided	No assessment was provided
#10	Worksheet	To assess both the content and AI concepts
#11	Peer feedback	To assess both the content and AI concepts
	Self-evaluation	To assess writing experience
#12-1	Reflective journal & Self-evaluation	To assess both the content and AI concepts
#12-2	Peer feedback	To assess the content, no relation between AI concepts
#13	Reflection	To assess both the content and AI concepts
#14	Self-assessment form	To assess both the content and AI concepts
#15	Concept map	To assess the content, no relation between AI concepts
	Reflection as a discussion	To assess the AI tool
#16	No assessment was provided	No assessment was provided

4.2.1.2 Summary of the lesson plan analysis

The analysis of the final lesson plans revealed that prospective teachers integrated AI into science, English, geography, and mathematics with an even distribution across these disciplines. Most lesson plans were designed for middle school students (7th and 8th graders), followed by high school students (10th and 12th graders), and were generally developed within or the participants' own teaching areas.

In terms of instructional design, a total of 25 instructional learning objectives (LOs) were identified, with multiple levels of Bloom's Taxonomy. The LOs mostly promoted understanding level, followed by applying, evaluating, creating, and remembering. The integration of AI concepts was guided by the Five Big Ideas in AI (Touretzky et al., 2023) progression charts' learning objectives (AI-LOs). A total of 24 AI-LOs were adapted for the lesson plans, mostly focusing on the big ideas of learning (i.e., The Big Idea 3) and societal impact (i.e., The Big Idea 5). When categorized under cognitive domains of AI literacy (Ng et al., 2021), objectives were mostly selected based on the use and apply AI. In addition, most lesson plans were explicitly designed to teach AI concepts like classification, ethical issues, and bias.

Moreover, activities were analyzed in alignment with UNESCO's AI competency framework for students (Miao & Shiohira, 2024), and the analysis revealed that activities were developed mostly for AI techniques and applications aspect, followed by ethics of AI, AI system design, and human-centered mindset. Application skills competency was the most selected competency for activities, followed by embodied ethics, ethics by design, problem scoping, AI foundations, citizenship in the AI era, and creating AI tools. According to the progression levels of competencies, these competencies were mostly based on the understanding level ($f = 9$), followed by the apply level ($f = 8$), and the create level ($f = 2$).

Lastly, the qualitative analysis indicated that the lesson plans lacked appropriate assessment strategies for the selected learning topics or AI concepts. Among 16 lesson plans, only 11 of them included at least one assessment, eight of the lesson plans included one strategy, whereas three of them included two different assessments.

There were 14 assessment strategies in total, three of them were designed to assess content knowledge without relation to AI concepts, and eight of them were for both content knowledge and AI concepts. In contrast to these assessments, three of them were designed as an activity in order to increase awareness of AI's water consumption, writing experience with AI, and assessing AI tools used in the classroom.

4.2.2 Research question 2.2: What are the prospective teachers' perceptions of AI regarding learning, teaching, and assessment practices before and after participating in the module?

The analysis of pre- and post-opinion forms to explore prospective teachers' perceptions of AI regarding learning, teaching, and assessment practices yielded different themes (see Table 27).

Table 27. Pre- and Post-Themes Regarding AI Learning, Teaching, and Assessment Practices

Data Source	Pre-Opinion Forms (Before the Module)	Post-Opinion Forms (After the Module)
Themes	AI as a tool for teaching and learning	AI facilitates and enhances teaching and learning
	Teaching AI as a tool	Enhancing content and pedagogical knowledge to teach and learn AI
	Negative student outcomes and ethical concerns	Concerns about overreliance on AI and its impact on skill development
		Equipping students with AI literacy

4.2.2.1 Perceptions of AI regarding learning, teaching, and assessment before the module

Before participating in the AI module, prospective teachers' perspectives mainly focused on how AI tools would be used in education. Three themes emerged regarding the incorporation of AI into teaching, learning, and assessment: (a) AI as a tool for teaching and learning, (b) teaching AI as a tool, and (c) negative student outcomes and ethical concerns.

Moreover, the data analysis conducted for the assessment revealed that either the prospective teachers did not have knowledge regarding how to assess AI learning or their opinions were not for assessment purposes. The results showed that activities like producing an AI definition, matching card activities, peer feedback, and discussions about AI in daily life assessments were associated with lower-order thinking skills. These tasks focused on recall, recognition, and basic understanding of AI concepts.

Theme 1: AI as a tool for teaching and learning

The analysis revealed that participants perceived AI as a technological tool for their fields. In other words, prospective teachers focused on how to integrate AI into their own subject areas as a tool.

The data analysis revealed that the first reason prospective teachers perceived AI as a tool for teaching and learning was to create more meaningful learning environments, increase the motivation and efficiency of lessons, and increase student engagement. For instance, prospective teacher 4 stated, “I would choose topics that were open to the use of artificial intelligence in the curriculum I would use and try to integrate it into them. This would make the lesson more interesting and effective,” whereas the prospective teacher 2 shared an initial idea that “. . . Integrating it into education can both enhance learning and make education more meaningful.” Moreover, prospective teacher 3 stated that “. . . in a positive sense, AI can be seen as an assistant and guide, and together with it, it can make the learning process easy, active, and effective.”

Secondly, prospective teachers perceived AI as a facilitator tool for both learning and teaching via visualization. For instance, prospective teachers emphasized AI-generated games for visualization and increasing understanding of complex concepts as follows:

For example, I can design a game with artificial intelligence while explaining functions. This helps them visualize the graph and explain what the function does. Instead of writing the theorems on the board and proving them, I can give the information in a different way . . . (P2, pre-opinion form)

For example, in the topic of liquid pressure, I would divide my students into groups and have each group explain why and how each variable in the liquid pressure formula changes, and explain this through artificial intelligence, either by visualizing it or by preparing a video (P5, pre-opinion form).

. . . for example, every physics teacher definitely hears the question, ‘What is inside a black hole?’ However, they cannot explain it to their students because even their own cats cannot know, but the visuals that artificial intelligence will present may be able to bring an image to the mind of the student . . . (P10, pre-opinion form)

Moreover, using AI for self-directed learning was also a perspective when considering AI-assisted problem-solving. In order to deepen students’ understanding of topics when they face complex problems, AI was seen as a valuable tool.

Prospective teacher 8 stated as follows:

For example, in a topic (for example, Interpol calculation in statistics), students can have the AI solve a simple formula, learn from there, and then ask how to adapt it to more complex problems and then learn on their own. (P8, pre-opinion form)

The perceptions indicated that participants viewed AI as a tool to enhance learning, motivation, and engagement by integrating it into their subject areas. They also emphasized visualization, self-directed learning, and AI-assisted problem-solving.

Theme 2: Teaching AI as a tool

The analysis revealed that participants primarily perceived AI as a tool to be taught.

In other words, at the beginning of the module, prospective teachers considered

teaching GenAI through its applications as a method of instructing students on AI.

Participants perceived AI as a tool to be taught, neglecting its broader conceptual and technological aspects.

Firstly, comparing human-based and AI-based research findings, which is a critical evaluation of AI outputs in terms of their accuracy, was considered a way to teach and learn GenAI. Integrated with this perspective, another opinion was the ability to gain practical skills by interacting with AI tools. Prospective teacher 9 shared an initial activity idea as follows:

I would have students choose a common movie and give each student a topic to research about the movie. First, I would tell students that they should watch the movie and research the topics themselves and then ask the AI and get the answers. In this way, students both develop themselves about the use of AI and learn that AI can sometimes provide incorrect or insufficient information and sometimes much more advanced information than expected. (P9, pre-opinion form)

Moreover, prospective teachers underlined the importance of hands-on experience in which students actively interact with AI technologies and expressed interest in practical projects using AI. In addition, doing projects and interacting with students allowed them to explore AI concepts independently, which was a way to foster a deeper understanding. Prospective teacher 11 stated as follows:

First, I give preliminary information about artificial intelligence. Then, I show them what I do in practice. Then, I allocate a class hour for them to research and collect data on a topic of their choice. This way, they can discover it themselves (P11, pre-opinion form).

Furthermore, a prospective teacher also argued that teaching advantages and issues around AI before fostering an understanding of AI was also important.

Prospective teacher 6 shared an initial activity idea as follows:

After providing general information about all the problems and advantages behind artificial intelligence and how to use it, I would introduce the artificial intelligence tools that could be used, and I would choose one or more of the programs together with the students, explain how we could use them, and have them do projects (P6, pre-opinion form).

Moreover, only one prospective teacher mentioned a pedagogical approach to using AI as a tool. Prospective teacher 7 shared an initial idea about teaching AI ethics is also a part of teaching AI as “I can say that it is about teaching the ethics of [AI] and evaluating artificial intelligence to produce more comprehensive works, not to take the easy way out . . . ” (P7, pre-opinion form).

To conclude, participants considered teaching AI as teaching generative tools through hands-on experiences, projects, and student interaction. They emphasized letting students discover AI through exploration and practical use. However, the broader conceptual, technological, and ethical dimensions of AI were often overlooked.

Theme 3: Negative student outcomes and ethical concerns in AI integration

The analysis revealed that prospective teachers were concerned about the impact of AI on student motivation, effort, and creativity. In other words, when the participants argued how to use AI as a tool for teaching and learning, they also highlighted their critical reflections on AI’s possible negative consequences, particularly in terms of student outcomes and the need for ethical implications for AI.

Prospective teachers expressed both negative and positive views about AI’s impact on student motivation and creativity. Participants claimed that AI could motivate students by making learning more engaging, as discussed in Theme 1, whereas AI could negatively impact creativity, as students might become too reliant on AI-generated content and lose the ability to think critically and creatively.

Prospective teacher 9 stated that:

I think the use of artificial intelligence will be beneficial as long as it does not distract students from creativity and production and does not remain at the level of only finding existing knowledge in another application in seconds (P9, pre-opinion form).

Prospective teacher 11 also shared an initial opinion about both negative and positive impacts on creativity and critical thinking as follows:

There may be advantages and disadvantages in terms of increasing their creativity. In a conversation where they ask questions, completely different ideas may come to their minds, and the answers given by artificial intelligence may be different. On the contrary, if they want artificial intelligence to do the homework directly, the homework will be done without any effort from the student and will not add anything to the student in terms of knowledge and critical thinking (P11, pre-opinion form).

Prospective teacher 3 also argued that students would become passive, where they may become dependent on ready-made answers rather than actively engaging in the learning process as “ . . . while children are passive recipients trying to learn based on what the AI gives them . . . ”

Furthermore, over-reliance on AI was also seen as a potential negative impact, leading to long-term learning difficulties and the loss of research skills. Prospective teacher 1 claimed that “ . . . however, if students lose their motivation to do research and rely on artificial intelligence, I think they will have long-term difficulties in the learning process.”

Moreover, some prospective teachers highlighted the risk of AI, where students could bypass learning tasks without putting in the necessary effort. Prospective teacher 2 stated, “ . . . The disadvantage is that they may copy from the artificial intelligence or get easy information without putting in the required effort.”

In addition to negative student outcomes, participants highlighted the importance of the ethical integration of AI into education, emphasizing the need for careful monitoring to ensure responsible use due to the nature of AI. For instance, prospective teacher 3 shared an initial opinion as follows:

. . . [AI should be integrated into education] within ethical rules because in today's information age, since we cannot fully understand where and how to use which information, artificial intelligence provides us with filtered information in a short time. This is very important for us humans, both in terms of time and accessing the right information (P3, pre-opinion form).

Moreover, prospective teachers emphasized that AI should be integrated into education with constant monitoring. For example, prospective teacher 9 stated “Yes, if it is prepared in a controlled manner and in a way that students can benefit from, I think it can be very useful.” In addition, because AI has misinformation and shares it with the students, constant monitoring is also necessary. Prospective teacher 8 briefly mentioned that “. . . and often conveys false information without filtering it . . . ”

Participants raised concerns about student passivity, over-reliance on AI, and loss of creativity, motivation, and research skills. They were worried that students might bypass learning tasks, rely on AI-generated content, and become disengaged from active thinking. The importance of ethical integration and constant monitoring was emphasized, especially due to AI's potential to spread misinformation and reduce student effort.

4.2.2.2 Perceptions of AI regarding learning, teaching, and assessment after the module

After participating in the module, four themes emerged regarding the incorporation of AI into teaching, learning, and assessment: (a) AI facilitates and enhances learning and teaching, (b) enhancing content and pedagogical knowledge to teach and learn AI, (c) concerns about overreliance on AI and its impact on skill development, and (d) equipping students with AI literacy.

Moreover, the data analysis revealed that prospective teachers either did not have sufficient knowledge on how to assess AI learning or their opinions were not intended for assessment purposes. The results showed that activities like worksheets about the foundations of AI, writing AI algorithms based on daily life examples, and activities for AI concepts were associated with lower-order thinking skills. These tasks focused on recall, recognition, and basic application of AI concepts. In contrast, tasks such as producing AI-based applications, producing AI models, AI programming, developing AI programs, and project-based assessments were designed to assess higher-order thinking skills.

Theme 1: AI facilitates and enhances learning and teaching

Participants perceived AI as a tool for teaching and learning before participating in the AI module. However, after the implementation of the AI module, prospective teachers perceived AI as a tool for facilitating and enhancing teaching and learning. This theme highlighted the AI's ability to enhance learning, improve teaching efficiency, and motivate students.

Participants recognized AI as a powerful tool to facilitate learning and make educational processes more efficient. AI was seen as a tool that can engage students, foster creativity, and help them to explain complex topics through multiple explanations and visualizations. Prospective teacher 5 stated, “. . . it [AI] can make learning easier by explaining unclear topics in different ways”, whereas prospective teacher 1 claimed “Correct use of artificial intelligence, that is, getting ideas for assignments and projects to be done, using artificial intelligence versions for visual materials will be the developer for the projects done . . . ”

Personalized learning experiences were also indicated as a facilitator in learning. Prospective teacher 11 stated that:

. . . at the same time, the role of artificial intelligence in the processing of information is quite large. For visual or auditory individuals, artificial intelligence offers individual teaching tools in different ways, thus providing a sort of personalized lesson opportunity (P11, post-opinion form).

AI's ability to save time in lessons was another positive impact, giving teachers more room to focus on more engaging and interactive aspects of teaching with facilitating the learning of students. Prospective teacher 6 stated that “. . . It can make it easier for students to understand and save time in classes.”

Furthermore, designed AI activities were considered to be especially useful in boosting creativity in students. Prospective teacher 7 stated that “. . . but on the other hand the fact that they can calculate/measure their findings and ideas with the help of AI as well as that they can get a creative boost from . . .” whereas prospective teacher 11 stated that “. . . in addition, studies can be conducted to increase students' creativity through artificial intelligence activities.”

Additionally, AI was seen as a useful tool in teaching, assisting in creating effective lesson plans and facilitating faster learning. This theme also reflects the importance of AI's ability to provide quicker solutions and explanations for complex topics, making learning more accessible.

Theme 2: Enhancing content and pedagogical knowledge to teach and learn AI

This theme explains prospective teachers' evolving understanding of content and pedagogical knowledge. The analysis revealed that while the participants initially lacked pedagogical knowledge about teaching AI, their engagement with the module fostered them to develop a perspective on how AI can be integrated into their teaching practices while supporting both ethical awareness and student engagement.

Participants argued that in order to teach AI to learners, teachers are expected to acquire the Five Big Ideas in AI and Bloom's taxonomy to design topics that reach lower-order and higher-order thinking activities. Prospective teacher 7 shared an idea as follows:

Just as it is for teaching any kind of topic, social or mathem[a]tical, Bloom's taxonomy seems the best to follow since it presents a lower-to-higher order of learning and applying (P7, post-opinion form).

The analysis revealed that AI ethics emerged as an important content knowledge for both students and teachers. Participants argued that teaching a human-centered mindset of AI, critical evaluation of AI inputs, and hands-on experiments about prompt engineering are practical approaches to helping students gain a better understanding of AI systems and raise awareness of AI ethics. Prospective teachers shared opinions as follows:

To teach artificial intelligence, I would start by talking about human-centered events in daily life because at the end of the day, artificial intelligence is also a human production and how different it can be from it. In fact, it imitates humans in a way. For example, just as we do a job sequentially, artificial intelligence performs a process by running the codes in order (P3, post-opinion form).

To teach artificial intelligence, I would start by teaching the dilemmas it has. For example, it gives false information along with true information. For example, I would observe that each student gets different answers depending on the type of question they ask and I would ask the students to discuss and notice. I would ask them to notice the type of question that they can get the most optimal answer from the artificial intelligence and then investigate this and check whether it is true or false information (P8, post-opinion form).

Moreover, participants also argued project-based AI ethics lessons design, where students could actively explore ethical challenges through real-world projects and develop their skills regarding use of AI. For example, “I would plan a lesson that was project-based and ethics. In this way, students could improve both their technical skills as well as their thinking and creativity skills” (P6, post-opinion form).

Furthermore, participants argued developing unplugged activities to teach AI ethics as crucial for fostering students' ability to understand AI's societal implications without relying on technology. For instance, prospective teacher 1 stated as:

. . . For example, if I am going to study the ethics of artificial intelligence, I can design it through an unplugged activity. Every time students ask me a question, I pour a glass of water, but when they discuss and pour water among themselves, I pour half a glass of water. However, if they discuss and answer among themselves, I do not pour any water . . . (P1, post-opinion form)

Furthermore, collaborative learning was perceived as another method for teaching AI and also for learning AI and prospective teachers support this argument as working together will make it easier to learn AI. Prospective teacher 4 shared an opinion as "Since using AI in a concrete way and integrating it into their learning experiences will be a new concept for many students, I would emphasize their collaboration . . ." Lastly, comparative learning where students compare human-based and AI-based outputs, was viewed as a method for teaching and learning AI.

One of the participants shared an idea as follows:

First of all, in order to demonstrate the working principle of artificial intelligence, I would show how all this information exchange is achieved with an activity where artificial intelligence is not used. As concepts begin to form in their minds, I would reinforce them with artificial intelligence applications (P11, post-opinion form).

Participants argued that integrating AI into lesson plans is a way to teach AI to students increasing their motivation and interests. For example, prospective teacher 10 explained that ". . . I have a plan in mind for teaching artificial intelligence. I plan to include artificial intelligence in my lesson plans in every subject, as appropriate, and to teach it by motivating the students," whereas prospective teacher 4 stated ". . . [to teach AI] Similarly, I could integrate artificial intelligence into a lesson plan or project so that they [students] could learn better."

Moreover, participants stated that using AI as a tool for teaching classification tools with building AI models through various curriculum topics allows students to understand the practical applications of AI in real-world scenarios. With these hands-on activities, students would gain both learning objectives of the topics and AI concepts. For instance, prospective teacher 2 shared an opinion as:

For example, I would use Desmos for data analysis in mathematics. It would be useful to use AI for data visualization, graphing and interpretation. I also think that it would be useful to make a classifier from MIT App Inventor for classifying geometric shapes in mathematics (P2, post-opinion form).

Prospective teacher 5 also shared that “ . . . I could cover topics involving mitosis and meiosis using classification applications.”

Theme 3: Concerns about overreliance on AI and its impact on skill development

This theme addresses the negative effects of overreliance on AI, including the devaluation of student effort, creativity, and skills development. While AI is widely accepted for its potential to enhance learning, prospective teachers concerned about the overuse of AI and its possible negative effects on students' development.

One of the major concerns was that overreliance on AI could negatively impact creativity. While AI can stimulate creativity when used in specific ways, prospective teachers highlighted that excessive reliance on AI might decrease creativity because students could become dependent on using AI-generated solutions rather than engaging in their own creative thought processes.

This concern was integrated with the perspective that overreliance on AI could lead to a decrease in participation in lessons, making students more passive and less engaged with the learning material. Additionally, prospective teachers argued that AI could lead to a decrease in focus time, as students may find it easier to access quick solutions.

Prospective teacher 9 stated that “. . . because if we cause students to use artificial intelligence excessively, this may lead to situations such as lack of participation or lack of creative ideas later in the lesson . . . ” whereas prospective teacher 6 claimed that “. . . in addition, different examples in different ways can provide different perspectives in a short time, but it can be a disadvantage in terms of students' attention span and creativity.”

Moreover, participants were concerned that overreliance on AI could lead to a loss of research skills, as students might depend on AI responses only rather than researching for their assignments. Prospective teacher 5 highlighted that “One of the disadvantages maybe that students do their homework only using artificial intelligence . . . ”

Furthermore, one of the prospective teachers argued that because of overreliance on AI, students would lose their real-life problem-solving skills. Prospective teacher 10 shared an idea that “. . . if students use artificial intelligence to take the easy way out, they will suffer and pay the price when they encounter situations in life that they cannot take the easy way out of . . . ”

The theme emphasized that participants expressed concerns that overusing AI could reduce student creativity, focus, engagement, and research skills. They noted that AI might cause students to become passive, lose patience, and avoid real-life problem-solving by depending on instant solutions. Concerns also included reduced participation in lessons, lower attention spans, and diminished creativity due to ease of access to answers.

Theme 4: Equipping students with AI literacy

Participants emphasized that AI has become an inevitable part of human life and that its integration into education is equally unavoidable. AI was seen as a tool that can contribute to societal and individual development by preparing students for the future. For instance, one of the prospective teachers shared an idea as follows:

. . . If the aim of the education system is to teach people to take care of social and individual interests in a changing world, it should be inevitable for individuals to integrate artificial intelligence at this point, because most of the developments in recent times have been on artificial intelligence, and this is a development that has an impact on the lives of societies. If we remain deficient in this respect, I think that social and individual interests will fall far behind other societies after a while (P3, post-opinion form).

Moreover, participants perceived traditional teaching methods do not adequately foster the creativity and technological progress that AI can support. Therefore, integrating AI into education is viewed as necessary for keeping up with technological advancements and encouraging innovation. Prospective teacher 1 stated that “ . . . however, in today's conditions, when technology [AI] has advanced so much, I believe that teaching lessons with traditional teaching methods will hinder creativity and technological processes . . . ”

Real-life experience with AI was considered crucial for helping students develop practical skills and understand the real-world applications of AI. Prospective teacher 2 stated that “ . . . because with the applications, students will use AI in real life. I think more emphasis should be given to the applications of AI, not just theoretical education [of AI].” Prospective teachers also emphasized that successful AI integration requires adequate classroom conditions and technology infrastructure to support its use in the classroom.

Moreover, the importance of teaching how to effectively use AI was highlighted. Prospective teachers highlighted that a curriculum is necessary to help students navigate the complexities of AI and understand how to use it responsibly. This curriculum should not only cover technical aspects but also emphasize ethical considerations in AI use. Prospective teacher 8 stated that “Yes, there must be an integrated curriculum for students to become AI literate.”

Participants viewed AI as essential for preparing students for the future. They argued that traditional methods are no longer sufficient and emphasized the need for real-life applications, infrastructure support, and an integrated curriculum that includes both technical and ethical aspects of AI.

4.3 Integration of findings

4.3.1 Research question 1: How does prospective teachers' AI literacy evolve after participating in the AI module?

The findings were obtained from quantitative and qualitative data analysis in this study. The quantitative results were collected through MAILS and analyzed with inferential and descriptive statistics to answer first sub-research question. The analysis revealed the specifically designed AI module elicited a statistically significant change in the MAILS scores $Z = -2.756$ and $p = 0.006$, with a large effect size ($r = .83$) (Cohen, 1992).

In order to examine the significant changes in the domain of AI literacy, additional quantitative analysis was performed, and results showed that there was a statistically significant change in the domain of AI literacy scores $Z = -2.847$ and $p = 0.004$ of the prospective teachers. This result supported the study's aim of developing prospective teachers' AI literacy scores.

Furthermore, additional quantitative analysis was performed to explore significant changes in the domain of AI literacy. Significant changes were obtained in the sub-domain of understand AI with $Z = -2.403$ and $p = 0.016$, in the sub-domain of detect AI with $Z = -2.185$ and $p = 0.029$, and in the sub-domain of Create AI with $Z = -2.938$ and $p = 0.003$. These sub-domains have a large effect size of $r = .73, .66$, and $.89$ (Cohen, 1992). There were no significant statistical differences between the sub-domains of apply AI and AI ethics between their pre and post-test scores.

However, when the scores of prospective teachers were examined, the data showed that five participants' ($N = 11$) post-test scores for the AI ethics sub-domain and four participants' ($N = 11$) post-test scores for apply AI sub-domain were decreased. This decrease in post-test scores may affect the overall average of pre and post-test scores, which likely contributed to the absence of a significant difference. Table 28 shows the negative and positive rankings of each domain.

Table 28. Wilcoxon Signed-Rank Test for Pre- and Post-AI Literacy Sub-Domains

		N	Mean Rank	Sum of Ranks
Post-Apply AI - Pre-Apply AI	Negative Ranks	4 ^a	4.25	17.00
	Positive Ranks	7 ^b	7.00	49.00
	Ties	0 ^c		
	Total	11		
Post-Understand AI - Pre-Understand AI	Negative Ranks	1 ^d	6.00	6.00
	Positive Ranks	10 ^e	6.00	60.00
	Ties	0 ^f		
	Total	11		
Post-Detect AI - Pre-Detect AI	Negative Ranks	2 ^g	4.25	8.50
	Positive Ranks	9 ^h	6.39	57.50
	Ties	0 ⁱ		
	Total	11		
Post-AI Ethics - Pre-AI Ethics	Negative Ranks	5 ^j	4.50	22.50
	Positive Ranks	6 ^k	7.25	43.50
	Ties	0 ^l		
	Total	11		
Post-Create AI - Pre-Create AI	Negative Ranks	0 ^m	.00	.00
	Positive Ranks	11 ⁿ	6.00	66.00
	Ties	0 ^o		
	Total	11		

a. Post-Apply AI < Pre-Apply AI

b. Post-Apply AI > Pre-Apply AI

c. Post-Apply AI = Pre-Apply AI

d. Post-Understand AI < Pre-Understand AI

e. Post-Understand AI > Pre-Understand AI

f. Post-Understand AI = Pre-Understand AI

g. Post-Detect AI < Pre-Detect AI

h. Post-Detect AI > Pre-Detect AI

i. Post-Detect AI = Pre-Detect AI

j. Post-AI Ethics < Pre-AI Ethics

k. Post-AI Ethics > Pre-AI Ethics

l. Post-AI Ethics = Pre-AI Ethics

m. Post-Create AI < Pre-Create AI

n. Post-Create AI > Pre-Create AI

o. Post-Create AI = Pre-Create AI

The qualitative analysis revealed that prospective teachers' perceptions of AI literacy yielded three main themes at the beginning of the study, namely (a) AI as merely a tool, (b) AI as a reliable source of information, and (c) AI's potential drawbacks. Participants' perceptions of AI literacy also yielded three main themes at the end of the study, namely (a) AI is a complex system that imitates humans, (b) using and applying AI to facilitate daily life and learning, (c) AI ethics and the societal impact of AI.

Firstly, the analysis showed an increasing awareness of prospective teachers' perceptions of AI ethics. In the beginning, most prospective teachers did not explicitly have a notion of AI ethics, they were aware of AI's potential drawbacks. However, at the end of the study, prospective teachers argued AI ethics and the societal impact of AI in terms of environmental problems, human rights, explainability of AI, data privacy, safety, and possible risks to humans' cognitive abilities.

Furthermore, prospective teachers perceived AI as merely a tool for facilitating daily life at the beginning of the study. They defined AI as software that facilitates their daily lives through generative production, simplifying complex problems, and finding answers to their questions. However, at the end of the study, the analysis showed that prospective teachers perceived AI as a complex system that imitates humans. They argued its complexity through AI concepts (e.g., perception, reasoning, logic, and learning), GenAI capabilities (e.g., visualization), how AI operates (e.g., finding patterns), and its advantages and disadvantages. Participants also considered AI as a generative tool for facilitating their daily lives and learning processes.

Moreover, participants perceived AI as a reliable source of information at the beginning of the study. This qualitative finding did not align with the initial MAILS responses because this theme reflected the potential uncritical acceptance of AI-generated content. However, at the end of the study, prospective teachers argued that AI could provide misinformation or information without credible sources that influence AI's reliability.

4.3.2 Research question 2: How do prospective teachers' AI competencies evolve after participating in the module?

Prospective teachers' AI competencies regarding teaching, learning, and assessment were analyzed through lesson plan analysis and pre- and post-opinion forms. The integration of findings from these analyses reveals how prospective teachers integrated AI into their teaching, learning, and assessment practices after participating in the module.

The lesson plan analysis indicated that participants developed activities across science, mathematics, geography, and English and their target groups were middle school (7th and 8th graders) and high school (10th and 12th graders) students. Prospective teachers utilized Web 2.0, AI tools and MIT-AI to teach AI concepts and subject specific topics to increase students' understanding. This analysis was aligned with the analysis of post-opinion form. Prospective teachers described AI as a facilitator that enhances learning, increases lesson efficiency, personalizes learning experiences, and supports student creativity and engagement. Participants highlighted AI's ability to explain unclear topics in different ways, offer individual teaching tools, and save time in lessons, aligning with their practical implementation of AI in their final projects.

The data sources indicated that prospective teachers developed their content and pedagogical knowledge. Lesson plans incorporated objectives from the AI4K12 framework and UNESCO's AI competency framework, focusing mainly on AI techniques and applications and ethics of AI. This finding was consistent with participants' opinions, where they emphasized using Bloom's taxonomy for lesson design, addressing ethical considerations such as AI dilemmas and human-centered mindsets, and creating hands-on and unplugged activities to foster students' critical evaluation of AI.

Concerns about overreliance on AI emerged consistently in both datasets. While lesson plans generally included activities encouraging students to engage with AI critically, participants argued that excessive use of AI might negatively affect creativity, research skills, and real-life problem-solving abilities. Their reflections on the risk of students becoming passive learners or relying too heavily on AI for quick answers corresponded with lesson plans that used AI tools more as supportive elements rather than central learning objectives.

Regarding assessment practices, findings from both the lesson plans and opinion forms show that this area is still developing. While eleven out of sixteen lesson plans included assessment strategies, only a portion of these directly focused on AI concepts. Some assessments targeted both subject content and AI concepts, while others were designed more as awareness-raising activities rather than formal evaluation strategies. Similarly, participants acknowledged their limited knowledge of how to assess AI learning but began to suggest strategies such as project-based tasks, AI application development, and AI programming to evaluate higher-order thinking skills.

Lastly, the findings highlight that prospective teachers perceived AI literacy as essential for preparing students for the future. Lesson plans integrated real-life AI applications and activities that addressed AI techniques and ethics, while opinion forms emphasized the necessity of curricula that foster both technical and ethical competencies. Participants underlined the inevitability of AI's role in education and advocated for using real-life examples to help students understand AI's societal impact, echoing the activities designed in their lesson plans.



CHAPTER 5

DISCUSSION AND CONCLUSION

The current study explored the development of prospective teachers' AI competencies and AI literacy through the implementation of a specially designed AI module. Quantitative data were collected using the MAILS to reveal significant changes in prospective teachers' AI literacy levels. Qualitative data were obtained from pre- and post-opinion forms and an in-depth analysis of the final lesson plans created by prospective teacher groups. The integration of quantitative and qualitative findings provided a comprehensive understanding of how prospective teachers' AI competencies evolved, how they integrated AI into their teaching, learning, and assessment practices, and how their perceptions of AI in educational contexts shifted throughout the module.

In the following sections, the findings related to each research question are discussed concerning the existing literature, followed by the study's recommendations, implications for future research, and an overview of its limitations.

5.1 Prospective teachers' progress in AI literacy and shifts in AI perceptions

The objective of the first research question was to explore how prospective teachers' AI literacy evolves after participating in the module. Specifically, the study aimed to examine whether there was a statistically significant difference between prospective teachers' pre- and post-AI literacy scores. The analysis revealed a statistically significant difference ($Z = -2.847$, $p = 0.004$, $r = .86$) in the AI literacy scores of prospective teachers, as measured by the MAILS. This indicates that a nine-week-

long engagement in a specifically designed learning module can enhance prospective teachers' AI literacy. This finding aligns with the existing literature on the importance of further empirical studies on the integration of AI into core subjects (e.g., STEM and non-STEM) teaching practices, as discussed in Chiu and Sanusi's (2024) research.

Moreover, quantitative analysis was performed to explore significant changes in the domain of AI literacy. The results showed that significant changes were obtained in the sub-domains of understanding AI, detecting AI, and creating AI, which are three of the core dimensions of AI literacy (Ayanwale et al., 2024; Long and Magerko, 2020; Lumanlan et al., 2025; Ng et al., 2021). In addition, the improvement in these domains aligns with the existing literature that has integrated AI into teacher education. Kim (2024) concluded that pre-service teachers showed significant development in pedagogical content knowledge (PCK) and technological pedagogical content knowledge (TPACK) after participating in an AI convergence education program.

In contrast, the results revealed that there were no significant statistical differences between the sub-domains of applying AI and AI ethics. A detailed examination of the participants' scores revealed that five out of eleven prospective teachers got lower post-test scores in the AI ethics sub-domain, while four participants demonstrated a decrease in applying AI sub-domain. These declines in individual scores appear to have impacted the overall mean scores between the pre- and post-tests, which likely contributed to the absence of a statistically significant difference in these areas.

The qualitative analysis of participants' opinion forms revealed that before participating in the module, prospective teachers mostly perceived AI as a tool that supports daily life, simplifies tasks, and provides quick access to information. Their understanding was largely limited to GenAI applications (especially ChatGPT) and their practical uses. This finding is consistent with the existing literature that emphasizes AI enhances the efficiency of tasks, facilitates to search for information and translation, and quickly solves complex problems (Adeshola & Adepoju, 2023; Fošner, 2024; Folmeg et al., 2024). Additionally, participants perceived AI as a reliable source of information at the beginning. This finding contradicts the existing literature that emphasizes students generally considered ChatGPT as a GenAI that provides unreliable and inaccurate information as well as false references (Kasneci et al., 2023; Ngo, 2023). Moreover, participants' perceptions regarding AI ethics were limited to the credibility of AI, malicious use, misinformation, privacy, and safety.

After completing the module, the findings revealed that prospective teachers began to develop AI literacy with respect to the cognitive domains of AI literacy (Ng et al., 2021). Firstly, participants' perceptions about AI were expanded to view AI as a complex system that imitates humans. They mentioned the foundational principles of AI and AI's adaptive, interactive, and cognitive abilities. The existing literature highlights that trying to understand the AI's concepts and techniques and being capable of how to use its applications are considered as the first step (i.e., cognitive level) of AI literacy (Burgsteiner et al., 2016; Kandlhofer et al., 2016; Ng et al., 2021) which indicates an increase in the know and understand level.

In addition, prospective teachers perceived AI as a facilitator of daily life and learning by using and applying it. Before participating in the study, prospective teachers did not articulate any ideas related to the cognitive dimension of using and

applying AI. However, after the module, they critically reflected on where and how AI should be integrated. This finding is consistent with existing literature that applying AI concepts and applications in different scenarios in daily life indicates an increase in the cognitive level of use and apply AI (Ng et al., 2021). This finding contradicts with the quantitative findings. According to the pre- and post-AI literacy scores, the analysis was revealed that there was no significant difference between the pre- and post-scores of the sub-domain of apply AI.

Moreover, prospective teachers argued the position of AI in learning in terms of the visualization of abstract or complex problems, increasing the interaction and engagement of learning, and elaborating ideas regarding subjects. The existing literature intersects with this finding because research shows that students' willingness to use AI results from writing and brainstorming support, multi-media support, and increasing engagement and motivation by providing interactive learning experiences (Chan & Hu, 2023; Riggs, 2025).

In contrast to quantitative findings, the qualitative analysis of participants' opinion forms revealed that they developed a critical understanding of AI ethics and societal impacts. Moreover, at the beginning of the module, participants contradicted the existing literature by considering AI to be a reliable source of information. After the implementation of the module, participants pointed out AI's potential for spreading misinformation, information without credible sources, and malicious use of AI. These findings aligned with the relevant literature because research highlights that AI lacks reliability, provides incorrect information, and AI has threats such as malicious use (Kasneci et al., 2023; Ngo, 2023; Shoufan, 2023; Zhang, 2023).

In addition, participants argued environmental problems, biased data, harmful designs, equality, fairness, transparency, explainability, safety, and privacy. These findings are relevant to the existing literature by emphasizing human-centered considerations of AI, which indicates the domain of AI ethics (Ng et al., 2021). Furthermore, Chan and Hu's (2023) research showed that university students in Hong Kong mostly raised concerns about GenAI's negative consequences, such as challenges in transparency and accuracy, privacy, and human values.

Lastly, prospective teachers argued about AI's negative impacts on people's cognitive abilities, such as people becoming less patient due to quick access to knowledge, losing research skills, and becoming over-reliant on AI. Obenza et al.'s (2024) research revealed that higher education students in the Philippines also expressed concerns regarding over-dependence on GenAI, emphasizing the potential decline in self-reliance and critical thinking skills. Similarly, research conducted by da Silva et al. (2024) revealed that higher education students fear over-reliance on AI and use it as a resource in their academic activities.

While the quantitative analysis did not reveal a statistically significant difference in the AI ethics domain, the qualitative data demonstrated meaningful shifts in participants' ethical awareness and critical reflections. Wang et al. (2025) demonstrated a positive yet moderate association between AI ethical reflection and AI literacy. The study implies that while these constructs are interrelated, they represent separate conceptual dimensions. This finding indicates that depending on AI literacy scales alone may not be sufficient to explore the extent of ethical reasoning and critical reflections.

Consequently, in this research, results showed that there was no significant difference in the ethics domain of the MAILS, despite qualitative data revealing a shift in participants' ethical awareness. Therefore, integrating qualitative methods with quantitative AI literacy scales may become important for a more comprehensive exploration of AI literacy.

5.2 Development of AI competencies and integration into teaching, learning, and assessment

The second main question of the study focused on how prospective teachers' AI competencies evolved throughout the module, particularly in terms of integrating AI into their teaching, learning, and assessment practices. The analysis of the final lesson plans revealed that prospective teachers integrated AI into science, English, geography, and mathematics with an even distribution across these disciplines. This interdisciplinary approach aligns with the existing literature by emphasizing that AI education should be for all K-12 students, implying it across different subject fields (Touretzky et al., 2019). Moreover, Miao and Shiohira (2024) highlight that integrating AI across various fields not only reflects AI's interdisciplinary nature but also ensures that all learners have meaningful opportunities to engage with AI.

Most lesson plans were designed for middle school students (7th and 8th graders), followed by high school students (10th and 12th graders). In addition, the lesson plans were generally developed within or near the teachers' own areas of expertise. This finding is consistent with the TPACK framework, which emphasizes the integration of content knowledge, pedagogical knowledge, and technological knowledge to provide more effective teaching practices (Koehler & Mishra, 2009).

By utilizing their own subject knowledge, teachers can design lessons that integrate AI concepts in a pedagogically appropriate and contextually meaningful way.

The learning objectives were taken from mostly the national curriculum, promoting understanding level, followed by applying, evaluating, creating, and remembering. This finding is consistent with the early stages of AI literacy development described in the existing literature, where foundational knowledge and understanding are seen as a prerequisite for higher-order thinking skills based on Bloom's Taxonomy (Ng et al., 2021).

The findings also indicate that the integration of AI learning objectives was guided by the Five Big Ideas in AI (Touretzky et al., 2023), and learning objectives were mostly selected based on the cognitive domain of use and apply AI, which corresponds to the apply domain in Bloom's Taxonomy (Ng et al., 2021). In line with this finding, results also indicate that prospective teachers mostly focus on the big idea of learning for their activities, and most lesson plans were explicitly designed to teach AI concepts like classification, ethical issues, and bias and were also developed mostly for AI techniques and applications based on UNESCO's framework (Miao & Shiohira, 2024).

Moreover, the emphasis on the use and apply AI domain, the big idea of learning, and the selection of AI techniques and application skills competencies reflects a focus on practical learning. According to the progression levels, these competencies are based on the understanding level, which supports engaging students in hands-on experiences that connect AI concepts to real-world applications. Touretzky et al. (2023) further highlight that focusing on the third big idea (i.e., learning) encourages students to apply AI knowledge in real-world contexts.

After the big idea of learning, the societal impact was the most mentioned idea. Most lesson plans were explicitly designed to teach AI concepts like classification, ethical issues, and bias. Furthermore, these activities were also developed mostly for AI techniques and applications, followed by the ethics of AI, AI system design, and a human-centered mindset in terms of UNESCO's AI competency framework for students.

The emphasis on AI ethics within these lesson plans aligns with the existing literature in terms of integrating ethical considerations into AI education. UNESCO's AI Competency Framework for Students underscores the necessity of fostering a human-centered mindset and ethical understanding of AI, aiming to prepare learners to navigate the societal implications of AI technologies responsibly (Miao & Shiohira, 2024). By incorporating ethical issues and bias into lesson plans, prospective teachers are not only addressing technical competencies but also promoting critical thinking and responsible citizenship in the context of AI.

A critical gap was identified in the research. The qualitative analysis indicated that the lesson plans lacked appropriate assessment strategies for the selected learning topics or AI concepts. Assessment is a key component of effective teaching and learning practices in AI education, where evaluating students' critical thinking about ethical considerations is prioritized over technical proficiency (Cukurova et al., 2024; Ng et al., 2023). While there is existing research in the literature on the use of AI for assessment (González-Calatayud et al., 2021; Xia et al., 2024), the development of assessment strategies for AI learning remains an emerging field.

Moreover, the qualitative analysis of pre- and post-opinion forms to explore prospective teachers' perceptions of AI regarding learning, teaching, and assessment practices yielded distinct findings. Before participating in the AI module, prospective teachers considered AI as a facilitating technological tool for teaching and learning. Participants mostly emphasized AI facilitates the creation of more meaningful learning environments by using visualization to increase the understanding of complex subject-specific concepts. In addition, they argued that using AI tools increases the engagement and understanding of concepts. These findings are consistent with the relevant literature that K-12 educators with experience using AI tools argued that AI facilitates complex concepts in contrast to traditional tools and increases comprehension and engagement, as outlined in the study conducted by Almuhanha (2024).

However, after the module, participants perceived AI as a tool for facilitating and enhancing teaching and learning. They expanded their perspectives on AI's ability to provide personalized learning experiences, AI's ability to save time in lessons by giving teachers more space to teach, boosting the creativity of students, and creating effective lesson plans. Chen et al. (2020) found that managing resources with AI enables teachers to spend more time teaching and engaging with their students. In addition, Kulik and Fletcher (2016) argued that personalized interventions have increased student engagement, increased educational outcomes, and decreased the achievement gap among students with different abilities.

Moreover, the findings highlight that participants were concerned about the impact of AI on student motivation, effort, and creativity. Most participants stated that AI negatively impacts creativity, as students might become too reliant on AI-generated content and lose the ability to think critically and creatively.

After the module, participants' perceptions expanded with the devaluation of student effort due to overreliance on AI and potential negative impacts on cognitive abilities (e.g., critical thinking, decision making, and problem-solving skills) as well as skill development (e.g., research skills).

These findings are consistent with the relevant literature. In an experiment with adults, Eng (2024) asked participants to write a 200-word essay either independently or with the assistance of ChatGPT, and the findings indicated that those who used AI support were more likely to undervalue the importance of hard work. Moreover, the paradox of expertise explains that while GenAI helps with basic tasks, it unintentionally limits the development of higher-order thinking skills by limiting learners' comprehension of essential foundational concepts (Valcea et al., 2024). In addition, the paradox of innovation suggests that while GenAI can enhance creativity by handling basic tasks and freeing users to engage in higher-level creative work, it may also suppress original thinking by presenting reassembled existing content as novel (Valcea et al., 2024).

Furthermore, at the beginning of the module, prospective teachers perceived AI as a tool to be taught to students, primarily by using GenAI applications as the method of instruction. However, their perspectives shifted towards enhancing content and pedagogical knowledge to teach and learn AI at the end of the module. They emphasized that adapting the Five Big Ideas in AI, AI ethics, and Bloom's taxonomy are important in order to teach AI. Ng et al. (2021) supported this content knowledge by establishing the revised AI literacy TPACK framework for AI literacy in the study. In addition, this revised framework guides how to successfully incorporate AI literacy into the classroom (Ng et al., 2021).

Moreover, prospective teachers developed an understanding of the necessity of pedagogical knowledge to teach AI. They argued that project-based lesson designs, unplugged activities, and collaborative learning are important to teach AI effectively. The revised TPACK framework of AI literacy (Ng et al., 2021) also provides a solid foundation for this finding. In addition, participants indicated that using AI to teach classification and model-building helps students understand its practical use in real-life contexts. This finding is consistent with the relevant literature, as Teachable Machine enables students to engage in machine learning classification tasks and supports various educational purposes, such as teacher training and instructional facilitation (Carney et al., 2020).

The findings also emphasize that participants underlined the importance of equipping students with AI literacy to prepare them for future challenges. They also pointed out that integrating AI into education is viewed as necessary for keeping up with technological advancements and encouraging innovation. Touretzky et al. (2019) also argued that teachers should support their students in critically and responsibly engaging with AI. Moreover, AI competencies can provide teachers with the necessary knowledge to use AI applications, enabling the implementation of more effective and innovative teaching methods (Uzumcu & Acilmis, 2024).

5.3 Recommendations and implications for future research

This research contributed to the literature on prospective teachers' AI competencies and AI literacy, with a particular emphasis on addressing an existing gap by exploring how the AI module supported participants in building their understanding of AI, improving their AI competencies, and effectively teaching and integrating AI into their instructional, learning, and assessment practices.

The AI module was implemented over a nine-week period within a single academic semester. The duration may have limited participants' opportunity to fully internalize and apply complex AI concepts in authentic teaching contexts. Although short-term developments in competencies and perceptions were observed, the study was not designed to capture the sustainability or longitudinal transfer of these competencies into future instructional practice. Longitudinal studies are necessary to examine whether the knowledge and skills acquired during the and meaningfully integrated into participants' evolving pedagogical practices. Furthermore, due to the duration of the module, AI concepts were briefly introduced. Future iterations of the module may consider expanding its duration or offering complementary follow-up sessions to address these deeper technical and ethical dimensions more comprehensively.

Another recommendation for future research is to incorporate observational data collection methods. This study primarily relied on self-reported opinion forms and final projects. They provided insights into participants' conceptual and pedagogical understanding. However, these data sources may not fully capture how AI competencies translate into real classroom practice. Future research may include microteaching sessions to provide a more meaningful results of how prospective teachers implement AI-integrated instructional strategies and how students respond to them. Moreover, future research could incorporate semi-structured interviews with prospective teachers to examine their AI competencies.

Additionally, further research is needed to design and evaluate assessment strategies in AI-related contexts. Although participants began to develop assessment strategies aligned with content and AI concepts, these remained limited and often lacked alignment with higher-order thinking skills. Future studies should explore

how prospective teachers can assess AI competencies in ways that move beyond content recall and foster critical thinking, ethical reasoning, and problem-solving.

Lastly, future research should explore how the AI module could be adapted and implemented across diverse teacher education contexts, particularly in programs that do not explicitly focus on educational technology. It remains uncertain how the module would be received and what kinds of learning outcomes it would produce among prospective teachers with less exposure to digital tools or instructional technologies. Comparative studies across varying institutional settings, disciplinary backgrounds, and program structures would offer valuable insights into how contextual factors shape the development of AI competencies. Such research could also help identify the essential scaffolds and supports needed to ensure equitable access to AI literacy and competency development, regardless of participants' prior technological experience.

In summary, this study offers a foundation for understanding how AI modules can be designed to foster prospective teachers' AI literacy and competencies. Future research should continue to explore the long-term development, implementation, and contextual adaptation of such modules in diverse teacher education settings.

5.4 Limitations of the study

Although this study provides valuable insights into how prospective teachers can develop AI competencies regarding teaching, learning, and assessment, there are several possible limitations. Firstly, generalizability could be a limitation of this research. Because of the study's small sample size ($N = 11$), the results might not fully represent the broader population of prospective teachers.

Even though purposeful sampling was applied to increase the trustworthiness of the study, the findings might not be generalizable. Furthermore, the homogeneity of the participant group in terms of institutional affiliation and educational background may limit the transferability of the results to other teacher education contexts. Future research may consider employing stratified or cross-institutional sampling to enhance external validity.

Another limitation of the study might concern the validity of the collected data from the instruments. The qualitative results were primarily based on prospective teachers' opinion forms. Participants might not provide honest responses regarding their AI literacy and competencies, which can impact the validity of the data. However, participants filled out opinion forms in the classroom with a constant monitoring of the researcher and efforts were made to prevent participants from answering the questions with help from any external sources. On the other hand, participants might not have shared their honest opinions about the MAILS at the beginning of the study assuming they were already proficient with AI. Future research will incorporate additional validation methods.

Lastly, the assessment of AI competencies in this study was limited to self-reported opinion forms and final projects. While these artefacts provided meaningful insights into participants' reflections and instructional planning, they may not fully reflect how AI competencies would affect in actual teaching practices. This reliance on self-reported and design-based evidence may have introduced bias or overestimation of their competencies, which should be taken into consideration when interpreting the findings.

APPENDIX A

THE META AI LITERACY SCALE (MAILS)

The Meta AI Literacy Scale (MAILS)		(0) Hardly or Not at all pronounced	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10) Very well or Almost perfectly pronounced
AI Literacy												
Apply AI												
1	I can operate AI applications in everyday life.											
2	I can use AI applications to make my everyday life easier.											
3	I can use artificial intelligence meaningfully to achieve my everyday goals.											
4	In everyday life, I can interact with AI in a way that makes my tasks easier.											
5	In everyday life, I can work together gainfully with an artificial intelligence.											
6	I can communicate gainfully with artificial intelligence in everyday life.											
Understand AI												
7	I know the most important concepts of the											

	topic "artificial intelligence".											
8	I know definitions of artificial intelligence.											
9	I can assess what the limitations and opportunities of using an AI are.											
10	I can assess what advantages and disadvantages the use of an artificial intelligence entails.											
11	I can think of new uses for AI.											
12	I can imagine possible future uses of AI.											
Detect AI												
13	I can tell if am dealing with an application based on artificial intelligence.											
14	I can distinguish devices that use AI from devices that do not.											
15	I can distinguish if I interact with an AI or a "real human".											
AI Ethics												
16	I can weigh the consequences of using AI for society.											
17	I can incorporate ethical considerations when deciding whether to use											

	data provided by an AI.											
18	I can analyze AI-based applications for their ethical implications.											
Create AI												
19	I can design new AI applications.											
20	I can program new applications in the field of "artificial intelligence".											
21	I can develop new AI applications.											
22	I can select useful tools (e.g., frameworks, programming languages) to program an AI.											
AI Self-Efficacy												
AI Problem Solving												
23	I can rely on my skills in difficult situations when using AI.											
24	I can handle most problems in dealing with artificial intelligence well on my own.											
25	I can also usually solve strenuous and complicated tasks when working with artificial intelligence well.											
Learning												

26	I can keep up with the latest innovations in AI applications.											
27	Despite the rapid changes in the field of artificial intelligence, I can always keep up to date.											
28	Although there are often new AI applications, I manage to always be "up-to date".											
AI Self-Competency												
AI Persuasion Literacy												
29	I don't let AI influence me in my everyday decisions.											
30	I can prevent an AI from influencing me in my everyday decisions.											
31	I realise if artificial intelligence is influencing me in my everyday decisions.											
AI Emotion Regulation												
32	I keep control over feelings like frustration and anxiety while doing everyday things with AI.											
33	I can handle it when everyday interactions with AI frustrate or frighten me.											

34	I can control my euphoria that arises when I use artificial intelligence for everyday purposes.											
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APPENDIX B

OPINION FORMS REGARDING AI TEACHING, LEARNING, AND ASSESSMENT PRACTICES

Pre-Opinion Form Regarding AI Teaching, Learning, and Assessment Practices

1. Yapay zeka nedir? Yapay zeka hakkında neler biliyorsunuz?
2. Yapay zeka okuryazarlığı ve yapay zeka becerilerinin ne demek olduğunu açıklayabilir misiniz?
3. Yapay zeka etiği hakkında neler biliyorsunuz?
4. Yapay zeka kullanımının avantajları neler olabilir?
5. Yapay zeka kullanımının dezavantajları neler olabilir?
6. Bir öğretmen adayının yapay zeka temelli dersleri tasarlayabilmesi için sahip olması gereken beceriler/yetenlikler neler olabilir? Örneklerle açıklayabilir misiniz?
7. Bir öğretmen adayının 6. soruda belirttiğiniz becerilere/yetenliklere sahip olması gerektiğini düşünüyor musunuz?
8. Yapay zekanın eğitim uygulamalarına entegre edilmesi gerektiğini düşünüyor musunuz?
9. Bir öğretmen adayı için yapay zekayı öğrencilerine nasıl öğretebileceğini bilmek önemli midir?
10. Yapay zeka kullanımı öğrencilerin öğrenmesini nasıl etkiler? Avantajları ve dezavantajları neler olabilir?
11. Öğrencilerinize yapay zekayı öğretmek için kullanacağınız pedagojiler neler olabilir? Ya da yapay zekayı öğretmek için nasıl bir yol izlediniz? Örnek bir konu/kazanım üzerinden yaklaşımınızı açıklayabilirsiniz.

12. Bloom taksonomisine göre, öğrencilerinizin yapay zeka hakkındaki alt düzey düşünme becerilerini ve üst düzey düşünme becerilerini ölçmek için aktiviteleri nasıl tasarladınız? (AI tanımını bilmek alt düzey düşünme becerisi iken, AI temelli yeni uygulamalar üretmek üst düzey düşünme becerilerine örnek olarak verilebilir.)
13. Öğretmen adayları için tasarlanmış AI becerileri modülünden beklentileriniz nelerdir?

Post-Opinion Form Regarding AI Teaching, Learning, and Assessment Practices

1. Yapay zeka nedir? Yapay zeka hakkında neler biliyorsunuz?
2. Yapay zeka okuryazarlığı ve yapay zeka becerilerinin ne demek olduğunu açıklayabilir misiniz?
3. Yapay zeka etiği hakkında neler biliyorsunuz?
4. Yapay zeka kullanımının avantajları neler olabilir?
5. Yapay zeka kullanımının dezavantajları neler olabilir?
6. Bir öğretmen adayının yapay zeka temelli dersleri tasarlayabilmesi için sahip olması gereken beceriler/yetenlikler neler olabilir? Örneklerle açıklayabilir misiniz?
7. Bir öğretmen adayının 6. soruda belirttiğiniz becerilere/yetenliklere sahip olması gerektiğini düşünüyor musunuz?
8. Yapay zekanın eğitim uygulamalarına entegre edilmesi gerektiğini düşünüyor musunuz?
9. Bir öğretmen adayı için yapay zekayı öğrencilerine nasıl öğretebileceğini bilmek önemli midir?

10. Yapay zeka kullanımı öğrencilerin öğrenmesini nasıl etkiler? Avantajları ve dezavantajları neler olabilir?
11. Öğrencilerinize yapay zekayı öğretmek için kullanacağınız pedagojiler neler olabilir? Ya da yapay zekayı öğretmek için nasıl bir yol izlediniz? Örnek bir konu/kazanım üzerinden yaklaşımınızı açıklayabilirsiniz.
12. Bloom taksonomisine göre, öğrencilerinizin yapay zeka hakkındaki alt düzey düşünme becerilerini ve üst düzey düşünme becerilerini ölçmek için aktiviteleri nasıl tasarladınız? (AI tanımını bilmek alt düzey düşünme becerisi iken, AI temelli yeni uygulamalar üretmek üst düzey düşünme becerilerine örnek olarak verilebilir.)
13. Öğretmen adayları için tasarlanmış bu modül beklentilerinizi karşıladı mı? Görüş ve önerileriniz nelerdir?

APPENDIX C

PARTICIPANT INFORMATION AND CONSENT FORM

Research sponsoring institution: BOĞAZİÇİ UNIVERSITY

Title of the research project: Developing Pre-Service STEM Teachers' AI Competencies: A Mixed Method-Study

Project Coordinator (Thesis Advisor): Dr. Mutlu Şen-Akbulut | E-mail address: | Phone:

Researcher: Bersu Ansen | E-mail address:

Dear Students,

Dr. Mutlu Şen-Akbulut and Bersu Ansen from the Department of Computer Education and Educational Technology at Boğaziçi University are carrying out a scientific research project. The research aims to explore pre-service STEM teachers' AI competencies and AI literacy levels through the specifically-designed AI competency module.

As CET 360 (Instructional Technologies and Material Development) students at Boğaziçi University, you will engage in learning activities to develop your AI competencies as well as your AI literacy as a pre-service STEM teacher. During the CET 360 course, over a period of nine weeks, you will develop several course artifacts such as a lesson plan or a term project. If you volunteer for this research, your course artifacts will constitute data. You will also be asked to complete an AI literacy survey and an opinion form on AI in education before and after you engage in the AI competencies module within the course schedule. Your identities will not be shared at any part of the research. Your involvement in the study is voluntary, and you may choose not to participate or to stop participating at any time without penalty. If you decide to stop participating in the study, your AI literacy scale, opinion form, and course artifacts will be removed from the data. The decision to be in the study or not to be in the study and researchers' evaluation of your work will not affect your grades and there are no incentives or rewards offered to voluntary participants. However, your participation in the research will contribute to supporting and creating effective teacher education curriculums for AI competencies. The stored records will be destroyed after the completion of the research. There are no known risks or inconveniences associated with this study.

Please ask if you have any questions about the study before signing this form. If you have any questions later, you can ask the project coordinator Dr. Mutlu Şen Akbulut (Phone: or the researcher Bersu Ansen (). You can also consult Boğaziçi University Social and Human Sciences Human Research Ethics Committee () regarding your rights in this study.)

I have read the text above and understood the scope and purpose of the research I was asked to participate in. I realized that I could quit this study whenever I wanted, without giving any reason, and that I would not encounter any negativity if I quit.

Participant Name-Surname: I approve of participating in the study. Date (day/month/year):...../...../.....	Project Coordinator Name-Surname: Mutlu Şen Akbulut
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APPENDIX D
FINAL REPORT INSTRUCTIONS

DEVELOPING ARTIFICIAL INTELLIGENCE-INTEGRATED
INSTRUCTIONAL DESIGN VIA THE MIT APP INVENTOR
FINAL REPORT TEMPLATE

The final project of the course will be designing at least four lessons organized around a specific subject. It will be based on the curriculum suggested in your field of teaching or address a need in your field of expertise (i.e., math/science/technology/engineering). You will be expected to design and develop “artificial intelligence (AI) integrated” learning materials via MIT App Inventor for your final project.

Please answer the following questions for your final report (write your detailed explanations under related questions).

1. PROJECT PROPOSAL & DEVELOPING PHASE

Three main components of each lesson plan will be the Introduction, Main Activity, and Follow-up.

- In the introduction, you will briefly present the topic and attract students’ attention to engage them in the learning process.
- In the main activity part, you will design several meaningful learning activities that are integrated with the artificial intelligence of your target learners for the specific subject.

- In the closure/assessment, you should summarize the specific subject by assessing what learners have learned. You may use quizzes, project assignments, or tasks.

You do not have to design every component of your project in MIT App Inventor (MIT-AI). You should develop the learning material for the main activity via MIT-AI, but students can use other AI tools. You are also expected to use Web 2.0 tools for other components.

1. a. DETAILS

- Course(s):
- Grade Level:
- Unit(s):
- Topics:
- How many lessons will be implemented? (There should be a minimum of four lessons; however, you may combine two lessons when designing your lesson plans. For example: Lesson 1, Lessons 2 & 3, Lesson 4.) :
- The Rationale Behind the Choice for the Topics (e.g., misconceptions, learning difficulties, relation to the need for technology integration, etc. Do not forget to give references if you facilitate articles. You should write a rationale for every topic.)
- Why are you interested in these topics for your “artificial intelligence integrated unit”?
 - Explain the rationale behind your choice.
 - Think about how you can use artificial intelligence foundations/pedagogies/ethics/assessments you are familiar with, those we have reviewed in this course, and those that can be helpful

while preparing this artificial intelligence-integrated unit/topic. How do your lesson plans match with the UNESCO competency framework for students? How do you facilitate the UNESCO competency framework for teachers? How do you facilitate the AI DigiCompEdu framework for teachers?

- Bloom's Taxonomy Level(s) of the MoNE (or CCSS, NGSS, CC or any other related...) Learning Objective(s) (Hint: When translating the learning objectives, please do not forget to align with Bloom's Taxonomy verbs.):
- The Learning Objective(s) from the AI4K12 for the Selected Topic and their Bloom Taxonomy Levels and their Cognitive Domains of the AI Literacy (Ng et al., 2021):
- The MoNE/CCSS/Other Relevant Educational Standards Objectives and the AI4K12 Objectives Relations (Please explain how the selected learning objectives from AI4K12 and the MoNE objectives are related and how you can teach AI to your students when you implement your lesson plan for your field.):
- As pre-service teachers, how did you support each other when selecting the topic/unit and designing the app?

How often did you support each other? How did you come to a common decision?

On what basis did you create your task sharing? Have you discussed your term project with your classmates? Or were there any other people you took feedback from?

Lesson Plan 1, 2, 3 & 4

Descriptive data

Area of learning:

Grade level:

Duration: 40 minutes

Topic outline (state your general topic and your outline):

Instructional objectives (state your instructional objectives as intended learning outcomes):

AI4K12 Learning Objectives:

AI Competencies for Students (UNESCO): Please briefly explain why you chose these competencies.

AI Competencies for Teachers (UNESCO and Supplement to the DigiCompFramework): Please briefly explain why you chose these competencies.

Other materials (add the copies of the worksheets / handouts/ activity sheets / tables / graphs / concept maps / screen shots / other resources to be used during the lesson as appendices -make references to these in your lesson steps)

Detailed explanations of the lesson: (explain all the class activities in terms of both teacher and student activities under the suggested lesson sections, add more sections if needed)

Steps	Explain what the teacher does /says	Explain what the students are expected to do	Related Standards & Conceptual Connections (e.g. MEB, ISTE, PRIMM)
1 5mins	Introduction:		
2 20-25 mins	Main activity (explain the core tasks sequentially with instructions for students with as much detail as possible to		

	address your instructional objectives):		
4 2-3 mins	Closure activity (the activity to wrap up the lesson)		
5 2-5 mins	Assessment (describe how you will assess student learning including diagnostic/formative/summative assessments):		

Suggestions for teachers who may implement this lesson plan in the future:

1. Detailed explanation of how technological tools will be used:

...

2. Are there any cautions or points to consider about the technological tools that are integrated into the lessons?

...

3. Other suggestion

PROJECT REPORTING PHASE

1. How did you facilitate Universal Design for Learning, Multimedia Design (for MIT App Inventor activity and lesson materials like presentations), ISTE Standards, and Communication & Collaboration & Creativity when you developed your artificial intelligence-integrated lesson plans?

Explain by giving the related references. You may use the course's lectures or Google Scholar.

2. Which artificial intelligence pedagogies did you use? How did you facilitate them (Revised TPACK framework, 5 Big Ideas, Ng et al.)?

Explain by giving the related references. You may use the course's lectures or Google Scholar.

3. How did you integrate AI ethics into your lesson plans and your MIT App Inventor activity (if your MIT-AI activity is AI-based)? Did you explain them in your app? Otherwise, how do target learners know them?

Explain by giving the related references. You may use the course's lectures or Google Scholar. Additionally, you should explain why AI ethics is important for your learning material and the target learners.

4. How do you plan to assess your target learners' lower-order thinking and higher-order thinking activities? How do you evaluate your target learners?

Explain how to assess your target learners' lower-order thinking and higher-order thinking activities.

5. What are the limitations and future recommendations of your lesson plans?

Explain the limitations of your app. How did you identify these limitations?

Did you get feedback from your classmates?

GRADING RUBRIC

Criteria	Exemplary (5 points)	Proficient (4 points)	Basic (3 points)	Needs Improvement (0-2 points)
Introduction & Engagement	Effectively introduces the topic, engages the audience, and provides a strong rationale for AI integration.	Engages the audience well with a clear topic introduction. Provides an adequate rationale.	The introduction lacks clarity or limited engagement. The rationale for AI integration is weak.	Little to no attempt to introduce the topic or engage the audience. Missing rationale.
Main Activity Design	Includes detailed, creative, and well-aligned AI-integrated activities.	AI-integrated activities are well-designed and mostly align with meaningful	Basic activities with limited AI integration; minimal alignment with	Activities are underdeveloped and lack AI integration or alignment with

	Supports meaningful learning and AI ethics.	learning.	meaningful learning.	objectives.
Follow-Up & Assessment	Comprehensive and effective follow-up with diverse assessments. Reflects understanding of student learning.	Includes follow-up with relevant assessments, mostly capturing student learning.	Follow-up and assessments are basic, with limited insight into student learning.	Inadequate or missing follow-up and assessment components.
Lesson Plan Alignment	Lessons align excellently with MoNE/CCSS/AI4 K12 standards and support Bloom's Taxonomy levels.	Lessons mostly align with standards and Bloom's Taxonomy levels.	Alignment with standards and Bloom's Taxonomy is minimal or inconsistent.	Lacks alignment with relevant standards and Bloom's Taxonomy.
Collaboration & Reflection	Clearly demonstrates collaboration, with thoughtful reflection on design decisions and peer feedback.	Shows collaboration with some reflection on design decisions.	Limited collaboration and basic reflection on design choices.	Minimal evidence of collaboration or reflection on design decisions.
AI Ethics & Pedagogical Integration	Integrates AI ethics and pedagogies (e.g., TPACK, 5 Big Ideas) meaningfully and effectively	AI ethics and pedagogies are integrated adequately.	Limited integration of AI ethics or pedagogies; lacks depth.	Little to no integration of AI ethics or pedagogical principles.
Universal Design & ISTE Standards	Applies UDL and ISTE creatively to ensure inclusivity and accessibility.	Addresses UDL and ISTE adequately with some inclusivity.	Basic or limited consideration of UDL and ISTE.	Lacks application of UDL and ISTE; limited inclusivity.
Report Quality & Clarity	The report is well-organized, clear, and professionally presented, with thorough explanations.	Mostly clear and organized; explanations are generally complete.	The report lacks clarity or organization; explanations are basic or incomplete	Poorly organized or unclear; explanations are missing or very limited.

APPENDIX E

ETHICS COMMITTEE APPROVAL



T.C.
BOĞAZİÇİ ÜNİVERSİTESİ REKTÖRLÜĞÜ
Sosyal ve Beşeri Bilimler İnsan Araştırmaları Etik Kurulu (Sbinarek)

Sayı : E-84391427-050.04-208494
Konu : 2024-59T Kayıt Numaralı Başvurunuz
Hakkında

25.11.2024

Sayın Dr. Öğr. Üyesi Mutlu ŞEN AKBULUT

Tez danışmanlığını yürüttüğünüz öğrenciniz Bersu Ansen'in "Developing Pre-Service STEM Teachers' AI Competencies: AMixed-Method Study" başlıklı projesi ile Boğaziçi Üniversitesi Sosyal ve Beşeri Bilimler İnsan Araştırmaları Etik Kurulu (SBİNAREK)'e yaptığınız 2024-59T kayıt numaralı başvuru 30.10.2024 tarih ve 2024/08 sayılı kurul toplantısında incelenmiş ve projeye etik onay verilmesi uygun bulunmuştur.

Bu karar tüm üyelerin toplantıya on-line olarak katılımıyla ve oybirliği ile alınmıştır. Onay mektubu tüm üyeler adına Komisyon Başkanı tarafından e-imzalanmıştır. Bilgilerinizi rica ederiz.

Saygılarımızla,

Dr. Öğr. Üyesi Işıl ERDUYAN
Kurul Başkanı

Bu belge, güvenli elektronik imza ile imzalanmıştır.

Belge Doğrulama Kodu : 0BYI-7DUV-0HKE

Belge Doğrulama Adresi : <https://www.turkiye.gov.tr/bogazici-universitesi-ebys>

Adres: Boğaziçi Üniversitesi 34342 Bebek/ İstanbul
Telefon No: Faks No:
e-Posta: İnternet Adresi: www.bogazici.edu.tr
Kep Adresi: bogaziciuniversitesi@hs01.kep.tr

Bilgi İçin: Nurşen MUNAR
Mühendis
Telefon No: 0 212 359-6749



APPENDIX F

FULL COURSE SCHEDULE

Week	Agenda	Related readings/resources/assignments
#1-1	Introduction to the Course	
#1-2	Universal Design for Learning (UDL)	
	Web-Based Portfolios	
#2-1	Meaningful Learning & ISTE Standards	
#2-2	Communication & Collaboration & Creativity	
#3-1	Communication & Collaboration & Creativity Mini Project	
#3-2	Communication & Collaboration & Creativity - Cnt'd	Submit C&C&C mini project by 11.59pm on Tuesday (October 15th)
#4-1	Introduction to Multimedia Design Basic Design Principles (Proximity, Alignment, Repetition, Contrast)	
#4-2	Introduction to AI in Education	In class: Reflections on Pre-MAILS and Opinion Forms
#5-1	Foundations of Artificial Intelligence	
#5-2	Activities for Foundations of the AI	
#6-1	REPUBLIC DAY - NO CLASS	

#6-2	Introducing the Term Project	
#7-1	Conceptualizing AI	Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. <i>Computers and Education: Artificial Intelligence</i>, 2, 100041. Unesco Competency Framework - Students and Teachers Assignment Regarding Conceptualizing AI: Submit your assignment by 11:59pm on Thursday (Nov 14th)
#7-2	AI4K12	Touretzky, D., Gardner-McCune, C., & Seehorn, D. (2023). Machine learning and the five big ideas in AI. <i>International Journal of Artificial Intelligence in Education</i>, 33(2), 233-266. https://ai4k12.org/
#8-1	AI Ethics & Issues Related to AI	
#8-2	MIT App Inventor: Introducing and Exploring the Tool	
#9-1	Collaboratively Work on Term Projects	
#9-2	MIT App Inventor: Educational Apps and Games	Submit the lab task by 11:59pm on Sunday (Nov 24th)
#10-1	Presentations of Draft Lesson Plans	Submit the draft lesson plan by 11:59pm on Monday (Nov 25th)
#10-2	MIT App Inventor: Training an Image Dataset and Adding the AI Model to the App	Submit the lab task by 11:59pm on Sunday (Dec 1st)
#11-1	Collaboratively Work on Term Projects	

#11-2	MIT App Inventor: Making ChatGPT Chatbot & Voice Calculator	Submit the lab task by 11:59pm on Sunday (Dec 8th)
#12-1	Collaboratively Work on Term Projects & Feedback Session	
#12-2	Exploring MIT App Inventor: Make a Quiz with Your Own Dataset	Submit the lab task by 11:59pm on Sunday (Dec 15th)
#13-1	Presentations of Term Project & Feedback Session	
#13-2	Presentations of Term Project & Feedback Session	In class: Post Reflections on MAILS and Opinion Forms
		The submission date for the final project will be announced.

APPENDIX G

THE INSTRUCTIONAL LEARNING OBJECTIVES OF THE LESSON PLANS

Instructional learning objectives (ILOs)	
LO1	Students will be able to define mixtures and distinguish between homogeneous and heterogeneous mixtures with examples from everyday life.
LO2	Students will be able to classify mixtures as homogeneous and heterogeneous and give examples.
LO3	Students will be able to create and observe mixtures using provided materials through photographs.
LO4	Students will be able to determine the factors affecting the dissolution rate by experimenting.
LO5	Students will be able to write a basic paragraph to describe a topic of their choice.
LO6	Students will be able to write simple descriptions on a topic of their choice.
LO7	Students will be able to give a simple description about a process.
LO8	Students will be able to give reasons and results to support their arguments.
LO9	Students will be able to explain the formation and characteristics of various landforms resulting from external geological processes.
LO10	Students will be able to associate the factors affecting the distribution of soils in Turkey with soil types.
LO11	Students will be able to classify the water resources on Earth according to their characteristics.
LO12	Students will be able to evaluate the effects of climate change on different geographical regions and propose sustainable solutions for minimizing its impacts.
LO13	Students will be able to create and interpret line graphs regarding the data.
LO14	Students will classify triangles based on side lengths as scalene, isosceles, or equilateral.

LO15	Students will be able to interpret the messages in the text.
LO16	Students will be able to use visual and auditory elements correctly and effectively.
LO17	Students will be able to write in accordance with the structural features specific to the text type.
LO18	The students will be able to use visual and auditory elements correctly and effectively.
LO19	The students will be able to prepare the visual and audio tools he will use in his speech.
LO20	The students will be able to prepare a presentation suitable for his speech.
LO21	Students will be able to describe the side and angle properties of regular polygons.
LO22	Students will be able to determine the diagonals, inner, and outer angles of polygons and calculate the sum of the measurements of the inner angles and the outer angles.
LO23	Students will be able to identify rectangles, parallelograms, trapezoids, and rhombuses and recognize angle properties.
LO24	Students will be able to derive area relations of rhombus and trapezoid and solve related problems.
LO25	Students will apply suitable methods for separating mixtures, focusing on evaporation and density differences.

APPENDIX H

THE AI4K12 LEARNING OBJECTIVES OF THE LESSON PLANS

AI4K12 Learning objectives (AI-LOs)	
AI-LO1	Model how unsupervised learning finds patterns in unlabeled data.
AI-LO2	Train and evaluate a classification or prediction model using machine learning on a tabular dataset.
AI-LO3	Illustrate how objects in an image can be segmented and labeled to construct a training set for object recognition.
AI-LO4	Describe how a vision system might exhibit cultural bias if it lacked knowledge of objects not found in the culture of the people who created it.
AI-LO5	Give examples of how humans combine information from multiple modalities.
AI-LO6	Illustrate translation of a structure such as a game board, road map, or mind map into a labeled graph and explain the contributions of the components.
AI-LO7	Classify a given image (e.g., "traffic scene", "nature scene", "social gathering", etc.) and then describe the kinds of knowledge a computer would need in order to understand scenes of this type.
AI-LO8	Evaluate the ways various stakeholders' goals and values influence the design of AI systems.
AI-LO9	Evaluate ways that AI system designers can learn about and incorporate the values of their stakeholders into the design process.
AI-LO10	AI systems process data to recognize patterns and make sense of the world.
AI-LO11	Evaluate an AI for social good project in terms of the problem it is addressing and the project's actual or potential impact
AI-LO12	Compare two real world datasets in terms of the features they comprise and how those features are encoded.

AI-LO13	Explain the difference between training and using a reasoning model.
AI-LO14	Explain how the choice of training data shapes the behavior of the classifier and how bias can be introduced if the training set is not properly balanced.
AI-LO15	Analyze an AI system to determine whether it satisfies ethical design criteria.
AI-LO16	Explain the kinds of debates that might arise as AI technology continues to evolve and is further woven into our culture.
AI-LO17	Explain how use of AI systems has led to disparate impacts on different groups.
AI-LO18	Investigate imbalances in training data in terms of gender, age, ethnicity, or other demographic variables that could result in a biased model, by using a data visualization tool.
AI-LO19	Create a dataset for training a decision tree classifier or predictor and explore the impact that different feature encodings have on the decision tree.
AI-LO20	Illustrate how a computer can solve a maze, find a route on a map, or reason about concepts in a knowledge graph by drawing a search tree
AI-LO21	Illustrate the concept of feature extraction from images by simulating an edge detector.
AI-LO22	Explain the knowledge a computer would need to solve a naive physics reasoning problem
AI-LO23	Describe the parts of a graph and how those parts are related.
AI-LO24	AI systems can create visualizations to help humans understand complex data.

APPENDIX I

TRANSLATED QUOTES

4.1.2.1 Participants' perceptions of AI before the module	
Theme 1: AI as a tool for quick solutions	
Yapay zeka, bir yazılım ile kurulan ve genel olarak günlük hayatı kolaylaştırmak için ortaya çıkan insan yapımı bir programlamanın sonucudur.	Artificial intelligence is the result of human-made programming that is established through software and generally emerges to make daily life easier. (P5, pre-opinion form)
Yapay zekayı chatgpt ile tanıdım. Daha sonrasında sosyal medya üzerinden yapay zeka ile oluşturulan sesler, görseller ve videolar ile konseptte hakim oldum. Bu sebeple yapacağım tanım yaptığım bir araştırmadan ziyade deneyimlediklerimden doğru yaptığım bir çıkarım olacak. Yapay zeka, belli kodlarla ve çeşitli formüllerle oluşturulmuş bir yazılımın anlık insan istek ve ihtiyaçlarına başka bir insanın eli değmeden (oluşturulan yazılım sayesinde) cevap vermesi diyebilirim. Repertuvarında olan verilerle, insanların kendi becerileri ya da araştırmaları ile yapabilecekleri şeyleri yazılımları sayesinde hızlı bir şekilde oluşturabiliyorlar. En azından benim deneyimlediğim yapay zeka programları bu şekilde çalışıyor.	I got to know artificial intelligence through ChatGPT. Later, I got involved in the concept [of AI] with sounds, images, and videos created with artificial intelligence on social media. For this reason, the definition I will make will not be a research I did but rather an inference I made from my experiences. I can say that artificial intelligence is software created with certain codes and various formulas that respond to instant human requests and needs without the intervention of another human (thanks to the software created). With the data in its repertoire, they can quickly create things that people can do with their own skills or research thanks to their software. At least, this is how the artificial intelligence programs I have experienced work (P1, pre-opinion form).

Yapay zeka kullanımı bence her alanda insanların yararına olabilir. Resim çizmekten hayali bir video oluşturmaya kadar . . .	I think the use of artificial intelligence can benefit people in every field, from drawing pictures to creating an imaginary video . . . (P9, pre-opinion form)
. . . Ya da bir afiş tasarlamak istediğinizde iyi örnekler karşınıza çıkarabiliyor. Bu sayede afiş tasarlarken aklınızda birçok fikir olabiliyor.	. . . Or when you want to design a poster, you can come across good examples. In this way, you can have many ideas in your mind while designing a poster (P1, pre-opinion form)
. . . ya da hiç bilmediğimiz bir şehirde tehlikeli olabilecek bölgeler hakkında bize yardımcı olabilir veya eğlenceli yerleri hakkında bilgi verebilir.	. . . or it can help us with potentially dangerous areas in a city we don't know at all, or give us information about fun places (P10, pre-opinion form)
Yaşadığımız hız dünyasında vakit kazanmak açısından yapay zekaya başvurmak ve onda sorularımızın cevaplarını çoğunlukla bulabilmek işimizi çok kolaylaştıran bir durum . . .	In the fast-paced world we live in, turning to artificial intelligence to save time and finding answers to most of our questions makes our job much easier (P4, pre-opinion form)
Bilgiye ulaşma konusunda tüm adımlar saniyeler içerisinde gerçekleşiyor . . .	All steps to access information are completed within seconds (P11, pre-opinion form)
Theme 2: AI as a reliable source of information	
. . . ya da hiç fikrimizin olmadığı bir konuda genel bir fikir oluşturmasını sağlayabilir . . .	. . . [AI] can help us form a general opinion on a subject we have no idea about . . . (P10, pre-opinion form)
. . . yapay zeka benim ödevlerimde, günlük hayatımda merak ettiğim şeylerde bana hızlı ve karşılaştırmalı bir çok datayı kullanarak bana yardımcı olan bir sistem	. . . artificial intelligence is a system that assists me in my homework and the questions I am curious about in my daily life by quickly using and comparing various data . . . (P3, pre-opinion form)

Problem çözümünde anlayamadığımız aşamaları detaylı anlatıyor olması . . .	It explains in detail the stages that we cannot understand in solving the problem (P8, pre-opinion form)
. . . [YZ'nin] bilginin daha güvenilir olması	. . . [AI's] information is more reliable (P2, pre-opinion form)
. . . duygulardan etkilenmeden realist ve mantıklı karar verebilmek . . .	. . . to be able to make realistic and logical decisions without being affected by emotions . . . (P6, pre-opinion form)
Theme 3: AI's potential drawbacks	
. . . Ayrıca ses ve görüntü taklit edebilmesi de çok korkutucu bir noktada. Artık sosyal medya üzerinden görülen her şey inandırıcı olmaktan uzaklaşıyor. Güven süreçlerini zedeliyor.	. . . in addition, its ability to imitate sound and image is at a very frightening point. Everything seen on social media is no longer credible. It undermines trust processes (P1, pre-opinion form)
Yapay zekayı kötüye kullanarak insanların kişisel bilgilerinin sızdırılması ya da hiç yapmadığı veya söylemediği şeyleri yapmış gibi gösterilmesi olabilir.	It could be misuse of artificial intelligence to leak people's personal information or make them appear to have done things they never did or said (P11, pre-opinion form)
. . . Onun dışında bence en büyük zararı yapay zekadan alınan bilginin yanlış olması durumunda yol açabileceği şeylerdir.	. . . apart from that, I think the biggest harm is what could happen if the information received from artificial intelligence is wrong (P9, pre-opinion form)
yanlış bilgiyi doğru sanmak.	assuming false information to be true (P8, pre-opinion form)
. . . teknolojinin gelişmesiyle yapay zekanın kontrolden çıkabilme kapasitesinin artması olabilir.	. . . with the development of technology, the ability of artificial intelligence to get out of control may increase (P5, pre-opinion form)
Yapay zekayı kullanırken şeffaflık, insan hakları, kişisel verilerin korunması	When using artificial intelligence, be conscious of issues such as

gibi konularda bilinçli olmak ve onları kötüye kullanmamak.	transparency, human rights, and protection of personal data, and not misuse them. (P4, pre-opinion form)
Yapay zekanın bilgi aktarımında şeffaf olması ve yönlendirici olmaması gerektiğini ve daha güvenilir olmak için kodunun halka açık olması gerektiğini biliyorum.	I know that AI should be transparent and non-directive in its knowledge transfer and that its code should be publicly available to be more trustworthy. (P7, pre-opinion form)
4.1.2.2 Participants' perceptions of AI after the module	
Theme 1: AI is a complex system that imitates humans	
[YZ] Makine öğrenimi, kendi kendine öğrenim, derin öğrenim yapabilen insan beynini taklit etmeye çalışabilen, insanların programladığı bir yazılım türü.	[AI] is a type of software that humans program that tries to mimic the human brain [with] machine learning, self-learning, deep learning (P8, post-opinion form)
Yapay zeka, teknoloji içerikli bir program modelidir. İnsanlar tarafında içerisine işlene data sayesinde kendi datasını ve içeriğini oluşturur. Bu sayede sorulan sorulara cevap verebilir ya da verilen yönergeleri yerine getirebilir.	Artificial intelligence is a program model with technological content. It creates its own data and content thanks to the data processed by humans. In this way, it can answer questions or follow given instructions (P1, post-opinion form)
Belli konular hakkında bir yol haritası çıkarmada iyi iş çıkartabiliyor. Mesela bir yazı yazmak istediğimde outline'nını oluşturmada iyi fikirler verebiliyor . . .	It can do a good job of creating a roadmap for certain topics. For example, when I want to write an article, it can give me good ideas for creating an outline . . . (P1, pre-opinion form)
Yapay zeka, kendi database'ini kullanarak insanlara her konuda yardımcı olabilecek kapasitede olan bir yazılımdır diye düşünüyorum. Resim çizdirmekten video oluşturmaya veya	I think artificial intelligence is a software that has the capacity to help people in every aspect by using its own database. It is a versatile technology with different areas of use, from

canlı destekten kek tarifi almaya kadar farklı kullanım alanları olan versatil bir teknoloji. Bence bize istediğimiz bilgiyi hızlıca ve direkt zaman kaybetmeden vermesinden dolayı yapay zeka arama motorlarının bir adım daha gelişmiş hali.	drawing pictures to creating videos or from live support to getting cake recipes. I think artificial intelligence is a step further developed than search engines because it gives us the information we want quickly and directly without wasting time (P9, post-opinion form).
Yapay zekayla fikir alışverişi yaparak sorumluluklarımızı daha hızlı ve etkili bir biçimde gerçekleştirebiliriz. Ayrıca bunu istediğimiz zaman ve mekanda gerçekleştirebiliyor olmak anında geri bildirim alabilmek açısından güzel bir özellik.	By exchanging ideas with artificial intelligence, we can carry out our responsibilities more quickly and effectively. Additionally, being able to do this whenever and wherever we want is a nice feature in terms of getting instant feedback (P4, post-opinion form).
Theme 2: Using and applying AI to facilitate daily life and learning	
. . . eğitim sistemi içerisine kazanımları daha aktif ve çekici bir şekilde planlanması noktasında bizlere değişik platformlar sunuyor	. . . it offers us different platforms to plan learning objectives within the education system in a more active and attractive way (P3, post-opinion form).
. . . öğretmen olarak derslerde kavramsal kalan bazı kısımları somutlaştırmada kullanılabilir.	. . . as a teacher, it can be used to visualize some parts of the topics that remain conceptual (P10, post-opinion form).
. . . Ya da bir konu hakkındaki düşüncelerini sorduktan sonra onları kullanarak halihazırda aklımızda olan bilgiyi daha da efektif bir şekilde kullanabiliyoruz.	. . . or, by asking its opinions on a subject and using them, we can use the information we already have in our minds more effectively (P9, post-opinion form).
Theme 3: AI ethics and the societal impact of AI	

... Ayrıca yapay zeka kullanımı sayesinde su tüketimi de çok artmaktadır.	... in addition, due to the use of artificial intelligence, water consumption is also increasing (P11, post-opinion form)
... Aynı zamanda yapay zekanın sorulan her soruda yaptığı içme suyu tüketimi bulunmakta. İklim krizin yoğun olduğu bir dönemde google aracılığıyla bile öğrenebileceğimiz soruların yapay zeka yoluyla kolayca kaçarak öğrenilmesini hem çevre hem de eğitim araştırma yapan bizler için olumsuz olduğunu düşünüyorum.	... At the same time, the answer that artificial intelligence gives to every question is wasting drinking water. In a time when the climate crisis is severe, I think that asking artificial intelligence questions that we can learn, even through Google, is a negative for us who do research and in the field of education (P1, post-opinion form).
... Yapay zeka amacına hizmet etmeyecek bir davranışta kullanılıyorsa bu toplum için bir dezavantaj olabilir. Kötü niyetli insanların elinde birçok zararlı tasarı gerçekleştirilebilir ...	... if artificial intelligence is used in a behavior that does not serve its purpose, this can be a disadvantage for society. In the hands of malicious people, many harmful designs can be realized ... (P11, post-opinion form)
Yapay zekayı oluşturan kişilerin etik görüşleri objektif olunmadığı takdirde oluşturulan yapay zekaya da aktarılabilir. Örneğin bu görüşler kadın-erkek eşitliğini yansıtmayabilir veya ırksal farklılıkları hissettirebilir.	The ethical views of the people who create artificial intelligence can also be transferred to the created artificial intelligence unless they are objective. For example, these views may not reflect equality between men and women or may reflect racial differences (P5, post-opinion form).
... yapay zeka kullanarak her şeyi çok kısa sürede halledebilecekleri için tahammül seviyelerinde de azalmalar meydana gelebilir.	“... since people can handle everything in a very short time using artificial intelligence, people’s patience levels may also decrease (P6, post-opinion form).

insanları hazır bilgiye alıştırması ve tembelliği artırması, çaba göstermenin veya emek vermenin anlamsız hale gelmesi.	It accustoms people to ready-made knowledge and increases laziness, making effort or labor meaningless (P2, post-opinion form).
4.2.2.1 Perceptions of AI regarding learning, teaching, and assessment before the module	
Theme 1: AI as a tool for teaching and learning	
Kullanacağım müfredattaki yapay zeka kullanımına açık konuları seçer ve onlara bunu entegre etmeye çalışırdım. Böylece ders daha ilgi çekici ve etkili hale gelirdi.	I would choose topics that were open to the use of artificial intelligence in the curriculum I would use and try to integrate it into them. This would make the lesson more interesting and effective (P4, pre-opinion form)
. . . Eğitime entegre edilmesi hem öğrenmeyi artırır hem de eğitimi daha anlamlı hale getirebilir.	. . . Integrating it into education can both enhance learning and make education more meaningful (P2, pre-opinion form)
. . . pozitif anlamda ise AI bir yardımcı ve rehber olarak görüp onunla birlikte öğrenme sürecini kolay, aktif ve etkin kılabilir.	. . . In a positive sense, AI can be seen as an assistant and guide, and together with it, it can make the learning process easy, active, and effective (P3, pre-opinion form)
Örneğin fonksiyonları anlatırken yapay zekayla bir oyun tasarlayabilirim. Bu hem grafiği görselleştirmelerine ve fonksiyonun ne işe yaradığını anlatmaya yardımcı olur. Tahtaya teorem yazıp ispatlamaktansa bilgiyi daha farklı bir yolla verebilirim . . .	For example, I can design a game with artificial intelligence while explaining functions. This helps them visualize the graph and explain what the function does. Instead of writing the theorems on the board and proving them, I can give the information in a different way . . . (P2, pre-opinion form)
Örneğin sıvı basıncı konusunda öğrencilerimi gruplara ayırıp her grubun sıvı basıncı formülündeki her bir	For example, in the topic of liquid pressure, I would divide my students into groups and have each group

değişkenin niçin ve nasıl değiştiğini anlatmasını ve bunu yapay zeka yoluyla hem görselleştirerek veya video hazırlayarak anlatmasını isterdim.	explain why and how each variable in the liquid pressure formula changes, and explain this through artificial intelligence, either by visualizing it or by preparing a video (P5, pre-opinion form)
. . . mesela her fizik öğretmeni muhakkak şu soruyu duyar " kara deliğin içinde ne var?" ancak bunu öğrencilerine anlatamaz zira kedisi de bilemez ancak yapay zekanın sunacağı görseller belki öğrencinin zihninde bir imge canlanmasını sağlayabilir . . .	. . . for example, every physics teacher definitely hears the question, ‘What is inside a black hole?’ However, they cannot explain it to their students because even their own cats cannot know, but the visuals that artificial intelligence will present may be able to bring an image to the mind of the student . . . (P10, pre-opinion form)
Örnek bir konu (örneğin, istatistikte İnterpol hesaplama), öğrenciler basit bir formülü yapay zekaya çözdürüp buradan öğrenip daha komplike problemleri bunu nasıl uyarlayacaklarını sorup daha sonra kendi kendine öğrenebilirler.	For example, in a topic (for example, Interpol calculation in statistics), students can have the AI to solve a simple formula, learn from there, and then ask how to adapt it to more complex problems and then learn on their own. (P8, pre-opinion form)
Theme 2: Teaching AI as a tool	
Öğrencilere ortak bir film seçtirip her öğrenciye araştırması gereken bir konu verirdim film hakkında. Öncesinde öğrencilerden filmi izleyip konuları kendileri araştırmaları gerektiğini sonrasında da yapay zekaya sorup cevapları almaları gerektiğini söyledim. öğrenciler böylelikle hem yapay zeka kullanımı hakkında kendilerini geliştirirken hem de yapay zekanın	I would have students choose a common movie and give each student a topic to research about the movie. First, I would tell students that they should watch the movie and research the topics themselves and then ask the AI and get the answers. In this way, students both develop themselves about the use of AI and learn that AI can sometimes provide incorrect or insufficient

bazen yanlış veya yetersiz bazen de beklenilenden çok daha ileri seviyede bilgi verebileceğini öğrenmiş olurlar.	information and sometimes much more advanced information than expected (P9, pre-opinion form)
İlk olarak yapay zeka hakkında ön bilgiler veririm. Sonrasında uygulamalı olarak benim neler yaptığımı gösteririm. Sonra onlara istedikleri bir konu hakkında araştırma yapıp veri toplamaları için bir ders saati ayırıyorum. Böylece kendileri de keşfetmiş olabilirler.	First, I give preliminary information about artificial intelligence. Then, I show them what I do in practice. Then, I allocate a class hour for them to research and collect data on a topic of their choice. This way, they can discover it themselves (P11, pre-opinion form)
Yapay zekanın arkasında yatan tüm sorunlar ve tüm avantajları hakkında, nasıl kullanılacağı hakkında genel bir bilgi sağladıktan sonra kullanılabilecek yapay zeka araçlarını tanıtır ve programlardan 1 ya da bir kaçını öğrenciler ile beraber seçerek onları nasıl kullanabileceğimizi anlatıp projeler yaptırırdım.	After providing general information about all the problems and advantages behind artificial intelligence and how to use it, I would introduce the artificial intelligence tools that could be used, and I would choose one or more of the programs together with the students, explain how we could use them, and have them do projects (P6, pre-opinion form).
Yapay zekayı kolayca kaçmak için değil daha kapsamlı işler üretmek için değerlendirmek üzerine, işin etiğiyle de ilgili konuları da öğretmek diyebilirim . . .	I can say that it is about teaching the ethics of [AI] and evaluating artificial intelligence to produce more comprehensive works, not to take the easy way out . . . (P7, pre-opinion form)
Theme 3: Negative student outcomes and ethical concerns in AI integration	
Yapay zeka kullanımı bence öğrenciyi yaratıcılıktan ve bir şeyler üretmekten uzaklaştırıp sadece halihazırda olan bilgiyi saniyeler içerisinde başka bir uygulamaya buldurmak seviyesinde kalmadığı sürece bence yararlı olacaktır.	I think the use of artificial intelligence will be beneficial as long as it does not distract students from creativity and production and does not remain at the level of only finding existing

	knowledge in another application in seconds (P9, pre-opinion form).
Yaratıcılıklarını arttırma konusunda avantaj ve dezavantajı bulunabilir. Soru sorarak ilerledikleri bir konuşmada yapay zekanın verdiği cevaplar ile akıllarına bambaşka fikirler gelebilir. Bunun tam zıttı olarak ise yapay zekaya direkt ödevi yaptırmak istediğinde öğrencinin hiçbir uğraşı olmadan ödev yapılmış olunacak ve öğrenciye hem bilgi hem kritik düşünme anlamında hiçbir şey katmamış olacaktır.	There may be advantages and disadvantages in terms of increasing their creativity. In a conversation where they ask questions, completely different ideas may come to their minds, and the answers given by artificial intelligence may be different. On the contrary, if they want artificial intelligence to do the homework directly, the homework will be done without any effort from the student and will not add anything to the student in terms of knowledge and critical thinking (P11, pre-opinion form).
. . . çocuklar pasif birer alıcı olarak AI ne veriyse onun üzerine öğrenmelerini gerçekleştirmeye çalışırken . . .	. . . while children are passive recipients trying to learn based on what the AI gives them . . . (P3, pre-opinion form).
. . . Ancak öğrenciler araştırma yapma güdülerini kaybedip yapay zekaya yaslanırlarsa öğrenme sürecinde uzun erimli zorluk çekeceklerini düşünüyorum.	. . . however, if students lose their motivation to do research and rely on artificial intelligence, I think they will have long-term difficulties in the learning process (P1, pre-opinion form).
Dezavantajı ise yapay zekadan kopya çekmeleri ya da istenilen emeği vermeyip kolay bilgiyi almal[a]rı olabilir.	The disadvantage is that they may copy from the artificial intelligence or get easy information without putting in the required effort (P2, pre-opinion form).
. . . [YZ eğitime entegre edilmeli] etik kurallar çerçevesinde çünkü günümüz bilgi çağında hangi bilgiyi nerede, nasıl kullanacağımızı tam anlamıyla çözemediğimiz için yapay zeka bu	. . . [AI should be integrated into education] within ethical rules because in today's information age, since we cannot fully understand where and how to use which information, artificial

noktada bize filtrelenmiş bilgiyi kısa sürede ulaştırıyor. Bu da biz insanlar için hem zaman bakımından hem de doğru bilgiye ulaşma bakımından çok önemlidir.	intelligence provides us with filtered information in a short time. This is very important for us humans, both in terms of time and accessing the right information (P3, pre-opinion form).
Evet, eğer kontrollü ve öğrencilerin yararına olup faydalanabileceği bir şekilde hazırlanırsa bence gayet faydalı olabilir.	Yes, if it is prepared in a controlled manner and in a way that students can benefit from, I think it can be very useful (P9, pre-opinion form).
. . . yanlış bilgileri de çoğu zaman süzmeden aktarıyor olması . . .	. . . and often conveys false information without filtering it . . . (P8, pre-opinion form).

4.2.2.2 Perceptions of AI regarding learning, teaching, and assessment after the module

Theme 1: AI facilitates and enhances learning and teaching

. . . [YZ] anlaşılmayan konuları farklı yollarla anlatım sunarak öğrenmeyi kolaylaştırabilir.	. . . it [AI] can make learning easier by explaining unclear topics in different ways (P5, post-opinion form)
Yapay zekanın doğru kullanımı, yani yapılacak ödevler ve projeler için fikir almak, görsel materyeller için yapay zeka sürümlerini kullanmak yapılan projeler için geliştirici olacaktır . . .	Correct use of artificial intelligence, that is, getting ideas for assignments and projects to be done, using artificial intelligence versions for visual materials will be the developer for the projects done . . . (P1, post-opinion form)
. . . Aynı zamanda bilginin işlenmesinde yapay zekanın rolü oldukça büyüktür. Görsel ya da işitsel bireyler için yapay zeka farklı yollarla bireysel öğreti araçları sunar ve bu sayede bir nevi kişiselleştirilmiş ders fırsatı yakalanmış olur.	. . . at the same time, the role of artificial intelligence in the processing of information is quite large. For visual or auditory individuals, artificial intelligence offers individual teaching tools in different ways, thus providing a sort of personalized lesson opportunity (P11, post-opinion form).

... öğrencilerin anlamalarını kolaylaştırabilir ve derslerde zaman tasarrufu sağlayabilir.	... It can make it easier for students to understand and save time in classes (P6, post-opinion form).
... Ayrıca yapay zeka aktiviteleri ile birlikte öğrencilerin yaratıcılıklarını arttırmaya yönelik çalışmalar yapılabilir.	... in addition, studies can be conducted to increase students' creativity through artificial intelligence activities (P11, post-opinion form).
Theme 2: Enhancing content and pedagogical knowledge to teach and learn AI	
Yapay zekayı öğretmek için günlük hayattaki insan temelli olaylardan bahsederek anlatmaya başladım çünkü yapay zeka da günün sonunda insan üretimi ve ondan ne kadar farklı olabilir.. Aslında bir bakıma insanı taklit ediyor. Mesela bizim bir işi sırasıyla yapmamız gibi yapay zekada kodların sırasıyla çalışmasıyla işlem gerçekleştiriyor.	To teach artificial intelligence, I would start by talking about human-centered events in daily life because at the end of the day, artificial intelligence is also a human production and how different it can be from it. In fact, it imitates humans in a way. For example, just as we do a job sequentially, artificial intelligence performs a process by running the codes in order (P3, post-opinion form).
Yapay zekayı öğretmek için sahip olduğu ikilemleri öğretmekle başladım. Mesela doğru bilginin yanında yanlış bilgi de vermesi gibi. Mesela her öğrencinin sorduğu soru tipine göre farklı cevaplar aldığını gözlemler ve öğrencilerin arasında tartışıp fark etmesini isterdim. Yapay zekadan en optimal cevabı alabilecekleri soru tipini kendi kendine fark etmelerini sonra da bunu araştırıp doğru bilgi mi yanlış bilgi mi diye kontrol etmelerini isterdim.	To teach artificial intelligence, I would start by teaching the dilemmas it has. For example, it gives false information along with true information. For example, I would observe that each student gets different answers depending on the type of question they ask and I would ask the students to discuss and notice. I would ask them to notice the type of question that they can get the most optimal answer from the artificial intelligence and then investigate this and check whether it is

	true or false information (P8, post-opinion form).
Proje tabanlı ve etik anlatımlı bir ders planlardım. Bu sayede öğrenciler hem teknik becerilerini hem de düşünme ve yaratıcılık becerini geliştirebilirdi	I would plan a lesson that was project-based and ethics. In this way, students could improve both their technical skills as well as their thinking and creativity skills (P6, post-opinion form).
. . . Örneğin yapay zeka etiği üzerinde çalışma yaparsam bunu unplugged aktivite üzerinden tasarlayabilirim. Öğrenciler bana her soru sorduğunda bir bardak su dökerim ancak kendi aralarında tartışıp su döktüklerinde yarım bardak su dökerim. Ancak kendi aralarında tartışıp cevaplarırsa hiç su dökmem . . .	. . . For example, if I am going to study the ethics of artificial intelligence, I can design it through an unplugged activity. Every time students ask me a question, I pour a glass of water, but when they discuss and pour water among themselves, I pour half a glass of water. However, if they discuss and answer among themselves, I do not pour any water . . . (P1, post-opinion form)
Yapay zekayı somut bir şekilde kullanabilmek ve öğrenme deneyimlerine entegre etmek birçok öğrenci için yeni bir konsept olacağı için işbirliği içinde olmalarını önemserdim . . .	Since using AI in a concrete way and integrating it into their learning experiences will be a new concept for many students, I would emphasize their collaboration . . . (P4, post-opinion form)
Öncelikle yapay zekanın çalışma prensibini göstermek adına yapay zekanın kullanılmadığı bir etkinlik ile tüm bu bilgi alış-verişinin nasıl sağlandığını gösterirdim. Zihinlerinde konseptler oluşmaya başladıkça yapay zeka uygulamaları ile bunları sağlamlaştırırdım.	First of all, in order to demonstrate the working principle of artificial intelligence, I would show how all this information exchange is achieved with an activity where artificial intelligence is not used. As concepts begin to form in their minds, I would reinforce them with artificial intelligence applications (P11, post-opinion form).

... yapay zekayı öğretmek için aklımda şöyle bir plan var her konuda uygun olduğu ölçüde yapay zekayı ders planlarıma dahil etmeyi ve öğrencileri heveslendirerek öğretmeyi düşünüyorum.	... I have a plan in mind for teaching artificial intelligence. I plan to include artificial intelligence in my lesson plans in every subject, as appropriate, and to teach it by motivating the students (P10, post-opinion form).
... [Yapay zekayı öğretebilmek için] Aynı şekilde yapay zekayı bir ders planına ya da projeye entegre ederek de onların daha iyi öğrenmesini sağlayabilirdim.	... [to teach AI] Similarly, I could integrate artificial intelligence into a lesson plan or project so that they [students] could learn better (P4, post-opinion form).
örneğin matematikte veri analizi için desmos kullanırdım. Verinin gorselleşmesi, grafiğinin oluşturulması ve yorumlanması için ai kullanmak faydalı olurdu. Ayrıca orneğin matematikte geometrik şekillerin sınıflandırılması için MIT App Inventor dan bir classifier yapmak faydalı olabilir diye düşünüyorum.	For example, I would use Desmos for data analysis in mathematics. It would be useful to use AI for data visualization, graphing and interpretation. I also think that it would be useful to make a classifier from MIT App Inventor for classifying geometric shapes in mathematics (P2, post-opinion form).
... Sınıflandırma uygulamalarını kullanarak mitoz ve mayoz bölünmeyi içeren konuları işleyebilirdim.	... I could cover topics involving mitosis and meiosis using classification applications (P5, post-opinion form).
Theme 3: Concerns about overreliance on AI and its impact on skill development	
... Çünkü eğer öğrencilerin yapay zekayı aşırı kullanmasına yol açarsak bu bize dersin ilerleyen zamanlarında katılım azlığı veya yaratıcı fikirlerin azlığı gibi durumlara yol açabilir ...	... because if we cause students to use artificial intelligence excessively, this may lead to situations such as lack of participation or lack of creative ideas later in the lesson ... (P9, post-opinion form).
... Ayrıca daha farklı şekillerde farklı örneklemelere kısa süre farklı bakış açıları kazandırabilir ama öğrencilerin	... in addition, different examples in different ways can provide different perspectives in a short time, but it can

dikkat süreleri ve yaratıcılıkları konusunda dezavantaj olabilir.	be a disadvantage in terms of students' attention span and creativity (P6, post-opinion form).
Öğrencilerin ödevlerini sadece yapay zeka kullanarak yapması dezavantajları arasında yer alabilir . . .	One of the disadvantages maybe that students do their homework only using artificial intelligence . . . (P5, post-opinion form).
. . . eğer öğrenciler kolayca kaçmak için yapay zekayı kullanırlarsa hayatta kolayca kaçamayacakları durumlarla karşılaştıklarında bunun zararını görürler ve bedelini öderler . . .	. . . if students use artificial intelligence to take the easy way out, they will suffer and pay the price when they encounter situations in life that they cannot take the easy way out of . . . (P10, post-opinion form).
Theme 4: Equipping students with AI literacy	
. . . Eğitim sisteminin amacı değişen dünyada toplumsal ve bireysel çıkarı gözetmeyi kazandırmaksa bireyler bu noktada yapay zekayı entegre etmesi kaçınılmaz bir durum olmalı çünkü son zamanlarda çoğu gelişme yapay zeka üzerine oldu ve bu toplumların yaşantısı üzerinde etkisi olan bir gelişme. Bu yönden eksik kalırsak toplumsal ve bireysel çıkarın bir yerden sonra diğer toplumlara göre çok geride kalacağını düşünüyorum.	. . . If the aim of the education system is to teach people to take care of social and individual interests in a changing world, it should be inevitable for individuals to integrate artificial intelligence at this point, because most of the developments in recent times have been on artificial intelligence, and this is a development that has an impact on the lives of societies. If we remain deficient in this respect, I think that social and individual interests will fall far behind other societies after a while (P3, post-opinion form)
. . . ancak günümüz koşullarında teknoloji bu kadar ileriye giderken geleneksel der yöntemleriyle ders işlemenin yaratıcılık ve teknolojik süreçlere ket vuracağı kanısındayım . . .	. . . however, in today's conditions, when technology [AI] has advanced so much, I believe that teaching lessons with traditional teaching methods will

	hinder creativity and technological processes (P1, post-opinion form)
. . . cunku uygulamalarla birlikte ogrenciler gercek hayatta ai kullanmis olacaklar. Sadece teorik eğitim degil ai in uygulamalarına daha cok ağırlık verilmeli diye dusunuyorum.	. . . because with the applications, students will use AI in real life. I think more emphasis should be given to the applications of AI, not just theoretical education [of AI] (P2, post-opinion form)
evet. öğrencilerin yapay zeka okuryazarı olması için entegre bir müfredat olmalı.	Yes, there must be an integrated curriculum for students to become AI literate (P8, post-opinion form).

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