# EXPLORING DIGITAL COMPETENCE AND AI LITERACY AT THE TERTIARY LEVEL

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# EXPLORING DIGITAL COMPETENCE AND AI LITERACY AT THE TERTIARY LEVEL

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# ABSTRACT

## Exploring Digital Competence and AI Literacy at the Tertiary Level

This explanatory sequential mixed-method study examined students' Artificial Intelligence (AI) literacy at one of the top universities in Turkey and whether or not their AI literacy levels may significantly correlate with their digital competence. Students' levels of digital competence and AI literacy, and how students' AI usage vary based on their digital competence and AI literacy scorers were investigated. Quantitative data were collected through the Self-Assessment Tool for Digital Competence (DigCompSAT), the Scale for the Assessment of Non-experts' AI Literacy (SNAIL), and a demographic questionnaire. Data from both scales were used to form four case groups, which were identified based on Digital Competence and AI Literacy levels. The students from all departments at the university were invited. 338 students participated in the study. Qualitative data were collected through semi-structured interviews, and 15 students were interviewed. The DigComp Framework and UNESCO AI Competency Framework for Students were used to analyze the qualitative data. The results indicated a significant and positive correlation between students' digital competence and AI literacy levels. The findings showed the dimensions of DigComp seem to be transformed from a system where individuals perform several tasks using digital tools to a structure where AI performs targeted tasks. The findings showed that AI tools can directly perform tasks individuals need to complete or want to perform for daily and academic purposes.

# ÖZET

## Üçüncü Düzeyde Dijital Yeterlilik ve Yapay Zeka Okuryazarlığını Keşfetmek

Bu açıklayıcı sıralı karma yöntem çalışmasında, Türkiye'nin en iyi üniversitelerinden birinde okuyan öğrencilerin yapay zeka okuryazarlığını ve yapay zeka okuryazarlık düzeylerinin dijital yeterlilikleriyle anlamlı bir korelasyon gösterip göstermediği araştırılmıştır. Öğrencilerin dijital yeterlilik ve yapay zeka okuryazarlık düzeylerinin incelenmesi ve öğrencilerin yapay zeka kullanımının dijital yeterlilik ve yapay zeka okuryazarlık puanlarına göre nasıl değiştiği araştırılmıştır. Nicel veriler Dijital Yeterlilik için Öz Değerlendirme Aracı (DigCompSAT), Uzman Olmayanların Yapay Zeka Okuryazarlığının Değerlendirilmesi Ölçeği (SNAIL) ve demografik anket aracılığıyla toplanmıştır. Her iki ölçekten elde edilen veriler, dijital yeterlilik ve yapay zeka okuryazarlığı düzeylerine göre belirlenen dört vaka grubunun oluşturulmasında kullanıldı. Üniversitenin tüm bölümlerinden öğrenciler katılıma davet edildi. 338 öğrenci çalışmaya katıldı. Nitel veriler yarı yapılandırılmış görüşmelerle toplandı ve 15 öğrenci ile görüşüldü. Nitel verileri analiz etmek için DigComp ve UNESCO Öğrenciler için Yapay Zeka Yeterlilik modelleri kullanıldı. Sonuçlar, öğrencileri dijital yeterlilik ve yapay zeka okuryazarlık seviyeleri arasında pozitif ve anlamlı bir ilişki olduğunu göstermiştir. Bulgular, DigComp'un boyutlarının, bireylerin dijital araçlar kullanarak çeşitli görevleri gerçekleştirdiği bir sistemden, yapay zekanın hedeflenen görevleri gerçekleştirdiği bir yapıya dönüştüğü görülmektedir. Bulgular, yapay zeka araçlarının, bireylerin günlük ve akademik amaçlar için tamamlanması gereken veya gerçekleştirmek istediği görevleri doğrudan gerçekleştirebildiklerini göstermiştir.

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# ABBREVIATIONS

| | |
|---|---|
| AI | Artificial Intelligence |
| AIED | Artificial Intelligence in Education |
| AI4K12 | Artificial Intelligence for K-12 |
| ATAI | Attitudes Towards Artificial Intelligence |
| DigComp | Digital Competence Framework for Citizens |
| DigCompEdu | Digital Competence Framework for Educators |
| DigCompSAT | Self-Assessment Tool for Digital Competence |
| ICT | Information and Communication Technology |
| ISTE | International Society for Technology in Education |
| LLM | Large Language Model |
| MAILS | Meta AI Literacy Scale |
| MAIRS-MS | Medical Artificial Intelligence Readiness Scale for Medical Students |
| SDiCos | Students' Digital Competence Scale |

# CHAPTER 1

# INTRODUCTION

Artificial intelligence (AI) has developed quickly, and it is now used in many areas of daily life (Kasinidou, 2023). During the early period of studies about AI, the term AI was used generally to describe any machine or computing system that could perform any task that humans can complete using their intelligence or cognitive behaviors (Wong et al., 2020). AI was defined firstly as the engineering and science of making artificial machines in 1956 (Ng et al., 2021). Throughout the years, many researchers defined the concept of AI, and the definitions of AI have evolved. Ng et al. (2021) indicated that the definition of AI has evolved as performing cognitive tasks, especially problem-solving and learning, with technological developments including neural networks, machine learning, and natural language processing.

As AI technologies have infiltrated daily life, including education, it has become important to help learners and teachers understand this technology and use it appropriately and effectively. Kong et al. (2024) explained that AI in education can address the global educational challenges and decrease difficulties and gaps in education. Therefore, AI literacy has become essential for individuals and society in today's world. Lérias et al. (2024) indicated that it is inevitable that AI will have an increasing impact on humanity; for this reason, "AI literacy" is crucial. AI literacy is centered around the ability to use AI in real-world situations, such as assisting with problem-solving, enhancing awareness about AI ethics (Kong et al., 2024). In addition, AI literacy and AI in education can foster lifelong learning, promote equality and inclusion globally, and reach some of the Sustainable Development Goals (Kong et al., 2024).

Examining how AI literacy can encourage social justice and economic growth in developing countries, and how AI literacy interacts with other essential skills such as data science competencies and digital literacy, can help close the gap in AI literacy worldwide and guarantee that everyone can benefit from AI technologies (Kathala & Palakurthi, 2024). In recent years, AI literacy has become one of the areas studied by researchers to examine skills and knowledge needed for using AI tools for different purposes, including academic purposes.

While AI literacy is rapidly becoming a new digital competence (Ma & Lei, 2024), the educational community has come to recognize AI with its potential to enhance learning in different contexts (Chen et al., 2022). In addition, Bozkurt & Gursoy (2023) proposed providing targeted information and education programs for minimizing the contradictory confusion, promoting AI literacy, and enhancing understanding of how AI technologies can improve the well-being of citizens and society. Studies about AI literacy help to observe how AI technologies are used for academic purposes, to observe their contributions to performing academic tasks, and the individuals' concerns in the use of AI in educational settings.

In addition, the research area provides a clear understanding of AI technology for the effective use of experiences for academic purposes. At this point, Schiff (2022) emphasized that broader AI policies and strategies in national and local settings were mostly absent in AI in education. Similarly, Lee et al. (2024) emphasized the necessity of extensive comprehension about AI's working mechanism, ethical issues, and wider social impacts. Therefore, observing the students' understanding of AI systems from different perspectives is needed, including the educational context, which brings along a need for more AI literacy studies.

In higher education, Bakiner (2023) indicated that with the daily introduction of new technologies, it is more essential to examine how the AI policies affect faculty, offer specific guidelines for using AI ethically, and bring together many different research projects. Azevedo et al. (2024) indicated the higher education institutions' necessity of effective technology infrastructure with particular policies and tools that guide faculty teaching, research, and entrepreneurial activities for effectively integrating AI technology and transforming digital learning environments. Therefore, encouraging more AI literacy studies provides an understanding of how students use, interact with, and evaluate AI technologies for academic purposes. Knowing students' real experiences and attitudes towards AI technologies will guide faculty members, departments, and developers of AI tools. In this way, it will be possible to decide how AI technology can be integrated into education more effectively and reliably. Similarly, Azevedo et al. (2024) emphasized that more research about AI is needed to guide faculty and other studies because of the unknown effects of AI in higher education.

A small but rapidly growing literature on AI literacy has shown that AI-related skills will increasingly be considered essential for any kind of work. AI literacy is regarded as a new digital competence essential in this rapidly evolving era (Ma & Lei, 2024). Digital competence includes a broader range of abilities and knowledge in the following domains: information science, communication and media, computing and technology, and literacy (Ilomäki et al., 2011). Digital competence, which has been considered essential for twenty-first century citizens, seems to now also require knowledge and skills related to the use of AI.

As indicated by Kathala & Palakurthi (2024), examining the interaction between AI literacy with other essential skills will help to bridge the gap of AI

literacy worldwide. Because AI literacy is a new set of skills arising with developing AI technologies, studying AI literacy with digital competence is a twenty-first century skill that will provide a better understanding of novel skills. It is expected that examining the interaction between digital competence and AI literacy will provide more comprehension about AI literacy and help close the gap in AI literacy.

It is thought that students who have higher digital competence would also be more skillful in AI literacy. In addition, AI literacy is rapidly becoming a new digital competence (Ma & Lei, 2024). However, the link between these two sets of skills has not been studied much because the concept of AI literacy has recently emerged along with the AI technologies that have recently been integrated into daily life. Therefore, investigating these two sets of skills can guide the students' guidance to the AI literacy levels, and also can contribute to increasing ways of AI literacy according to their digital competence level. Observing at different levels can help to understand what the differences are, and what can be done to increase the two sets of skills.

At this point, digital competence has become an essential skill in an environment with increasingly digital technologies. Digital Competence Framework for Citizens (DigComp) originally emerged in 2013 as a framework to help individuals develop their digital competence in Europe (Kluzer & Priego, 2018). In addition, the framework defines the competencies required to use digital technologies critically, creatively, collaboratively, and confidently to reach goals about education, employment, leisure, inclusion, and engagement in our digital society (Kluzer & Priego, 2018).

## 1.1 Purpose of the study

The purpose of the study was to investigate the nature of the relationship between digital competence and AI literacy levels among university students at one of the top universities in Turkey and whether or not there is a meaningful relationship between digital competence and AI literacy levels. The study aimed to investigate students' levels of digital competence and AI literacy, and how students' AI usage vary based on their digital competence and AI literacy scorers.

## 1.2 Significance of the study

AI technologies are becoming widely integrated into many of the digital tools already in use, a new level or type of digital competence seems to be also needed in these enhanced digital technologies. Despite that AI technologies require the use of digital tools, being AI literate seems to involve a whole new set of skills. Therefore, this study investigated whether there was a correlation between individuals' digital competence and their AI literacy levels. In this way, the research will provide an understanding of the relationship between the two sets of skills. Therefore, it will help to observe how one variable behaves when the level of the other variable increases. The study will enable the development of intervention strategies based on the correlation between the variables. If a correlation exists between two of the skills, the higher level of variable can help how to improve the lower level of variable.

In addition, the students' uses of AI tools were investigated in more detail to examine how vary on their digital competence and AI literacy levels. How high scorers in digital competence differ from low scorers in terms of their usage of AI tools, participants' use of AI in their daily life and in education, ethical issues of using AI in daily life, and in education, what they know about how AI applications

work, and technical concepts about AI were examined. In addition, participants' problem-solving with AI and participants' future design of AI were investigated.

## 1.3 Organization of the sections

Chapter 2 includes a literature review of AI literacy and digital competence. Chapter 3 covers the research methodology: research design, participants, data collection instruments, procedures, data coding and analysis, and trustworthiness. Chapter 4 consists of the results of the demographic questionnaire, findings based on quantitative data, and findings based on interview data. Lastly, the discussion of the findings, implications and recommendations, and the limitations of the study are presented in Chapter 5.

# CHAPTER 2

# LITERATURE REVIEW

In this chapter, AI literacy and digital competence will be explained. The literature about research in and models of AI literacy in education will be reviewed. In addition, the digital competence framework and research on the students' digital competence will be reviewed. Then, the research questions will be listed.

## 2.1 AI literacy

Literacy was defined as the ability to process information through text, to communicate and express oneself through written language (McMillan, 1996), and has evolved as a fundamental social skill for people to comprehend the society they live in (Yi, 2021). Literacy involves particular ways of thinking and acting in writing and reading to understand or represent ideas or thoughts in writing within a specific context of use (Keefe & Copeland, 2011). Yi (2021) pointed out that literacy helps people recognize the necessary skills for the era and gain knowledge from other members of society. While reading and writing were essential social skills in the era of print, using computers became an important competence in the era of digitalization. Similarly, as Long & Magerko (2020) stated, the concept of literacy has recently been used to define skill sets across a range of disciplines that share the potential to facilitate communication, expression, and knowledge acquisition, such as scientific literacy, computational literacy, digital literacy, and data literacy.

AI literacy has emerged as a new set of skills in response to this new era of intelligence, similar to classic literacy which includes reading, writing, and

mathematical abilities (Ng et al., 2021), and is considered a new digital competence essential in this rapidly evolving era (Ma & Lei, 2024).

Since AI literacy has emerged as a new competence needed in today's world, a variety of frameworks and definitions to study the concept have been suggested (e.g. Chiu et al., 2024; Laupichler et al, 2023; Long & Magerko, 2020, Ng et al., 2021, Pinski & Benlian, 2024; Walter, 2024). Yi (2021) indicated AI literacy is a crucial skill for becoming a citizen who is not excluded from society which is changing as a result of AI because a lack of AI competencies will result in a "digital divide and digital exclusion" among the society's members. The definition also shows the importance of AI literacy for surviving in a developing society, and the ability to live in the AI era with the basic skills needed, without being restricted to using AI alone. Yi (2021) also identified anticipation and metacognition as necessary in AI literacy. Anticipation is considered the subjective act of employing technology to expand one's scheme, which requires metacognition. At the same time, metacognition is seen as an important competency in the era of AI, which strengthens self-learning. Liu & Xie (2021), on the other hand, emphasized digital literacy, computational thinking, programming ability, and deep cognition of intelligent society as essential in AI technology literacy.

Long & Magerko (2020) defined AI literacy as a set of competencies needed for users to evaluate AI technologies effectively, communicate and interact with AI efficiently, and use AI technologies online, in school, or in the workplace. Chiu et al. (2024) extended Long & Magerko's (2020) definition by including effective communication and collaboration in any setting using AI tools ethically and responsibly, as well as the ability to explain clearly how AI technologies work and affect society. The researchers indicated that Long & Magerko's (2020) explanation

of AI literacy was incredibly broad, possibly too complex, and inappropriate for K-12 education. Moreover, the definition lacked the self-reflective mindsets that are essential for lifetime learning regarding AI technology. Therefore, they revised the definition of AI literacy by considering K-12 education including self-reflective mindsets and student confidence. After revisions, AI literacy was defined as the ability of individuals to communicate and collaborate effectively in any setting, to use in a responsible manner and ethically, as well as to explain clearly how AI technologies work and affect society.

When defining AI literacy, Laupichler et al. (2023) pointed out an important aspect of the concept. They clarified that the concept of AI literacy targeted non-experts, people who are not computer scientists or programmers. Their definition seems consistent with Long & Magerko's (2020) framework, as they stated that AI literacy involved "competencies that include basic knowledge and analytical evaluation of AI, as well as critical use of AI applications by non-experts" (Laupichler et al. (2023), p.1). They argued that while it is needed for children to learn about the possibilities of AI in the early period of life, adults in higher education and beyond should have a fundamental knowledge of AI (i.e. AI literacy) to engage with technology efficiently (Laupichler et al., 2022). Therefore, they recently carried out a scoping literature review to evaluate the current state of literature related to AI in higher and adult education, which concluded that the research in this field was still in its early stages and required improvements in defining AI literacy and the topics to be covered in adult education for non-experts. Laupichler et al. (2022)'s conclusions were similar to that of Long & Magerko (2020) in their seminal review that AI is a relatively new research area.

Recently, Walter (2024) argued that for AI literacy understanding AI technologies and their wider societal effects is essential. Similarly, Tzirides et al. (2024) indicated that AI literacy is a broad term that includes knowledge of AI technologies, their responsible and efficient use, and the application of critical thinking to their development and application. Moreover, Hazari (2024) mentioned that a set of skills that allow someone to explain terms connected to AI technology could be considered part of AI literacy.

Ng et al. (2021), who studied the concept of AI literacy for defining and examining applications in educational settings, argued that sound justification for how to conceptualize AI literacy was missing in the literature. Therefore, they identified four categories based on cognitive domains in Bloom's Taxonomy, to achieve a better understanding of AI literacy as a concept. These categories were: 1. Know and understand AI: knowing the fundamental functions of AI and knowing the usage of AI applications; 2. Use and apply AI: applying AI knowledge, applications, and concepts in different environments; 3. Evaluate and create AI: higher-order thinking skills with AI systems, and, 4. AI Ethics: ethical considerations of AI.

Yi (2021) also studied the concept and characteristics of AI literacy and indicated that AI literacy requires important competencies to successfully navigate and prosper in today's world of AI. Yin (2021) conceptualized learner competencies required in the AI era through functional, social, and technical literacy. Unlike Ng et al. (2021), Yi (2021) considered these three types of literacy as the basis of AI literacy. Understanding functional, social, and technological literacy is essential because it formed the foundation of AI literacy. Functional literacy includes the learning of reading, writing, and arithmetic. Social literacy started with critically comprehending social phenomena, and social practice and critical thinking were

essential for social literacy. While functional literacy provided the basis for understanding AI, social literacy fostered critical thinking, much needed in the AI era.

Another framework developed by Kong et al. (2024) proposed four dimensions for AI literacy, cognitive, metacognitive, affective, and social. The cognitive dimension in Kong et al. (2024)'s framework relates to understanding AI concepts such as neural networks and supervised learning, while the ability to use AI concepts for solving problems formed the metacognitive dimension. This conceptualization of the metacognitive dimension differed from previous studies in the literature. For example, while Long & Magerko's (2020) framework focused on the cognitive and social dimensions, Zhang et al. (2023) focused on the confidence and readiness to use AI (Kong et al., 2024). Based on Schraw et al. (2006) model, the four steps of problem-solving with AI were expressed as describing the problem, finding associated AI concepts and solutions, choosing, organizing, and carrying out AI-based solutions, and evaluating the outcomes of the solutions. In addition to cognitive and metacognitive dimensions, individuals' psychological readiness to use AI make up the affective dimension. In addition, social dimension indicates how individuals contributed to society when solving problems by using AI, including ethical considerations when using AI-based solutions.

To sum up, there are several definitions and frameworks for AI literacy in the literature. As indicated by Ng et al. (2021), AI is currently being used in a variety of fields such as art, education, business, and science to increase productivity and improve user experiences, and several areas in daily life where AI applications are popular. Because AI technologies take a role in different areas of our lives, AI in education has emerged as an important area of research.

### 2.1.1 AI in education

Chen et al. (2020) pointed out early on, the increasing impact of and interest in AI in education. However, they observed little effort in combining deep learning technologies into an educational context and concluded that there were insufficient studies on the use of AI technologies that engaged deeply with educational theories. In addition, Hwang et al. (2020) indicated that in recent years, the educational community has come to recognize the potential of AI technologies or programs in education, such as machine-based approaches with algorithmic power to make diagnoses, predictions, decisions, and recommendations, to provide feedback, personalized guidance, and support to students, assisting teachers and policymakers. Similarly, Su & Yang (2022) pointed out that educators and researchers are becoming more interested in the topic of AI in education because AI appeared to significantly improve education by contributing to personalized learning experiences, and AI has a role in facilitating learning, teaching, assessment from robotic instruction to automated systems for scoring answer sheets.

AI in education appeared firstly in the form of computer-related systems, then in online education and web-based platforms, and embedded systems, and finally made it possible to use robots and as well as chatbots (Chen et al., 2020, 2022) listed intelligent tutoring systems, recommender systems for personalization, natural language processing, educational robots, educational data mining, neural networks for teaching assessments, discourse analysis for collaborative learning, and affective computing for learner emotion identification as some examples of the uses of AI in education. Akgun & Greenhow (2021) stated that the benefits of AI in education included automated assessment systems, social networking sites, chatbots,

personalized learning systems, and the characteristics of facial recognition and predictive systems.

Other researchers also described the benefits of using AI for educational purposes, as the rapid development of AI technologies significantly affected teaching and learning, to such an extent that Hwang et al. (2020) claimed the beginning of a new era in computer-supported education with the development of AI. For example, Celik et al. (2022) identified the advantages of AI for planning, implementing, and assessment in education. Planning activities, making decisions about learning content, and providing information about students' backgrounds could be assigned to AI technologies. The use of AI can reduce teachers' workload by following students' progress, monitoring, giving immediate feedback, and assessment and evaluation could be automated, making better predictions about performance, and assisting decision-making. AI could combine multiple technologies and different disciplines of knowledge simultaneously, providing great potential for strengthening students' learning (Yang, 2022).

Recently, Daniels et al. (2023) focused on developing a Future Skills framework to help individuals, organizations, and educational institutions in improving the AI-related competencies needed for a world increasingly shaped by AI in private and working life. These competencies encompassed three areas, namely, innovation and creative design with and for AI, learning to act autonomously with and for AI, and co-creation with and through AI. The researchers listed digital competence, design thinking competence, innovation competence, and system competence under the area of innovation and creative design with and for AI. Ethical decision-making, learning, reflection, self-determination, and self-competence were categorized in the learning to act autonomously with and for AI. Finally, future and

design competence, cooperation competence, and communication competence were classified in the co-creation with and through AI.

Su & Yang (2022) carried out a scoping review of 17 articles from 1995 to 2021 about the integration of AI in early childhood education, to observe AI-related activities used, AI-interfaced tools, and methods used in research. They found that workshops, lectures, and hands-on units were extensively used in the design of AI-enabled learning activities. The findings of the studies demonstrated that integration with children's toys stimulated higher-order cognitive processes, and fostered imaginative, affective, and cooperative learning, and related literacy skills. The researchers concluded that AI has significantly enhanced children's concepts related to AI, including computer science, machine learning, robotics, and skills including creativity, emotional regulation, computational thinking, collaborative inquiry, and literacy.

To observe students' engagement in AI-integrated learning environments, Hao & Cukurova (2023) investigated the effect of AI-generated post summaries on students' online engagement. The findings indicated that providing students with an AI-generated summary of a forum post may not always enhance their online engagement. Gedrimiene et al. (2023) explored the advantages and challenges of AI-enhanced learning analytics tools, offering user-centered evidence for future studies and identifying how users experience AI-enhanced learning analytics tools for their career guidance. The findings showed that the AI-enhanced learning analytics tools provide users with primary advantages: career information, easing investigation and analysis of the information, a range of ideas for potential career paths, guidance, decision support, and self-reflection.

### 2.1.2 Challenges of AI in education

Apart from the opportunities and benefits of AI in education, the challenges inherent in employing AI for educational purposes were also addressed in the literature. For example, Walter (2024) pointed out the challenges of including AI literacy in curricula, such as the requirement for extensive educator training and adaptation to conform to societal norms. Celik et al. (2022) listed the difficulties encountered when teachers used AI as limited reliability of AI algorithms, limited technical capacity of AI, inefficiency of AI for evaluation and assessment, technical infrastructures at schools, inapplicability of AI in multiple settings, and slow AI feedback.

An important challenge identified in the literature was the ethical concerns regarding the use of AI in education. In Akgun & Greenhow's (2021) investigation of the ethical concerns of AI applications in education, a major concern was students' privacy because of face recognition and recommender systems. Bias and discrimination of gender or race, and surveillance by personalized learning systems were also of concern. Borenstein & Howard (2021) argued that the challenges related to ethics were too complex for any one area of expertise to address, and they suggested due to the cross-over of disciplinary boundaries when deciding how to teach students about ethics, perspectives from engineers, scientists, policy scholars, philosophers, and other experts would be beneficial. Similarly, Smyrnaiou et al. (2023) emphasized that AI ethics was currently unable to keep pace with how AI systems were being developed in our society; because ethics needs to be approached through the lenses of interdisciplinarity, the identification of inclusive solutions might result from a comprehensive approach involving philosophers, linguists, lawyers, sociologists, psychologists, and AI-experts. Likewise, Graesser et al. (2023)

pointed out the need to develop ethical standards and guidelines to direct research and products, and offered explicit procedures for minimizing biases.

Holmes et al. (2021) emphasized the necessity of accountability, fairness, bias, autonomy, inclusion, transparency, and agency in AI in education research. The researchers stated that the goal of learning, selection of pedagogy, the role of technology according to teachers, and ethics of education needed to be considered in AI in education research. They conducted a survey to identify understandings and existing beliefs of the Artificial Intelligence in Education (AIED) community and to stimulate engagement with ethics. The survey results showed that the AIED community had a low level of interest in the ethics of AIED. The importance and worth of discussing the ethics of their work, but further investigation, discussion, and resolution of issues related to data, human cognition, and pedagogical choices were needed to bring the engagement to light and explore nuances of ideas were indicated. The ethics in the AIED framework emphasized three main areas of focus including ethics of data, computational approaches, and education. To provide transparency and ethical consideration in the development of AI-powered ed-tech tools, Chaudhry et al. (2022) recommended the Transparency Index framework for AI systems in education. The Transparency Index is a comprehensive framework for assessing, checking, and analyzing how AI systems work in classrooms effectively. The framework can be used in education by different stakeholders such as teachers, students, ed-tech specialists, educators, executive leaders, and AI practitioners who develop ed-tech products.

### 2.1.3 AI Literacy in education

Although there is no strict agreement on the full scope of the term AI literacy, it is already needed for both students and teachers, as it is becoming a fundamental component of contemporary education (Walter, 2024). For example, Stolpe & Hallström (2024) emphasized today's students need to develop AI literacy in addition to having a broad technological multiliteracy. For educational settings, Ding et al. (2024) stated that in addition to the necessary knowledge and abilities, collaborative engagement strategies, and the ability to evaluate the pedagogical and ethical consequences of their AI integration efforts in instruction can all be considered indicators of a teacher's AI literacy. According to Walter (2024), AI literacy allows learners to navigate and benefit from AI effectively in different fields of personal and professional contexts beyond conventional learning models. Some sub-skills of AI literacy were suggested which were architecture, limitations, problem landscape, applicability, best practices, and AI ethics as well.

AI in education research at both k12 and college levels seems to have increased due to the rapid increase in everyday applications of large language models, and other AI-based applications. Mertala et al. (2022) carried out a study to analyze Finnish 5th and 6th grade students' pre-instructional conceptions of AI. After analyzing students' conceptions, the researcher suggested some pedagogical implications for AI literacy education. The study showed that the initial ideas of students were diverse and generally misinformed about the importance of data in training AI applications. Therefore, they recommended including AI literacy in compulsory education curricula, introducing the role of data early, differentiating between narrow and general AI, integrating media literacy in AI literacy, and

clarifying AI by investigating the technical basis of human-like AI solutions found in daily life.

Further, Ng et al. (2022) indicated the absence of studies that offer justifications for how to conceptualize AI literacy. The researchers carried out a study to examine digital story writing as a pedagogical strategy to improve primary students' AI literacy in four aspects, as defined by Ng et al. (2021), which are know and understand AI; use and apply; evaluate and create; and ethics. They analyzed the students' inquiry-based learning processes when creating digital stories to learn AI. According to the study, this approach effectively increased the students' AI literacy, boosted their problem-solving and critical thinking skills, and enhanced their AI awareness as well. It was observed that inquiry-based learning was an effective strategy, through five steps which are orientation, conceptualization, investigation, conclusion, and discussion to increase students' AI literacy by strengthening to creation of ideas, observations, and questions, and gaining practical experiences similar to professional scientists.

Hazari (2024) argued that AI skills were essential to compete in the twenty-first century economy and the students who have AI literacy would be the ones equipped with the knowledge and abilities needed to interact with and navigate the quickly changing field of artificial intelligence. It was indicated that colleges could help students become responsible users of AI while fostering the creativity and critical-thinking abilities necessary for success in the future by providing them with AI literacy. Magrill & Magrill (2024) addressed prompt engineering, critical thinking development, and AI literacy. The researchers suggested that although AI integration in higher education has potential, it also needs to be managed carefully, ethical issues

need to be considered, and specialized skills must be developed to ensure responsible and efficient use.

To investigate university students' AI understanding, AI literacy, and their AI empowerment, Kong et al. (2021) designed, implemented, and evaluated an AI literacy course for university students in Hong Kong. To measure the progress of course students' development of AI literacy, the researchers designed and applied an AI Concepts Test, an AI Empowerment Test, and an AI Literacy Survey, which were developed by the researchers. They aimed to investigate whether the AI literacy course conducted using the flipped classroom model improved university students' comprehension of AI concepts, and decreased gender and background differences. The results showed that the AI literacy course improved students' understanding of AI concepts and self-perceived AI literacy. Moreover, the course reduced the gender gap in AI literacy and AI empowerment, as well as decreased the gap between participants from different backgrounds.

Recently, Tzirides et al. (2024) investigated how a combination of human and artificial intelligence can improve AI literacy in higher education. Using mixed study methodology, they examined the students' perceptions of AI literacy in higher education. The data collected by pre- and post-course surveys, the students' reflections expressed with AI image generation tools, and in text. The study demonstrated that the participants felt more at ease utilizing generative AI tools and showed improved capacity to evaluate AI applications in education. The study emphasized the significance of AI literacy as a necessary competency for responsible and successful AI use, which includes comprehending, assessing, and utilizing AI technologies.

### 2.1.4 AI Competency framework students

Recently, UNESCO, which has been keeping an eye on the disruptive effects of AI, offered recommendations for both practice and policy. An AI competency framework was developed for both students and teachers. Human rights issues, and the need to maintain human agency and protect privacy and dignity, serve as the foundation of the framework (Miao et al., 2024).

For students, the AI Competency framework aims to outline the knowledge, abilities, attitudes needed to comprehend and actively interact with AI in a safe and meaningful way (Miao et al., 2024). The framework indicates the importance of providing students insight into the possible effects of technology on society and the environment, besides providing them with knowledge and abilities to use AI, as well as providing students with values, abilities, and information needed for the efficient use and collaborative co-creation of AI, given the revolutionary potential of AI for humans by educational programs. The framework aims to provide a guide for public education systems to develop the skills needed for all students and citizens to effectively carry out national AI strategies and create equitable, inclusive, and sustainable futures in the new technological era. The AI Competence Framework for students contains twelve competencies across four dimensions which are human-centered mindset, ethics of AI, AI techniques and applications, and AI system design. These competencies are formed into three progression levels which are understand, apply, and create (see Figure 1).

| Competency aspects | Progression levels | | |
|---|---|---|---|
| | Understand | Apply | Create |
| • Human-centred mindset | • Human agency | • Human accountability | • Citizenship in the era of AI |
| • Ethics of AI | • Embodied ethics | • Safe and responsible use | • Ethics by design |
| • AI techniques and applications | • AI foundations | • Application skills | • Creating AI tools |
| • AI system design | • Problem scoping | • Architecture design | • Iteration and feedback loops |

Figure 1. The AI Competency framework students (Miao et al., 2024).

The first dimension in this framework, the Human-centered mindset, emphasizes the students' beliefs, values, and abilities of critical thinking about AI (Miao et al., 2024). The dimension of a human-centered mindset allows students to consider the human agency from designing to using AI systems. In addition, the aspect focuses on the effect of AI systems on human rights, and the interaction between human lives and AI systems, and societies as well (Miao et al., 2024). In other words, it is expected that students become aware of the impact of AI on societies by providing responsible and inclusive design and use of AI.

The second dimension, the Ethics of AI, focuses on the ethical judgments of the AI systems. The dimension provides an understanding of ethical issues related to AI systems, and it is expected that students become aware of ethical issues about AI such as human rights, and equity (Miao et al., 2024). The dimension of the Ethics of AI provides students to understand AI systems and demonstrates the safe and responsible use of AI with the consciousness of the possible harmful effects on society.

The third dimension, AI techniques and applications, covers the basic understanding, knowledge, and skills of AI (Miao et al., 2024). Also, the dimension

concentrates on the understanding of AI algorithms, and programming (Miao et al., 2024). This dimension provides an essential and most applicable technical foundation for understanding and applying human-centered mindset and related ethical values (Miao et al., 2024).

The final dimension, namely, AI system design, concentrates on the engineering and design thinking skills for designing, problem-solving, architecture design, optimizing, testing, and training of AI systems (Miao et al., 2024). The dimension aims to encourage students to develop a deeper understanding of AI systems and help their exploratory learning for further studies in the area of AI (Miao et al., 2024).

### 2.1.5 AI literacy scales

Wang et al. (2022) developed an AI literacy scale including 12 items with seven-point Likert for the general population, and the scale was grounded on four factors, which are awareness, use, evaluation, and ethics. Although the scale has since been revalidated in Turkish in the studies carried out by Çelebi (2023), Polatgil & Güler, (2023), no direct cross-cultural validation has been carried out (Lintner, 2024). Later Gökçearslan et al. (2024) adapted this AI Literacy Scale into Turkish to assess the university students' GenAI Literacy. The scale consisted of ten items with four dimensions, which are awareness, usage, evaluation, and ethics.

There are also performance-based general AI literacy scales, such as the ones developed by Hornberger et al. (2023) and Chiu et al. (2024). Hornberger et al. (2023) developed and validated an AI literacy test to measure German higher students' AI literacy. The test included 30 multiple-choice questions and one sorting question for higher education based on the conceptualization of AI literacy by Long

& Magerko (2020). Lintner (2024) emphasized that the test is a performance-based test, and there is strong evidence for the scale's structural validity, construct validity, and internal consistency, but there is weak evidence for the scale's content validity. Moreover, Lintner (2024) indicated that although the test is available in German and English, the English form has not been validated yet. One of the other performance-based assessment scales of AI literacy developed by Chiu et al. (2024) included 25 multiple-choice questions for AI education in K-12 based on the topics of the Knowledge of AI, Processes in AI, and the Impact of AI.

Similar to Hornberger et al. (2023), Carolus et al. (2023) developed and validated the MAILS- Meta AI Literacy Scale including 34 items with 11-point Likert items for measuring AI literacy by including psychological competencies for adults based on the conceptualization of Ng et al. (2022), and the factors of AI Self-Efficacy and AI Self-Competency as well. As in the case of, Lintner (2024) indicated that although the scale's construct validity, internal consistency, and structural validity have strong evidence, the content validation on the target group was not conducted, as in the case of Hornberger et al. (2023)'s AI literacy test. The MAILS scale is available in German and English, the English version has not been revalidated.

Another questionnaire, the Scale of Artificial Intelligence Literacy for All (SAIL4ALL), was developed by Soto-Sanfiel et al. (2024), and included 56 items across four dimensions: 1) What is AI?; 2)What can AI do?; 3) How does AI work?; 4) How should AI be used? in both true/false or a 5 Likert scale. Lintner (2024) emphasized that the scale was developed based on the conceptualization of Long & Magerko (2020) for the general population similar to Hornberger et al. (2023) and

Carolus et al. (2023), the structural validity and internal consistency showed mixed evidence, but content validation was performed.

To assess AI readiness of medical students, Karaca et al. (2021) developed the Medical Artificial Intelligence Readiness Scale for Medical Students (MAIRS-MS). This scale included 22 items with 5 point Likert in a four-factor structure, which were cognition, ability, vision, and ethics. The scale items were generated in Turkish, and translated into the Persian language. Lintner (2024) pointed out that there was high evidence for structural validity, invariance by gender, internal consistency, and limited positive evidence for content validity.

Later, Pinski & Benlian (2023) developed an AI Literacy scale consisting of 13 items with a seven-point Likert for the general population, and the scale was grounded on the four factors which are AI technology knowledge, human actors in AI knowledge, AI steps knowledge, AI usage experience, and AI design experience for the general population. Lintner (2024) emphasized that the researchers developed the scale based on their conceptualization, and because of the small sample size, there is only moderate support for internal consistency and limited support for the scale's content and structural validity.

Another recent instrument, the Scale for the Assessment of Non-experts' AI Literacy (SNAIL), was developed by Laupichler et al. (2023). It comprised 31 items on a seven-point Likert scale based on three factors, which are Technical Understanding, Critical Appraisal, and Practical Applications. The researchers aimed to assess the AI literacy of non-experts in high school and further (Laupichler et al., 2023). The studies showed that the participants completed the final questionnaire in 5.39 minutes on average (Laupichler et al., 2023). The scale has been adopted in Turkish (Karacaoğlan Yılmaz & Yılmaz, 2023) and German language for use in

learning gains utilizing retrospective-post assessment, but cross-cultural validation has not been done directly (Lintner, 2024). A Delphi Study and factor analysis were used to confirm the validity of the scale (Laupichler et al., 2023). The scale's reliability studies were calculated for measuring the internal consistency of items for measuring three factors of Technical Understanding, Critical Appraisal, and Practical Applications. The Cronbach's alpha for the Technical Understanding is 0.93 (Confidence Interval: 0.92-0.94), Critical Appraisal is 0.91 (Confidence Interval: 0.89-0.93), and Practical Applications is 0.85 (Confidence Interval: 0.81-0.88) (Laupichler et al., 2023).

### 2.1.6 TUCAPA-Model of AI literacy

TUCAPA-Model of AI Literacy refers to the intersection of the three factors in the SNAIL scale, which was developed by Laupichler et al. (2023). When the researchers developed the scale, the three-factor model was adopted, which consisted of Technical Understanding, Critical Appraisal, and Practical Applications. With the intersection of these three factors, the researchers called the TUCAPA-Model of AI Literacy. The first factor is called "Technical Understanding". This factor is related to comprehending machine learning such as describing general and narrow AI or explaining machine learning models. The second factor is called "Critical Appraisal", which is about data security, data privacy, and ethical issues related to AI. The final factor is called "Practical Applications" which is related to "examples of technical applications that are supported by artificial intelligence" or assessing "if a problem in [one's] field can and should be solved with artificial intelligence methods" (Laupichler et al., 2023, p.6).

According to Laupichler et al. (2023), their TUCAPA-Model of AI Literacy overlaps with the framework developed by Ng et al. (2021). The categories of "Know and Understand" overlapped with "Technical Understanding", "Use and Apply" overlapped with "Practical Applications", and "Evaluate and Create" overlapped with "Critical Appraisal". The TUCAPA model also had similarities with MAIRS-MS developed by Karaca et al., (2021) which aimed to assess AI readiness of medical students. The "cognition" factor in MAIRS-MS was found similar to "Technical Understanding", the "Ability" factor to "Practical Applications", and "Vision and Ethics" to "Critical Appraisal". There were also minor relationships with Long and Magerko's (2020) 16 competencies of AI literacy Laupichler et al (2023).

UNESCO's AI literacy framework was published after the development of the TUPACA model. Nonetheless, it is possible to map its three components onto the UNESCO framework. TUPACA's "technical understanding" overlaps with UNESCO's AI foundations and AI system design. The "critical appraisal" component overlaps quite closely with the Ethics of AI, while "practical applications" match application skills in the UNESCO framework.

There are also studies using SNAIL developed by Laupichler et al. (2023). For example, Laupichler et al. (2023) carried out a study to investigate whether SNAIL can be used for evaluating AI courses and to analyze the effectiveness of the scale. The courses about artificial neural networks including lectures and exercises took approximately 150 hours. 25 students who are approximately 22.9 years old from different departments participated in the study. The participants competed for SNAIL as a retrospective self-assessment and post-course self-assessment, an AI Attitude Scale (Sindermann et al., 2020), demographic questionnaires, and instruments related to prior AI education. The SNAIL questionnaire was changed

with two parameters which were language adoption to German as students' native language and self-assessment of differences through retrospective self-assessment and post-course self-assessment. Because of the technical mistake, 30 items were used in the SNAIL. The results showed that the adapted SNAIL questionnaire can evaluate AI course's learning gains reliably and validly. In addition, there was not a significant relationship between AI literacy and attitudes toward AI, and these were correlated only weakly which could be a sign of discriminant validity. Prior AI education affected both retrospective self-assessment and post-course self-assessment, but it didn't have an effect on learning gains. Finally, the study suggested that efficient, reliable, and valid AI course evaluation instruments support systematic assessment and the development of AI education.

In addition, Toker Gokce et al. (2024) investigated university students' AI literacy level and the variables that affect the level including gender, faculty, participation in AI-related courses, and the frequency of using AI applications. There were 664 students in the study from the departments of the Faculty of Science, Education, Physical Education, Technology, Engineering, Medicine, and postgraduate students. The data collected by the Personal Information Form and the adapted Turkish version of the Deveci Topal et al. (2025) of SNAIL developed by Laupichler et al. (2023). According to the analysis, the students' AI literacy level is average. Participants' levels of critical appraisal and practical applications are moderate, but technical understanding is low. The frequency of using AI applications was found the most essential factor, students who use AI applications every day or once a week showed the highest AI literacy level. In addition, students' AI literacy levels from the faculty of Science and Arts, Technology, Engineering, and Medicine were moderate, and their AI literacy levels were higher than other faculties.

Moreover, males have higher scores in the dimension of technical understanding than female students, and also students who participated in the AI-related courses demonstrated higher AI literacy levels. Finally, the study suggested that it is essential to enhance students' AI literacy level through different training programs, to gain a useful understanding of the topic, and to grow up comprehending how to utilize these technologies in an ethical, efficient, and effective way.

One of the other studies developed by Laupichler et al. (2024) investigated medical students' AI literacy and their attitudes towards AI. At the same time, the factors of technical understanding, critical appraisal, and practical application rate were examined, and the effects of AI education and interest in AI were investigated. There were 377 medical students in the study. For collecting data, SNAIL developed by Laupichler et al. (2023) and the scale of Attitudes towards Artificial Intelligence (ATAI scale) by Sindermann et al. (2021) were used. The results showed that medical students rated themselves higher at critical appraisal of AI and practical applications of AI, but students rated themselves as low in the technical applications of AI. Both positive attitudes and negative attitudes were observed in the students, but the positive attitudes towards AI outweighed the negative attitudes towards AI. Moreover, the researchers found that students' prior AI education and interests in AI were positively correlated with students' AI literacy. The study emphasized that more technical elements of AI should be included in courses aimed at enhancing medical students' AI literacy. Also, the researchers indicated that there was a weak negative correlation between AI literacy and negative attitudes and a strong positive correlation between AI literacy and positive attitudes. Therefore, it was underlined that when planning AI courses, the correlation between AI literacy and attitudes towards AI should be considered.

## 2.2 Digital competence

Digital competence has become a crucial skill in an environment with increasingly digital technologies. Ilomäki et al. (2016) emphasized that the term digital competence is relatively new, and the term is not completely defined. Moreover, Ilomäki et al. (2016) mentioned that digital competence emerged at first in policy-related documents. Digital competence is an evolving concept about the developments in technology, political objectives, and citizen expectations in a knowledge-based society (Ilomäki et al., 2011). Similarly, during the past ten years of the study, there has not been a clear consensus or common understanding of what digital competence in the educational context is and what the competence includes (Pettersson, 2017). The term digital competence is used in some studies, and correlated with digital literacy (Punie, 2007; Ala Mutka et al., 2008).

In the last few years, technology skills, information and communication technology (ICT) skills, information technology skills, twenty-first century skills, digital literacy, information literacy, and digital skills are some of the terms that have been used to define the skills and proficiency in using digital technologies (Ilomäki et al., 2011). Also, in recent years, digital competence has emerged as an essential concept in discussions about the skills and knowledge that learners need in the knowledge age (Gallardo-Echenique et al., 2015). While digital competence is perceived as the technical use of ICT, others are perceived as twenty-first century skills or knowledge applications more generally (Gallardo-Echenique et al., 2015).

The concept of digital competence has been described many times by different researchers. For example, Ferrari (2012) defined digital competence as the critical, confident, and innovative use of information and communication technologies to accomplish goals involving learning, work, leisure, inclusion,

employment, and/or participation in society. As indicated by Ilomäki et al. (2011) digital competence encompasses a wide range of abilities and knowledge in the following domains: information science, communication and media, computing and technology, and literacy. Similarly, Rokenes and Krumsvik (2014) pointed out that digital competencies include a broad range of skills involving cognitive, emotional, and sociological knowledge to use the digital environment efficiently. In addition, Su & Yang (2023) defined digital competence as essential sets of skills, knowledge, and attitudes needed to digital tools and technologies in the modern world efficiently and ethically.

According to the EC Recommendation on Key Competences, digital competence is the ability to use ICT with confidence and critical thinking for work, participation in society, education, and personal growth, which provides information, abilities, and attitudes for working, surviving, and learning in the knowledge society (Halász & Michel, 2011). Sillat et al. (2021) emphasized that digital competence is considered essential in multiple policy documents and national trends as an essential ability and future competence in a knowledge-intensive economy that supports the digital transformation of society. Considering these conceptualizations of digital competence, Vieru (2014) pointed out that all of them present digital competence as a multifaceted concept that exists at the intersection of media studies, education, information sciences, information systems, and communication studies which shows their one commonality. While ICT is becoming a more important tool for work, education, and leisure across all areas, digital competence ought to be prioritized in lifelong learning strategies (Ala-Mutka et al., 2008).

In the setting of today's increasingly digitalized modern community, the improvement of digital competence from an early age becomes more important,

which forms a challenge for educational institutions at all levels the point of ensuring the development of students' digital competence level and training their teachers' digital competence (Verdú-Pina et al., 2023). As more teaching and learning takes place online, comprehending educators' digital competency to support their career development and, in turn, the quality of education will be needed (Sillat et al., 2021). Assessment of digital competence can provide insights into analyzing students' areas of mastery, inform educators and schools about the important parts of digital competence, and plan for future instructional methods (Calvani et al., 2012). For example, Edvard Hatlevik et al. (2015) indicated that academic achievements, mastery orientation, student's family background, cultural capital, and language integration predict students' digital competence.

In a systematic literature review carried out recently on digital competence in higher education, Zhao et al. (2021) concluded that most university students and teachers had a basic level of digital competence, and emphasized the improvements required, particularly in more complicated areas, including digital content creation, security, and information literacy. They also identified some factors that influenced digital competence skills in higher education among students and teachers, such as previous digital experience, gender, participation in research and innovation projects, technology usage, age, and attitude. Therefore, it was recommended to improve educational quality, higher education organizations were encouraged to give priority to the development of both students' and teachers' digital competence, develop relevant learning strategies, and use appropriate tools.

### 2.2.1 Frameworks related to digital competence

To analyze the concept of digital competence, researchers in different countries and organizations developed various frameworks and standards to meet the increasing need for digital abilities and knowledge in daily life, learning environments, and professional development. DigComp and DigCompEdu from the European Commission, ISTE standards for students, teachers, and education leaders from the United States, and the UNESCO ICT Competency Framework for Teachers are some of the internationally adopted frameworks. These frameworks differ from each other in the target group, description of sub-skills, and approaches for enhancing digital competence.

Ikramovich (2023) stated that digital competency benchmarks have been developed in the United States by several institutions and organizations and some important examples are the partnership for twenty-first century education, which places a strong emphasis on digital literacy and twenty-first century skills, and then, the International Society for Technology in Education (ISTE), which is a US-based organization that provides technology-related standards for students, teachers, and educator leaders (ISTE, 2024). ISTE created a set of standards that describe the types of tasks the students would be expected to do and roles they would need to assume in a technology-dominated world from students' perspectives, since today's students need to be ready to succeed in a rapidly changing technological environment, the ISTE Standards' aims to give students a voice and make sure that learning is a student-driven process (ISTE, 2024). The ISTE Standards for students include seven standards which are empowered learner, digital citizen, knowledge constructor, creative communicator, innovative designer, computational thinker, and global collaborator (ISTE, 2024).

Digital competence is a universal field of study. Therefore, many different countries have developed their frameworks in this field. For example, The Digital Competence Framework was also developed by Curriculum for Wales in 2019, and published by the Welsh Government, United Kingdom in 2022, and the framework's main goal was to enable digital citizens to use electronic communication and creativity to positively impact the digital world (*Digital Competence Framework*, 2019).

Another framework is the Quebec Digital Competency Framework, published by the Ministry of Education and Higher Education, Quebec, Canada in 2019. The framework aims to improve digital competency, described as a set of abilities needed to use digital technologies confidently, critically, and imaginatively for achieving goals related to leisure, work, education, and participation in society (Ministère de l'Éducation du Québec, 2022).

One of the other frameworks is the European DigCompEdu framework which were centered on the educators' digital competence skills for using digital technologies and the digital competencies they will need for their professions. DigCompEdu framework focuses on six professional areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence (Redecker et al., 2017).

In addition, the supplement to the DigCompEDU Framework has emerged to develop the European DigCompEdu framework. The supplement to the DigCompEDU has been designed to integrate AI into education, especially adult training and vocational educational training and education around the professional areas in the DigCompEdu framework (Bekiaridis & Attwell, 2024). The AI supplement to DigCompEdu framework integrates AI-specific competencies,

emphasizing the growing significance and importance of AI in education, and also the supplement of the framework focuses on integrating AI literacy and competencies into the current framework to guarantee that educators not only digitally literate but also competent at comprehending and using AI technologies into the current framework (Bekiaridis & Attwell, 2024). Integrating AI competencies into the DigCompEdu framework ensures that educators are prepared to manage challenges and opportunities presented by AI in education, preparing them and their students for a future in which AI will play an important role (Bekiaridis & Attwell, 2024).

Although there are different frameworks and standards for digital competence, the European Commission's DigComp Framework will be adopted in this study, because, as Redecker (2017) emphasized, the framework provides detailed guidance for enhancing citizens' and educators' digital competence and utilizing these frameworks can offer scientific basis for the development of digital competence models and guiding policies related to education. Moreover, Santos et al., (2021) underlined the frameworks that have been employed for the data analysis and training proposal development, emphasizing the need for students to develop digital skills.

### 2.2.2 The DigComp framework

DigComp was originally released in 2013 as a framework to assist individuals in Europe in developing their digital competence, and DigComp outlines the competencies required to use digital technologies in a critical, creative, collaborative, confident manner to accomplish goals to reach goals education employment, leisure, inclusion, and engagement in our digital society (Kluzer & Priego, 2018). In other

words, the DigComp framework defines the elements and scope of digital competence for citizens (Kluzer & Priego, 2018). The DigComp, the European Digital Competence for Citizens, provides citizens become more digitally competent as well as DigComp offers a common language for defining and identifying crucial elements of digital competence, and the main objective of DigComp was to develop a tool to improve citizens' digital competence, support policymakers in developing policies, and organize training and education programs to raise digital competence (Różewski et al., 2021). Digital competencies are regarded as essential competencies in the framework for lifelong learning in the European context (Ala-Mutka et al., 2008).

The first DigComp framework was released in 2013 by defining digital competence as a set of 21 competences structured into five basic areas which are called Information and data literacy, Communication and collaboration, Digital content creation, Safety, and Problem-solving since 2016 as shown in Fig 2 (Vuorikari et al., 2022). In other words, The DigComp framework identifies five components of digital competence needed by the citizens of today's highly digitized society: information, communication, digital content creation, security, and problem-solving (Ferrari & Punie, 2013, Vuorikari et al., 2022).




Figure 2. DigComp areas (Vuorikari et al., 2022, p. 4)

The first area is Information and data literacy, which provides browsing, investigating, and managing information and digital content, by evaluating the data found. The second area is Communication and collaboration, which provides interacting, sharing, collaborating through digital technologies, and also managing one's digital identity. The third area is Digital content creation which maintains creating digital content by considering the copyright and licenses or developing clear instructions for computing systems. The fourth area is Safety, which provides the protection of devices, personal data, privacy, well-being, and the environment. The final area is Problem solving, which provides the solving technical problems in the digital environment by identifying the needs and selecting the digital tools.

At the same time, the DigComp framework provides four broad levels of proficiency (foundation, intermediate, advanced, and highly specialized) (Kluzer & Priego, 2018). Since 2013 the DigComp framework has been used for many purposes, especially lifelong learning, education and training, employment, and policy aims (Vuorikari et al., 2022). DigComp offers a comprehensive approach to digital competence that is adaptable to many aspects of life (Liu, 2023). In addition, the framework helps understand where to focus efforts and then measure their

success by assessing digital competence levels, strengths, and weaknesses of individual or target populations (Kluzer & Priego, 2018).

In a recent study based on the Digital Competence framework, Barboutidis & Stiakakis (2023) examined the factors including age, use of technology, educational level, and specialization that affect the digital competence level of students in Vocational Training Institutes in Greece adopting the DigComp Framework. The data was collected by a questionnaire including personal information and laboratory tests. The results showed that the factors of age, specialization, possessions, and use of smartphones, affected Communication and collaboration. Educational level affected Digital content creation. Information and data literacy was affected by internet use and possession and the use of computers, which also affected problem-solving. According to the results, educational institutions should modify their curricula to ensure that their graduates have sufficient digital competence by considering updating, upskilling, and reskilling programs to improve five DigComp areas.

In a study with 587 participants from 63 universities in Turkey, Çebi & Reisoğlu (2020) investigated in an online digital competence course, the opinions of pre-service teachers about their digital competence, to determine whether their opinions differ by age, perceived digital competence level, and area of study, The digital competence questionnaire developed based on the DigComp Framework was used for data collection. The results showed that the digital competence levels of students were moderate and their digital competence changed significantly by age, area of study, and perceived level of digital competence. The pre-service teachers felt more confident in the areas of communication, collaboration, information and data literacy, and safety than in problem-solving and digital content creation.

Moreover, Guarini & Peconio (2023) carried out a study to enhance pre-service teachers' digital skills especially special needs teachers for enhancing their use and knowledge of digital skills when they planned courses, lessons, and interventions at the University of Foggia. The data was collected from 338 pre-service teachers. The university holds Tirocinio Formativo Attivo which is a one-year university course to qualify to give courses to special needs students. The Information and Communication Technologies (ICT) courses which consist of 150-hour courses were structured under the program aiming to provide digital tools, digital knowledge, and digital competencies for teachers. Gamification, serious games, digital game-based learning, instructional design, and hybrid and blended learning were examples of the topics of the courses. The data were collected both at the beginning of the course and the end of the course, in this way, the initial and final scores of digital competence were compared. The DigComp 2.2: The Digital Competence Framework for Citizens (DigComp) was used as a survey. The participants solve the Italian version of DigComp on the mydigiskills platform, and they reach their scores via email. After the participants get their results, they upload their anonymous scores document on the Google Form. The researchers focused on competence 3 which is named Digital Content Creation because of the most related areas of teachers' digital skills. The results showed that participants had a moderate level of digital skills in digital content creation, skills of developing digital content were higher than in programming. The researchers emphasized the results of the study will provide better insights into the roles of ICT courses in enhancing the integration of digital tools into the teaching environments of pre-service special needs teachers.

### 2.2.3 Digital Competence Scales

Tzafilkou et al. (2022) developed a students' digital competence scale (SDiCos) for higher education, including 28 items with a five-point Likert for six digital competence areas: 1) Search, find, access, 2) Develop, apply, modify, 3) Communicate, collaborate, share, 4) Store, manage, delete, 5) Evaluate, 6) Protect. The studies for the scale demonstrated that the scale had internal validity, reliability, and factor loadings. However, one of the main limitations of the scale was the sample size for when the study was carried out for factor analysis.

Another digital competence scale was developed by Alarcón et al. (2020), namely, an instrument for assessing educators' digital competence based on DigCompEdu framework aimed to assess the educators' digital competence, including 29 items with a six-point Likert for eight areas. The areas were: 1) Professional engagement, 2) Digital resources, 3) Teaching and learning, 4) Assessment, 5) Empowering learners, 6) Facilitating learner's digital competence, 7) Digital environment, and 8) Extrinsic digital engagement. The studies regarding the reliability of the scale showed that the scale was valid and reliable. The limitation of the scale was language limitation that the scale was validated in the Spanish.

Schwarz et al. (2024) developed the Digital Competence Scale, a self-assessment instrument based on the DigComp framework, including 12 items. The scale showed internal consistency and high discriminatory power. On the other hand, one limitation indicated for the study was incremental validity and discriminant validity.

### 2.2.4 The Self-Assessment Tool for Digital Competence (DigCompSAT)

The Self-Assessment Tool for Digital Competence (DigCompSAT) is a self-reflection tool for DigComp aims to evaluate participants' proficiency in each five areas by emphasizing strengths and weaknesses in the particular competence and to improve respondents' comprehension and awareness of how to describe digital competence through the DigComp framework (Clifford et al., 2020). The DigComp framework offers a common language for identifying and explaining the key components of digital competence (Guarini & Peconio, 2023). The framework provides a basis for an online self-assessment tool that enables individuals to evaluate their digital competence and identify any knowledge, skills, or attitude gaps across five essential domains for career development and employability in the digital age (Nguyen et al., 2024). The tool was developed from a methodological approach that enables the evaluation of digital competence by the 3 elements of knowledge, skill, attitude, and 5 DigComp areas which offers participants a path for self-reflection about their digital competence and is available in English, Spanish, and Latvian (Clifford et al., 2020).

The first and second pilot studies were carried out for the creation of the final item bank. After the last revisions in the second pilot study, the final item questionnaire has been developed. As shown in Fig 3. shows the steps and tasks that were agreed with The Joint Research Centre (JRC) to provide the final item bank and methodology (Clifford et al., 2020).

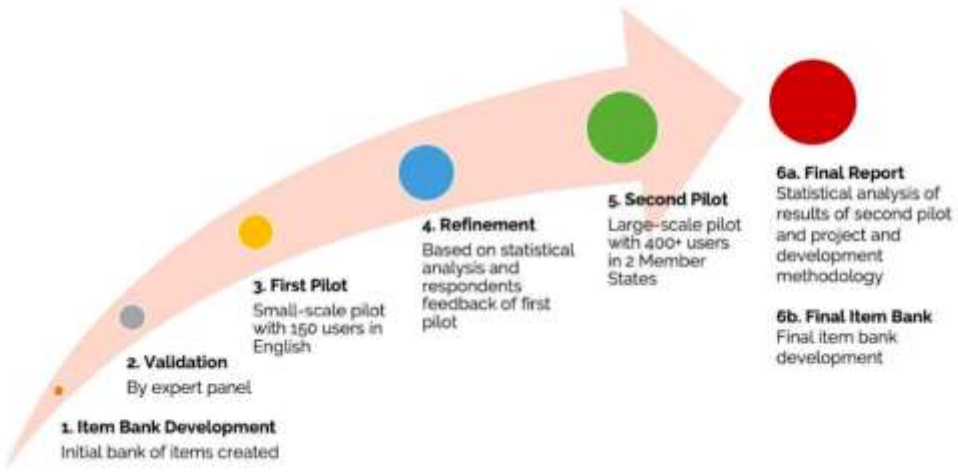


Figure 3. The DigCompSat project overview (Clifford et al., 2020, p.11)

The study developed by Budai et al. (2023) investigated the initial and final digital competence level of undergraduate students in public administration after one semester of training. Training took 14 weeks and included both 30 hours of theoretical and 30 hours of practical sessions for enhancing digital skills in public administration settings. The researchers took reference to the EU's Citizen Digital Competence Framework. The DigCompSat self-assessment questionnaire was used for collecting data. 58 students completed both the initial and final survey. According to the results, it was observed that the digital competence level was enhanced after the training, and the areas with the most improvement are digital content creation, safety, and problem-solving. Female students showed higher development although male students' digital competence levels were higher than female students before the training. The 35-39 age group students demonstrated the highest positive development.

Also, Liu (2023) investigated the level of digital competence of university students in China and examined the relationship between digital competence and

students' factors including age, gender, living place, involvement in competitions, and how much digital tools are used. 151 university students participated in the study. DigCompSat was used as a survey for collecting data. The results showed that the digital competence of the Chinese students was intermediate level, and also the area of Safety was at the basic level. There weren't significant differences between digital competence and gender, age, and living place, but there were significant differences between digital competence and students who used more digital tools.

Nguyen et al. (2024) carried out a study to examine the digital competence level of Vietnamese citizens and analyze personal factors on digital competence. The number of participants was 723. The design of the study was sequential exploratory mixed methods. Firstly, the researchers collected via a self-assessment tool, including 82 items developed based on DigCompSat. Then, interviews were done with ten random citizens online, and finally focus group discussions were carried out with eight stakeholders. According to the results, overall the citizens' digital competence level was basic and intermediate. The highest digital competence area was Information and data literacy, and the lowest digital competence area was Digital content creation. Individual factors including age, gender, education level, job sector, and location have significant effects on digital competence.

## 2.3 Research questions

The following research questions were addressed:

What is the nature of the relationship between digital competence and AI literacy levels among university students?

1. Is there a meaningful relationship between digital competence and AI literacy levels?

2. How do participants' AI usage vary based on their digital competence and AI literacy scores?
    2.1. What are the higher education students' levels of digital competence and AI literacy?
    2.2. How do higher education students' AI usage relate to their digital competences?

# CHAPTER 3

# METHOD

In this chapter, the research design, participants, details of the data collection instruments, procedures and data collection, data coding and analysis, and then trustworthiness are explained.

## 3.1 Research design

This study is a mixed methods study, which makes use of both quantitative and qualitative data collection and analysis methodologies. The explanatory sequential research design is adopted, which involves two-phase data collection where the researchers first collect quantitative data and then qualitative data to answer the research questions (Creswell, 2014). The explanatory sequential research design is that the quantitative data and their following analysis offer a general understanding of research problems, and it includes the benefits of the facility and opportunities of the investigation of the quantitative findings in depth (Ivankova et al., 2006).

The quantitative component consisted of the collection of the data through The Scale for the Assessment of Non-experts' AI Literacy (SNAIL) (Laupichler et al.,2023), Self-Assessment Tool for Digital Competence (Clifford et al.,2020), and The Demographic Questionnaire.

The qualitative component consisted of the collection of the data through a semi-structured interview protocol developed based on Laupichler et al. (2023) definition of AI literacy, as well as the UNESCO AI competency framework for students.

The explanatory sequential research design was adopted (Figure 4) to describe the digital competence and AI literacy levels and the relationships through surveys first, and then investigate them in more detail through interviews. The design is chosen to gain more understanding of the research phenomena. Firstly, quantitative data was collected through the surveys aimed to measure participants' digital competence and AI literacy levels and analyzed. Then, qualitative data collection and analysis were carried out through semi-structured interview questions. After completing analysis of qualitative data, the findings were interpreted to gain more comprehension of research phenomena.

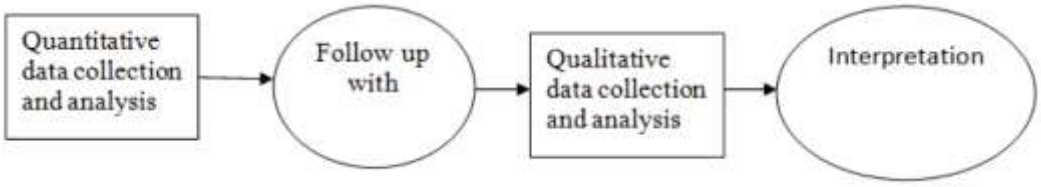


Figure 4. Explanatory sequential research design (Subedi, 2016, p.573)

## 3.2 Participants

The participants of the study are students at at one of the top universities in Turkey. Convenience sampling was used to select participants. The students from all departments at the university were invited to participate via email. Those who volunteered to respond to the call constituted the participants of the study. Quantitative data was collected from 340 participants, however, two of the participants did not complete either of the scales, and were excluded from the dataset. After the exclusion of the data with two missing data, a final sample consisted of 338 participants, 309 undergraduate and 29 graduate students.

The age of the participants ranged from 18 to 44 years old. The following table shows the age range of participants (Table 1). The distribution of the data according to age demonstrates that the majority of the participants belong to the 18-24 age group, which contains 83.4% (n = 282) of the total sample, 13.3% (n = 45) of the participants were between the ages of 25-34, and 3.3% (n = 11) of the participants belong to 33-44 age group.

Table 1. Age Range of Participants

| | Frequency | Percentage |
|---|---|---|
| Age | | |
| 18-24 | 282 | 83.4 |
| 25-34 | 45 | 13.3 |
| 35-44 | 11 | 3.3 |

The distribution of the data across gender showed that 60.7% (n = 205) of the total sample were female, while 37% (n = 125) were male, and 2.4% (n = 8) preferred not to say their gender.

The distribution of the data across year in college showed that the majority 36.7% (n = 124) of the participants were junior students, while the smallest group (2.4%) was in the preparatory year, (n = 8). Table 2 shows the participants' year in college. In addition, postgraduate students belonged to 8.6% (n = 29) of the total sample.

Table 2. Year in College

| | Frequency | Percentage |
|---|---|---|
| Year in College | | |
| Preparatory class | 8 | 2.4 |
| 1 | 21 | 6.2 |
| 2 | 76 | 22.5 |
| 3 | 124 | 36.7 |
| 4 | 80 | 23.7 |
| Postgraduates | 29 | 8.6 |

When the participants' departments were examined, the programs in which the participants were enrolled ranged from Science, and Engineering, to Social Sciences, and Humanities. Table 3 below shows the number of participants and their percentages according to their area of study. 48.8% of the participants were from the School of Education (English Language Education, Preschool Education, Science Education, Chemistry Education, Primary Mathematics Education, Guidance and Psychological Counseling, Secondary School Mathematics Education, Computer Education and Educational Technology, and Physics Education). 20.4% of the participants were in the Humanities (History, Philosophy, Linguistics, English Language and Literature, Translation and Interpreting Studies, and Turkish Language and Literature), 8.3% of the total sample were enrolled in an undergraduate program in the Social Sciences (Psychology, Sociology, Economics, Management, Political Science and International Relations, Management Information Systems, and International Trade). 7.1% were enrolled in a Science program (Mathematics, Physics, Chemistry, Molecular Biology and Genetics), and 6.8% were in Engineering (Computer Engineering, Civil Engineering, Chemical Engineering, Mechanical

Engineering, Industrial Engineering). Finally, 8.6% of the total participants were graduate students, in the graduate programs of Educational Technology, Secondary School Science and Mathematics Education, Guidance and Psychological Counseling, Psychology, History, Asian Studies, Chemistry, Chemical Engineering, Computer Engineering, Business Information Systems, Electrical and Electronic Engineering, and Environmental Technology.

Table 3. The Distribution of Participants' Faculties

| Participants | Science & Engineering | Social Sciences | Humanities | Education | Graduate |
|---|---|---|---|---|---|
| N | 47 | 28 | 69 | 165 | 29 |
| Percentage (%) | 13.9 | 8.3 | 20.4 | 48.8 | 8.6 |

The participants were invited to a semi-structured interview for the qualitative part of the study. An invitation for the interview was emailed to the 338 participants. As in the quantitative phase of the study, those who volunteered to respond to the invitation constituted the participants of the qualitative stage of the study. A total of 15 participants accepted the invitation for a semi-structured interview. Nine of the 15 interviewees were female. First-year and second year college students constituted 26.6% of the total interviewed. (13.3% (n= 2) each). Third-year students constituted 26.7% (n=4), and fourth-year students constituted 40.0 % (n=6) of the total number of interviewees. There was 1 postgraduate interviewee (6.7%, n=1). The interviewees were enrolled in the undergraduate programs in Mathematics, Psychology, Linguistics, Literature, English Language Education, Early Childhood Education, and Mechanical Engineering. There was also one graduate student from the program in Environmental Technology.

## 3.3 Data collection instruments

Two surveys and a demographic questionnaire were used to collect quantitative data. A semi-structured interview protocol was used for collecting qualitative data.

### Self-Assessment Tool for Digital Competence (DigCompSAT)

The scale used for collecting data about the participants' digital competence was the Self-Assessment Tool for Digital Competence (DigCompSAT) (Appendix A). The scale is a self-reflection tool for the Digital Competence Framework that enables citizens to evaluate all 21 DigComp competencies corresponding proficiency levels from 1 to 6 (levels are foundation, intermediate, advanced) with 82 questions that have strong psychometric qualities such as internal consistency and validity (Vuorikari et al., 2022).

The internal consistency of the scales items were measured in two studies, Pilot 1 and Pilot 2. In Pilot 1, The Cronbach's alpha for the scale was 0.980 measured for 100 items, and in Pilot 2 with the improvement of the value, the Cronbach's alpha for the Self-Assessment Tool for Digital Competence was 0.987 measured for 82 items (Clifford et al., 2020). The second pilot's items don't include any items with discrimination lower than 0.2, which should be removed, and also the questions have been more balanced, and none of the questions have a difficulty level higher than 80% (Clifford et al., 2020).

In this study, the DigCompSAT is adopted to identify students' digital competence levels. Given the studies carried out using this scale, it was shown that the scale is a reliable and valid tool. Especially, its reliability has been proven with its high Cronbach's alpha values. Also, the scale's usage areas are appropriate for the aim of the study, as the scale provides the opportunity to conduct a detailed investigation by measuring 21 competencies in 5 digital competence areas. One of

the other reasons for selecting the scale is its suitability for different ages, gender, digital skills, and educational areas. At the same time, the scale is available in English, and the participants whose language of instruction is English participated in the study. For this reason, the DigCompSAT scale was found appropriate for investigating university students' digital competence levels.

The Scale for the Assessment of Non-experts' AI Literacy (SNAIL)

The scale developed by Laupichler et al. (2023) called The Scale for the Assessment of Non-experts' AI Literacy (SNAIL) (Appendix B) comprised 31 items with 7-point Likert scale, based on three factors, Technical Understanding, Critical Appraisal, and Practical Applications. The researchers aimed to assess the AI literacy of non-experts in high school and further (Laupichler et al., 2023). A Delphi Study and factor analysis were used to confirm the validity of the scale (Laupichler et al., 2023). The scale's reliability studies were calculated for measuring the internal consistency of items for measuring three factors TUCAPA Model. The Cronbach's alpha for the Technical Understanding is 0.93 (Confidence Interval: 0.92-0.94), Critical Appraisal is 0.91 (Confidence Interval: 0.89-0.93), and Practical Applications is 0.85 (Confidence Interval: 0.81-0.88) (Laupichler et al., 2023).

The scale was appropriate for non-experts in AI and educational settings in high school and beyond. The scale was developed by the preliminary item set in a Delphi expert study with 53 experts in the field of AI education, and tested for reliability and validity (Laupichler et al., 2023). Similar to the DigComSAT scale, the language of the SNAIL is English. For these reasons, the SNAIL provided effective contributions to the researchers in the studies of AI literacy.

### The Demographic questionnaire

The demographic questionnaire was developed by the researcher and thesis advisor to get information about the student profile (Appendix C). It included questions to get information about the participants' department, age range, and AI tool use.

### The Interview protocol

A semi-structured interview protocol was developed by the researcher, thesis advisor, and committee members based on Laupichler et al. (2023)'s definition of AI literacy, and the UNESCO AI competency framework (Appendix D). The semi-structured interviews can be an efficient tool in interpretive research because of the detailed data about participants' experiences and perspectives described by the participants (Al Balushi, 2018). In addition, semi-structured interviews allow interviews to discuss anything they believe is important (Brinkmann, 2014).

There were ten interview questions aimed to uncover the aspects of UNESCO AI competency framework including human-centered mindset, ethics of AI, AI techniques and application, and AI system design, which overlap with Laupichler et al. (2023)'s definition of AI literacy.

The participants were asked how they use AI in their daily life and education. Then, their latest attempt to use AI tools was examined, and what their goals for the latest attempt were, and whether they achieved the solution they were aiming for, were investigated. Furthermore, what ethical problems they encounter when using AI in their daily lives, and what ethical issues they pay attention to when using AI for academic purposes were investigated. In addition, participants' opinions about the benefits and risks of using AI were examined. What kind of problems do participants find it appropriate or meaningful to employ AI to solve, and what kind of problems do they find it appropriate or meaningful to employ AI to solve, and if they had the

opportunity, what kind of a tool they would design using AI technology for academic purposes were investigated. Lastly, what participants know about how AI applications work, and technical concepts about AI, including neural networks, machine learning, and deep learning, were examined.

The table 4 provides a summary shows how interview questions releted to the UNESCO AI competency framework for students and Laupichler et al. (2023)'s definition of AI literacy.

## 3.4 Procedures

Before the data collection period, ethical approval was secured from the Institutional Review Board in Social Sciences and Humanities. The collection of data started at the end of December of the first semester of the 2024-2025 academic year and continued in March of the second semester. In the quantitative part of the study, the e-mail about the research was sent to professors and research assistants in all departments of the university via e-mail at the end of the first semester of the 2024-2025 academic year. The quantitative data collection process took 14 weeks. Since the student participation rate was low, and also students were on semester break, a reminder e-mail about research was sent to professors and research assistants in all departments at the beginning of the second semester.

Table 4. The Interview Questions' Relationship with the UNESCO AI Competency Framework for Students and TUCAPA-Model of AI Literacy

| Interview Questions | Competency Aspects of AI Competency Framework for Students | Factors of TUCAPA-Model of AI Literacy |
|---|---|---|
| Use of AI<br>• Daily Life<br>• Education<br>• Examples from most recent usage | AI techniques and applications | Practical Application |
| Problem Solving with AI | AI system design | Practical Application |
| Future Design for Academic Purposes | | Technical Understanding |
| Ethical Concerns<br>• Daily Life<br>• Education | Ethics of AI | Critical Appraisal |
| Technical Understanding<br>• How does AI work<br>• Awareness of AI related concepts | AI techniques and applications | Technical Understanding |
| Benefits and Risks of AI | Human-centered mindset | Critical Appraisal |

The researcher requested to visit laboratory classes, to collect data during one of their lab sessions at a convenient time for the instructors. The professors who found it suitable accepted the researcher into their classes, the researcher went to the classes face to face on the date and time invited by the professors, explained her research aim and contributions to the literature, and shared surveys with the students. The research purpose and procedures were explained to students who volunteered to participate. If the professors who did not find it suitable accepted the researcher into their classes due to the intensity of the curriculum, the researcher requested to share the questionnaires with their students if it was found suitable.

During the data collection period, it was ensured that the participants' informed consent was secured. The participants were asked to sign the consent form who accepted participation in the study voluntarily after the reading of the consent form (Appendix E, Appendix F).

After the students completed the surveys, four groups of participants were identified based on Digital Competence and AI Literacy levels: those who scored high in both, those who scored low in both, those who scored high in Digital Competence, but low in AI Literacy, and vice versa. The reason for grouping participants into four groups was to examine how to differentiate the higher scorers in digital competence and higher scorers in AI literacy from the lower scorers in their usage of AI tools. In other words, the aim was to investigate how AI tools are used for academic and other purposes by higher and lower scorers.

The participants who responded to the questionnaire were divided into groups based on their scores. When examining Digital Competence, the score intervals were calculated as follows: Low (0-29%), Foundation (30-47%), Intermediate (48-80%), and Advanced (81-100%) (Clifford et al., 2020, p.130). Based on these score intervals, the first two intervals were grouped as low, and the last two intervals were grouped as high. When examining AI literacy, because direct level ranges were not indicated by the researchers, the participants were grouped similarly to the score intervals of Digital Competence. Group 1 includes participants who scored higher in Digital Competence and AI Literacy, Group 2 higher scores in Digital Competence and lower scores in AI Literacy, Group 3 lower scores in Digital Competence and higher scores in AI Literacy, and Group 4 lower scores in Digital Competence and AI Literacy.

After the grouping, 253 participants were in Group 1, 48 participants in Group 2, 13 participants in Group 3, and 24 participants in Group 4. Table 5 shows the number of participants in each group.

Table 5. Number of Participants in Case Groups based on Digital Competence and AI Literacy Scores

| | Number of Participants |
|---|---|
| Case Groups | |
| Group 1 (High DigComp & AI Lit) | 253 |
| Group 2 (High DigComp & Low AI Lit) | 48 |
| Group 3 (Low DigComp & High AI Lit) | 13 |
| Group 4 (Low DigComp & AI Lit) | 24 |

After collecting quantitative data at the end of the first semester, an invitation for the interview was emailed to the all 338 participants. In the quantitative phase of the study, students who volunteered to respond to the invitation participated interviews. Each participant who agreed to participate in the study was interviewed. Follow-up reminders were emailed to reach as many participants as possible. A total of 15 participants accepted the invitation for a semi-structured interview. Table 6 shows the number of participants who participated in the qualitative phase of the study from each group.

Table 6. Number of Interview Participants in Case Groups based on Digital Competence and AI Literacy Scores

| | Number of Participants |
|---|---|
| Case Groups | |
| Group 1 (High DigComp & AI Lit) | 4 |
| Group 2 (High DigComp & Low AI Lit) | 5 |
| Group 3 (Low DigComp & High AI Lit) | 2 |
| Group 4 (Low DigComp & AI Lit) | 4 |

Before the interviews were carried out, the semi-structured interview protocol was piloted, and the interview questions were examined and updated based on the pilot study. In the qualitative part of the study, an email was sent to students for a meeting invitation at the end of the first semester and the second semester of the 2024-2025 academic year. The interviews were conducted online via video-conferencing depending on the availability of the students who volunteered to participate. Follow-up reminders were emailed in a week to reach as many participants as possible. The interviews lasted approximately 20 minutes. The research purpose and procedures were explained to students who volunteered to participate. It was ensured that the participants' informed consent was secured. The participants were asked to sign the consent form and accepted participation in the study voluntarily after the reading of the consent form.

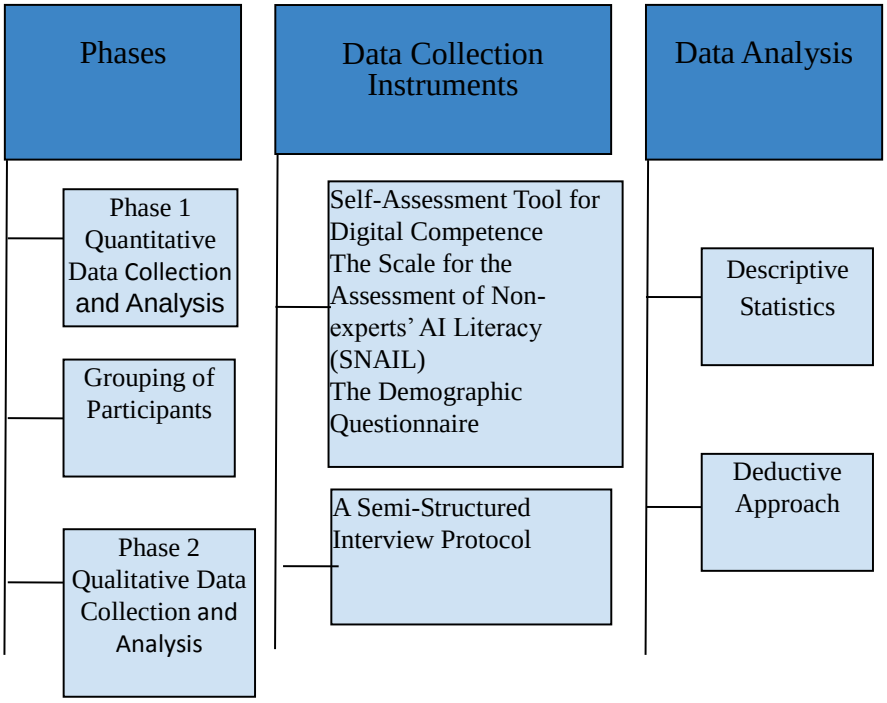


Figure 5. Procedure of the current study

The participants' names were replaced during data coding and analysis for data anonymity. For the interview data, pseudonyms were used instead of the interviewees' names.

## 3.5 Data coding and analysis

The quantitative data were coded in SPSS 29. Instead of indicating the participant's name, ID numbers were given to each participant. DigCompSAT consisted of 82 items, and each item was scored on the 0 to 3, with a maximum possible score of 246. In addition, SNAIL consisted of 31 items, ranging from 1 to 7 with a maximum possible score of 217.

Descriptive statistics, such as the mean, median, and standard deviation, were calculated for the data collected via the DigCompSAT and SNAIL questionnaires, and the frequencies of data such as age, gender, departments, AI tools used by the participants were calculated to understand the participants' characteristics.

Visualizations of box plots were prepared for understanding the distribution of data, and assumptions of the statistics tests were checked before further analysis. Because the sample size was larger than 30, it assumed that the data showed the normal distribution based on the central limit theorem. According to the central limit theorem, it could be assumed that the normal distribution assumption was maintained because the sample size was significantly higher than n = 30 (Chang et al., 2006). The Kolmogorov-Smirnov test was applied to check the normality of the data because the sample size was higher than fifty. The tests of the two variables yielded a significance value of .200, higher than the threshold of .05. Therefore, the distribution of data in both scales was considered normal. In addition, the histograms and the Q-Q Plot of both scales were examined. The demonstrations of both histograms and the Q-Q Plots supported the Kolmogorov-Smirnov test results.

Correlation analysis was carried out to test the relationship between the variables of digital competence and AI literacy. There are two types of correlation analysis, including the Pearson correlation coefficient, and Spearman rank correlation. Because the both variables are continuous and normally distributed, the Pearson correlation coefficient was calculated.

Pearson correlation coefficient takes a value between -1 and + 1. In addition to the correlation coefficient, a p-value is also calculated. The significance of the correlation coefficient was tested with the p-value, which is accepted to be $p \leq 0.05$ for the statistically meaningful relationship between two variables.

The data collected through the semi-structured interviews was examined by deductive approach. Deductive approach was employed to deeply understand what differences exist in the use of and approach to AI for academic purposes by different groups of students. This helps the researcher to understand how participants use AI

tools and the impact of this use on their academic goals, and uncover key themes in varied competence levels. A deductive approach was adopted for the analysis of the qualitative data. Based on the The DigComp Framework and UNESCO AI Competency Framework for Students that guided study, a set of a framework-derived set of themes and codes were established. At the beginning of the study, the interview questions were structured based on theoretical frameworks. After the interviews were completed, codes were developed based on the data, and themes were established from structured a framework.

After the interviews were completed, qualitative analyses were carried out. These phases were familiarization with the data, generating the initial codes, searching themes, reviewing the themes, defining and naming these themes, and finally preparing the report (Braun & Clarke, 2006).

The first phase was familiarization with the data. The audio-recorded data was transcribed. Transcribing audio-recorded data provided familiarity with the data. Then, the transcribed data was read and re-read to gain familiarity. When reading data, notes were taken for initial ideas.The second phase was generating initial codes. Codes were created by dividing the data into meaningful pieces. In this stage, Maguire & Delahunt (2017) recommended that the data be organized meaningfully and systematically to reduce the data into meaningful chunks through coding. All data was studied systematically, and initial codes were produced from the entire data set. Searching themes was the third phase. In this phase, the codes from the entire data set were listed, and they were sorted into the possible themes. Different codes were categorized into potential themes, and the relevant codes were brought together. The fourth phase was reviewing the themes. In this phase, themes were examined to determine whether they were related to codes and the entire data set. In addition,

potential themes were examined one by one. The themes were reviewed by an experienced researcher to check whether they were relevant and whether the data were relevant to these themes. For example, potential themes that were related to each other were combined as one theme. Defining and naming these themes was the fifth phase. In this step, each theme was named according to the main idea of the theme. The last phase was producing the report. After all previous phases, the writing of the report has begun. The report was prepared within a flow depending on the research questions. In addition, the report was supported by the participants' quotations from the data.

The majority of the themes were from the DigComp framework, while themes emerged from the UNESCO AI Competency Framework Students as well. After the coding of interview data, themes were generated and defined appropriately. Firstly, the codes from the DigComp framework were categorized and themes were defined. There are five themes from the DigComp framework which are Information and data literacy, Communication and collaboration, Digital content creation, Safety, and Problem solving. Secondly, the themes that emerged from the UNESCO AI Competency Framework Students and TUCAPA-Model of AI Literacy were formed and defined. There are three themes which are How AI Works (Technical Understanding), Future Design, Benefits and Risks of AI.

Table 7 shows the themes structured by DigComp dimensions and the codes with their frequency in parentheses. In addition, what digital competence covers for the five dimensions is included under the relevant dimension.

The first theme is information and data literacy. This component refers to browsing, investigating, and evaluating the relevance of the information and digital content. It also covers managing information and digital content by evaluating the

data found. The following codes emerged from the data: Accessing information, help with assignments, finding a synthesis of specific, summarized information in a limited time, accessing multiple and reliable sources.

Communication and collaboration is the second theme adopted from the DigComp framework. This component refers to interacting, collaborating, sharing through digital technologies, and also managing one's digital identity. The theme includes codes related to sharing and collaborating through AI tools, such as translation and brainstorming were coded to indicate the tasks through interaction with AI, and simulate a psychology experiment. The last code was included as a type of task for the interviewee's interactions with AI technologies.

The third theme based on the framework is digital content creation. This component focuses on creating digital content or re-elaborating digital content. There were 10 codes that emerged under this theme, regarding tasks of creating digital content through the use of AI technologies. These included preparing a summary, image/visual generation, such as image, background, or album cover, personal planner (for travel or daily schedule), text production, preparing bibliography, having assignments done, and lastly, study tool– question generation. In addition, the theme is divided into a subcategory, which is digital content editing. The sub-area includes the codes for editing the digital content in digital environments to improve the content and make it better organized. The codes about editing written and visual content included text editing, grammar checking, and photo editing.

Table 7. Themes and Related Codes Based on the DigComp Framework

| Dimensions of the DigComp framework | Codes |
|---|---|
| Information and data literacy<br>To browse, locate, investigate information<br>To evaluate the relevance of information<br>To manage and organize information and digital content | Accessing Information (15), Help with assignments (9), Finding synthesis of specific summarized information in a limited time (8)<br>Access to multiple and reliable sources (2) |
| Communication and collaboration<br>To interact, collaborate, share through digital technologies<br><br>To manage digital identity | Translation (4), Brainstorming (3), Simulate psychology experiment (1) |
| Digital content creation<br>To create digital content<br>To integrate and re-elaborate digital content<br><br>Digital content editing<br>To edit digital content | Preparing a summary (7), Image/visual generation (6), Personal planner (for travel or daily schedule) (6), Text production (2), Preparing bibliography (2), Have assignments done (2), Study tool– Question generation (2)<br><br>Text Editing (5), Grammar Checking (2), Photo Editing (1) |
| Safety<br>To protect personal data<br>To protect environment<br>To protect privacy<br><br>Ethical concerns | Privacy & Security of personal data (4), Copyright of AI generated material (image/sound/text) (4), High energy consumption by AI tools(1)<br><br>Plagiarism (14), Producing misinformation (7), Lack of real learning (1), Laziness/Lethargy (1) |
| Problem solving<br>To solve problems in digital environments<br>To use digital tools for responses for problems<br>To identify needs and evaluate the tools for problem solving. | Making calculations<br>● Complex multivariate problems (2)<br>● Math problems (2)<br>● Physics problems (1)<br>● Grade point average (1)<br><br>Programming problems (4),<br>Work/school/personal problems (1),<br>Troubleshooting when using mobile app (1),<br>Determining strategy in computer games (1) |

The fourth theme based on the framework is safety. This component refers to protecting devices, personal data, privacy, well-being, and the environment. The following codes emerged from the data: Privacy & Security of personal data, copyright of AI generated material (image/sound/text), and high energy consumption by AI tools. In addition, the theme is divided into a subcategory, which is ethical concerns. The sub-area includes the codes for ethical considerations. These included plagiarism, producing misinformation, lack of real learning, and laziness/lethargy.

The final theme based on the framework is problem solving. This component refers to solving technical problems in the digital environment by specifying the needs and selecting the digital tools. There were 5 codes that emerged under this theme, regarding solving problems in the digital environment through the use of AI technologies. These included making calculations, including complex multivariate problems, math problems, physics problems, and grade point average, programming problems such as writing routine codes, preparing codes for Python, and debugging, work/school/personal problems, troubleshooting when using a mobile app, and determining strategy in computer games, statistical analysis, and guidance.

In addition to the themes and codes driven from the DigComp framework, the codes used when analyzing the interview data were categorized under the following three themes which were HowAI Works (Technical Understanding), Future Design, Benefits, and Risks of AI from the UNESCO AI Competency Framework Students and TUCAPA-Model of AI Literacy. The following Table 8 demonstrates the themes emerged from the UNESCO AI Competency Framework Students and TUCAPA-Model of AI Literacy and the codes with their frequency in parentheses.

Table 8. Themes and Related Codes that Emerged from UNESCO AI Competency Framework Students and TUCAPA-Model of AI Literacy

| Themes emerged from the data | Codes |
|---|---|
| How AI Works (Technical Understanding) | Browses all databases to gather info (6), Uses data to learn (5) |
| AI Related Concepts<br>● Machine learning<br>● Neural networks<br>● Deep learning | Uses data to learn (3), Conducts categorization/ pattern recognition (1), Permanent learning (1) |
| Future Design | Reliable tool for literature review and analysis (8), Reliable complex calculations in Math (2), Question generator to study for exams (1), Text Editor & Grammar Checker Tool (1), AI checker (1), A tool for statistical analysis and guidance (1), Support for assignments (1) |
| Benefits and Risks of AI | Benefits: Save time in time-consuming tasks (10), Accessing Information (4), Access to multiple and reliable sources (3), Simulating situations to support human thinking (1), Accessibility (1), Preparing a summary (1), Image/visual generation (1), Making calculations (1) |
| | Risk of : Laziness/Lethargy (6), Producing misinformation (5), Privacy & Security of personal data (5), Increasing Dependency on AI (2), Potential loss of jobs (2), Decrease in Social Interaction/Isolation (1), Waste of Earth's resources (1) |

The first theme is How AI works (Technical Understanding) based on the AI techniques and applications competency aspect of UNESCO AI Competency Framework for Students. The competence of AI techniques and applications in UNESCO framework refers to the basic understanding, knowledge, skills of AI, and understanding of AI algorithms, and programming (Miao et al., 2024). In addition, Technical Understanding is the first factor in SNAIL scale, and refers to comprehending machine learning such as describing general and narrow AI or explaining machine learning models (Laupichler et al., 2023). The emerging codes

were found to be aligned with the competency aspect of AI techniques and applications in UNESCO AI Competency Framework for Students in the areas of understanding and knowledge of AI, and understanding of AI algorithms. The codes were adapted and improved based on the descriptions of the indicated competence. In addition, the theme has a subcategory, which is AI Related Concepts. The sub-area includes the codes for technical concepts related to AI, including machine learning, neural networks, and deep learning. The codes about these AI related concepts included using data to learn, conducting categorization/ pattern recognition, and permanent learning.

Future design is the second theme based on the AI system design competency aspect of UNESCO AI Competency Framework for Students. The competence of AI system design refers to the engineering and design thinking skills for designing, problem-solving, architecture design, optimizing, testing, and training of AI systems (Miao et al., 2024). The theme of future design was found to be aligned with the descriptions of the competence which as skills for engineering and design thinking of AI systems. In addition, the emerging codes were adapted based on the competency aspect of AI system design competency in the area of designing, making architecture design of AI systems. The following were used to code the data in this category: Reliable tool for literature review and analysis, reliable complex calculations in math, question generator to study for exams, text editor and grammar checker tool, AI checker, statistical analysis and guidance, and lastly support for assignments.

The final theme is Benefits and risks of AI, based on the Human-centered mindset competency aspect of UNESCO AI Competency Framework for Students. Human-centered mindset refers to the students' beliefs, values, and abilities of critical thinking about AI (Miao et al., 2024). The theme of benefits and risks of AI

was found to be aligned with the descriptions of the competence which as students' beliefs, values, and abilities about AI.

The theme includes both the positive and negative effects of AI. In the area of benefits, the codes were: Save time in time-consuming tasks, accessing information, access to multiple and reliable sources, simulating situations to support human thinking, accessibility, preparing a summary, image/visual generation, and making calculations. On the other hand, the area of risks included: Laziness/lethargy, producing misinformation, privacy & security of personal data, increasing dependency on AI, potential loss of jobs, decrease in social interaction/isolation, waste of Earth's resources.

### 3.6 Trustworthiness

Several strategies were adopted to support the study's trustworthiness. One of the strategies adopted was triangulation. Triangulation was ensured by collecting quantitative and qualitative data, forming themes based on the DigComp framework, and the competency aspects of the UNESCO AI Competency Framework for Students. For the trustworthiness of the qualitative part of the study, transparency was ensured by documenting all meetings, keeping detailed interview session notes, and analyzing the collected data during the study. It was also supported by direct quotations from the participants. Moreover, reflexivity was maintained during the research. Controlling personal biases helps maintain objective processes and prevent the possibility of distortions. In addition, consistency and adaptability were ensured by revisiting the coding regularly and collaborating on the coding processes with the thesis advisor. After the researcher had formed the initial version of the codes and themes, all the codes and emerging themes were revised by the thesis advisor, and then they were revised and renamed accordingly to maintain the reliability of the

coding. This collaborative work included multiple revisions and checks to refine codes and themes systematically.

## 3.7 Researcher's position

In a mixed method study, a researcher's role is important to carry out both the quantitative and qualitative part of the study in a comprehensive viewpoint. As a researcher, I received my bachelor's degree Science Education Undergraduate Program in Mathematics and Science Education from Boğaziçi University. Afterwards, I started a Master's Program in Educational Technology in Boğaziçi University.

In this study, I was actively take role for carrying out both quantitative data and qualitative parts. At the beginning of the study, my role was to explain the aim and importance of the study and answer possible questions from the participants throughout the study. My responsibility was to protect participants' privacy. Therefore, personal information was kept confidential during the study.

For the qualitative part of the study, interviews were conducted with volunteer students. During the interviews, I used clear communication with participants that they could make explanations freely, without being impacted by my researcher role, and I escaped from asking leading questions to prevent directing participants' thoughts, and explanations. For the data coding and analysis process, I collaborated with my thesis advisor for the coding process to enhance credibility of the study.

My researcher role during all phases of the study contributed to the enhancing credibility of the study. In addition, continuous review of the study regularly helped the study's trustworthiness and reliability.

# CHAPTER 4

# FINDINGS

In this chapter, the findings based on quantitative data, qualitative data, and integration of findings are reported for each research question.

## 4.1 The relationship between participants digital competence and AI literacy levels

The distributions of the responses to each of the 82 items in the DigCompSAT and the 31 items in the SNAIL questionnaires were examined. The mean (M) and standard deviation (SD) values were calculated. It was observed that the mean value in the DigCompSAT questionnaire ranged from 1.03 to 2.79 (APPENDIX G). As for the SNAIL, it was observed that the mean value ranged from 3.28 to 5.42 (APPENDIX H). Descriptive statistics for both scales were calculated, and accordingly, mean (M), standard deviation (SD), median, min, max, skewness, and kurtosis values were presented in Table 9. Descriptive statistics indicated that the mean scores for DigCompSAT was 164.11 (*SD* = 34.43), and the mean scores for the SNAIL was 139.60 (*SD* =39.16). The descriptive statistics showed DigCompSAT scores with the skewness of .78 (*SE* = .133) and kurtosis of -.159 (*SE* = .265), and SNAIL scores with skewness of -.211 (*SE* = .133) and kurtosis of -.291 (*SE* = .265).

Participants' mean score on the DigCompSAT was 164.11 (*SD* = 34.43), demonstrating a higher level of performance compared to the SNAIL, where the mean score was 139.60 (*SD* =39.16). The standard deviation values show that the variability of the scores was similar for both tests.

DigCompSAT scores showed a skewness of .78, indicating a positively skewed distribution. The kurtosis of -.159 shows a close distribution to normal in

peakedness. In addition, SNAIL scores with skewness of -.211, and kurtosis of -.291, indicating close to zero. The distribution of data shows approximately symmetry and peakedness.

Table 9. The Descriptive Statistics of Digital Competence and AI Literacy Scale

| | N | M | SD | Median | Min | Max | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| DigCompSAT Scale | 338 | 164.11 | 34.43 | 163.00 | 62 | 246 | .78 | -.159 |
| SNAIL Scale | 338 | 139.60 | 39.16 | 143.00 | 35 | 217 | -.211 | -.291 |

Box plots were prepared for visualization of the distribution of data to observe the outlier data. The following figure (Fig. 6) shows the visualizations of box plots.

The distribution of the scores were mostly symmetrical. It was observed that the majority of the data was located around the mean, which demonstrates that the data is close to the normal distribution, but there are a few outlier data. For both digital competence scores and AI literacy scores the outlier data was located at the lower whisker.

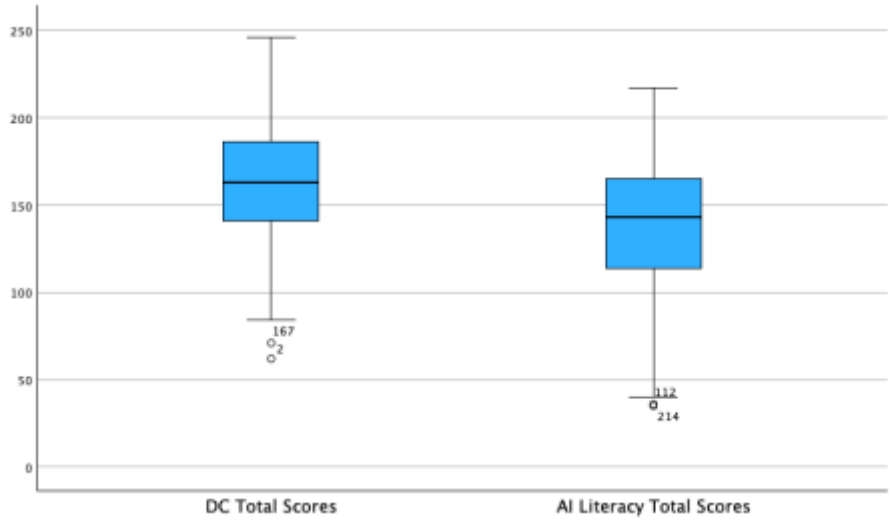


Figure 6. Box plot visualizations

To determine the normality of the distribution of the data, Kolmogorov-Smirnov and Shapiro Wilk tests were applied. Firstly, the normality of the DigCompSAT questionnaire data was checked. Four outlier data were removed from both scales. Therefore, the sample size dropped to 334. Kolmogorov-Smirnov statistic was used because the sample size is higher than 50. The Kolmogorov-Smirnov test result for the DigCompSAT questionnaire demonstrated that the data was normally distributed (See Table 10).

Table 10. Tests of Normality of DigCompSAT Scores

| | Kolmogorov-Smirnova | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| DigCompSAT Scores | .039 | 334 | .200* | .991 | 334 | .037 |

* This is a lower bound of the true significance.

The histograms of DigCompSAT scores are shown in Figure 7. In addition, the Q-Q Plot of DigCompSAT Scores is shown in Figure 8. The histograms and Q-Q

plot below supported the DigCompSAT Scores' normality. While the histograms demonstrated the symmetric distribution, the Q-Q plot showed that the data points were clustered around the diagonal line.

Similarly, the normality of AI Literacy questionnaire data was checked. Kolmogorov-Smirnov statistic was used because the sample size is higher than 50.

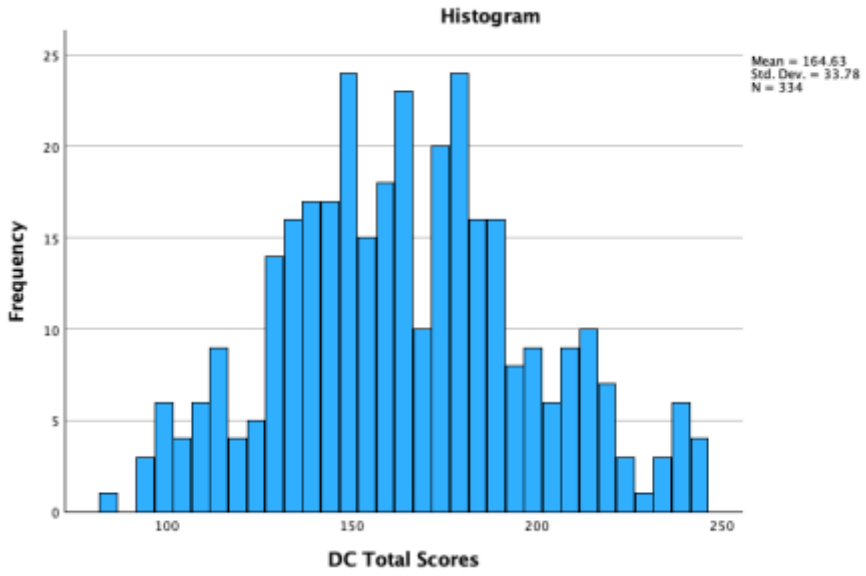


Figure 7. Histogram of DigCompSAT scores

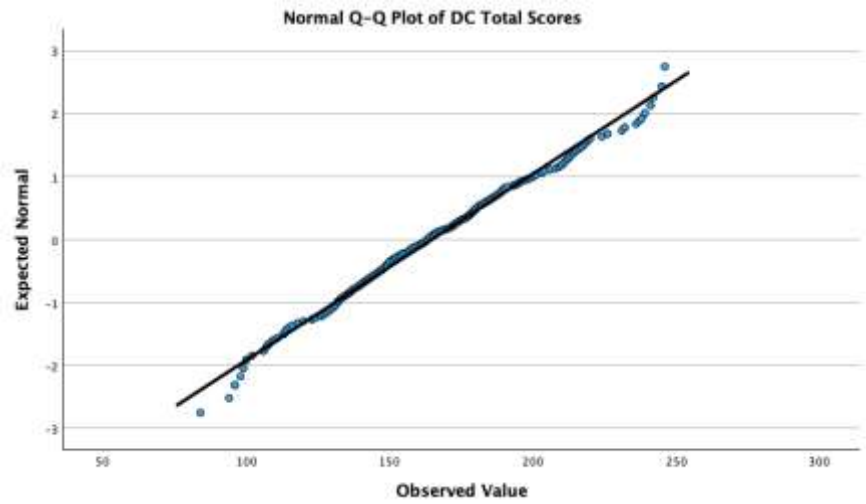


Figure 8. Q-Q plot of DigCompSAT scores

As the outliers were removed, the sample size was 334. The Kolmogorov-Smirnov test result showed that the data obtained via the SNAIL was also normally distributed. (See Table 11).

Table 11. Tests of Normality of SNAIL Scores

| | Kolmogorov-Smirnova | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| SNAIL Scores | .041 | 334 | .200* | .991 | 334 | .033 |

* This is a lower bound of the true significance.

a Lilliefors Significance Correction

The histograms of SNAIL scores are shown in Figure 9. In addition, the Q-Q Plot of SNAIL scores is shown in Figure 10. The histograms and Q-Q plot below supported the SNAIL Scores' normality. While the histograms demonstrated the symmetric distribution, the Q-Q Plot showed that the data points were clustered around the diagonal line.

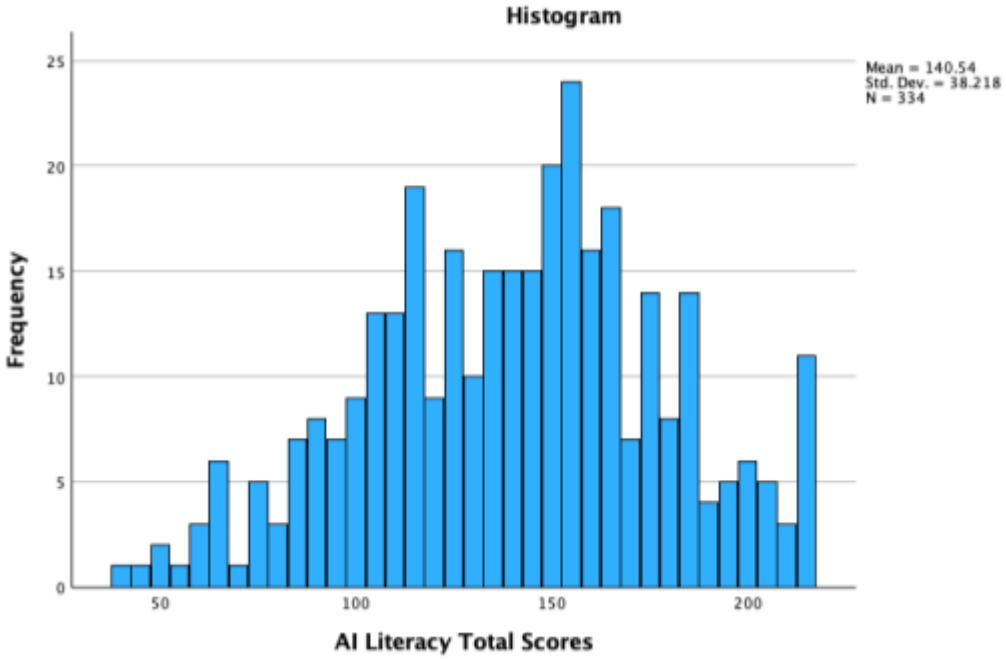


Figure 9. Histogram of AI literacy scores

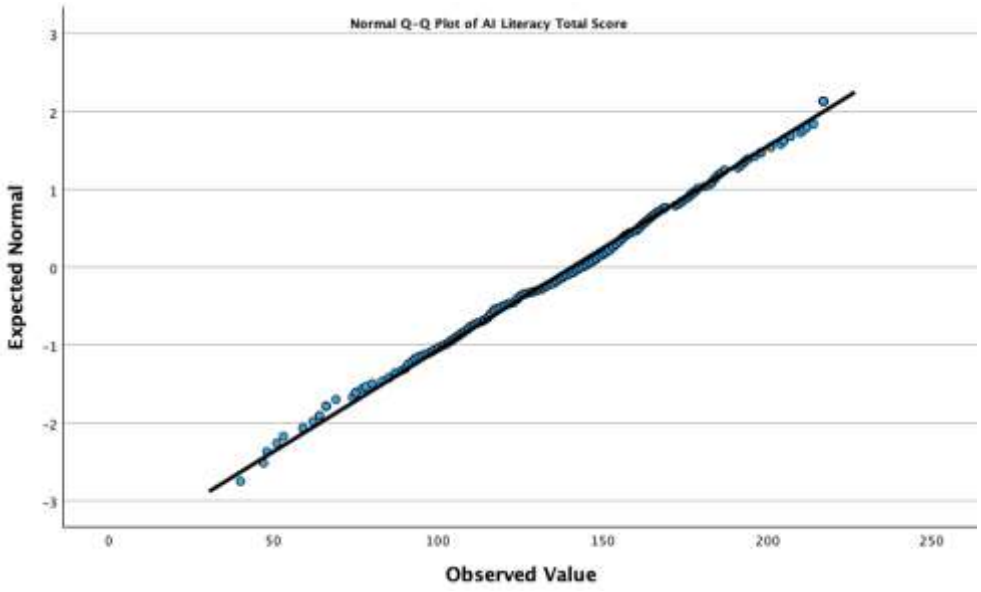


Figure 10. Q-Q plot of AI literacy scores

As shown above, the p-values of the data from DigComp and SNAIL were both greater than 0.05, demonstrating that both were normally distributed. The statistical values of .039 and .041 for DigCompSAT and SNAIL, respectively,

supported the normality of the data. The statistical values of both scales were close to zero, which indicated the data did not deviate from the normal distribution, and was close to the normal distribution.

Research Question 1: Is there a meaningful relationship between digital competence and AI literacy levels?

To investigate whether there is a statistically significant correlation between digital competence and AI literacy levels, correlation analysis was carried out to test the relationship between the variables (see Table 12). Because both data showed normal distribution, the Pearson Correlation test was used. The Pearson correlation value was .650, $p<.001$ which indicates that the correlation was significant and positive. The findings showed that both variables were significantly related to each other and that the participants who had high scores on one scale tended to score high on the other scale.

Table 12. Correlation of Digital Competence and AI Literacy

| | | DC Total Scores | AI Literacy Total Scores |
|---|---|---|---|
| DC Total Scores | Pearson Correlation | 1 | .650** |
| | Sig. (2-tailed) | | <.001 |
| | N | 334 | 334 |
| AI Literacy Total Scores | Pearson Correlation | .650** | 1 |
| | Sig. (2-tailed) | <.001 | |
| | N | 334 | 334 |

** Correlation is significant at the 0.01 level (2-tailed).

## 4.2 Participants AI usage based on their digital competence and AI literacy

Research Question 2: How do participants' AI usage vary based on their digital competence and AI literacy scores?

After completing the coding and analysis of interview data, how participants' AI usage vary based on their digital competence and AI literacy scores were investigated. Higher education students' levels of digital competence and AI literacy, and how higher education students' AI usage relate to their digital competences were investigated.

Research Question 2.1: What are the higher education students' levels of digital competence and AI literacy?

When investigating which AI tools the participants used was investigated, the following table lists the AI tools with the number and percentage of the participants using these tools (Table 13). The most frequently used AI tool among the participants was ChatGPT, which was marked by 97.6% of the total participants. The second most frequently used AI tool was Canva (77.3%) and the third most frequently used AI tool was Grammarly (71.5%).

Another question aimed to investigate whether the participants followed the recent developments in the field of AI. 57.4% (n=194) of the total sample indicated that they followed the developments and studies about AI.

Table 13. The AI Tools Used by Participants

| | The Number of Participant | The Percentages of Participants (%) |
|---|---|---|
| AI Tools | | |
| ChatGPT | 330 | 97.6 |
| Canva | 263 | 77.8 |
| Grammarly | 244 | 72.2 |
| Gemini | 163 | 48.2 |
| Quillbot | 138 | 40.8 |
| Copilot | 80 | 23.7 |
| DaLLE | 51 | 15.1 |
| Sora | 33 | 9.8 |
| Scribe | 22 | 6.5 |
| Slides AI | 16 | 4.7 |
| Other | 49 | 14.5 |

In addition, the participants were asked whether they attended a workshop, seminar, or a course about AI. It was observed that 61.5% (n = 208) of the total sample responded in the negative. As seen in Table 14, among the 38.5% who responded positively to this question, 60.8% took a course in AI, 59.2% attended a seminar, and 20.8% a workshop. In addition, 6.2% participated in another informational activity. When the participant's responses to informational activity were examined, 75% took online training, 12.5% attended a summer research internship, and %12.5 attended a fair. When this ratio corresponds to the total number of participants, 23.4% took a course in AI, 22.8% attended a seminar, and 8.0% a workshop. In addition, 2.4% participated in another informational activity.

Table 14. How the Participants Get Informed About AI

| Type of activity | Number | Percentage |
|---|---|---|
| Workshop | 27 | 20.8 |
| Seminar | 77 | 59.2 |
| Course | 79 | 60.8 |
| Other | 8 | 6.2 |

After analyzing the demographic questionnaire, the quantitative data collected via the questionnaires were examined and analyzed for the first research question.

First, the distributions of the responses to each of the 82 items in the DigCompSAT and the 31 items in the SNAIL questionnaires were examined. The mean (M) and standard deviation (SD) values were calculated.

It was observed that the mean value in the DigCompSAT questionnaire ranged from 1.03 to 2.79 (APPENDIX G). The participants got the highest and lowest scores in the items for the Communication and Collaboration area in the DigComp framework. Each item in the questionnaire was scored on 0 to 3 points. When the highest scoring item was examined, item thirteen about how to send, reply, and forward email, was rated highest ($M$ = 2.79, $SD$ = .431), 79.6% of the total participants having rated it 3, they can do with confidence, and support others if they need, 19.5% rated 2, being able to do it on their own, and remaining the 0.9% rated 1, they can do with help.

On the other hand, item thirty-four was the lowest-rated item ($M$ =1.03, $SD$ = .963). The item aimed to examine participants' knowledge about the EU's regulation on The Right to Be Forgotten was scored 0 by 34.9% of the total sample, indicating that they have never heard of it before, and 36.7% of the sample scored 1,

that they have limited understanding and they need more explanations. 18.6% of the sample rated 2, they have good comprehension about the item, and 9.8% rated 3, fully mastering the related issue, and they can explain it to others.

Since item thirty-four was about a European regulation, it was expected to be less known among the participants. The second lowest-scored item that participants received was item forty-seven (*M*= 1.08, *SD* = .965), which aimed to examine the area of Digital content creation in the DigComp framework. The item about whether participants know different types of licenses apply to the use of digital content was scored 0 by 32.2% of the total sample, indicating that they do not know how to do it, and 37.6% of the sample scored 1, indicating that they can do it with help. 19.8% of the sample rated 2, they can do it own, and 10.4% rated 3, they can do with confidence, and if needed they can support and guide others.

As for the SNAIL, it was observed that the mean value ranged from 3.28 to 5.42 (APPENDIX H). The participants had the highest score in the factors of practical application and the lowest score in the factor of technical understanding. When the highest and lowest items were examined for AI literacy, each item was rated on a seven-point Likert scale, ranging from 1: strongly disagree to 7: strongly agree. When the highest scoring item was examined, item thirty, use of examples of AI in daily life for personal and professional purposes, was the highest rated item (*M* = 5.42 and *SD* = 1.577). When the response rates were examined, 30.8% of the total sample rated 7, 26.9% of the sample rated 6, and %19.2 rated 5. In addition, 9.5% of the sample rated 4, 6.5% rated 3, and 4.7% rated 2. Finally, 2.4% of the participants rated 1.

On the other hand, item thirteen was the lowest rated item (*M* = 3.28, *SD* = 1.989). The item aimed to investigate participants' knowledge about neural network

means. When the response rates were examined, options 1, 2, and 3 were rated by 26.6%, 16.6%, and 15.7% of the total sample, respectively. Then, options of 4, 5, and 6 were rated by 11.2%, 11.8%, and 9.8% of the participants, respectively, and 8.3% rated themselves as selecting the option of 7.

The interview data was examined according to the four case groups to explore the participants' AI usage. Group 1 includes participants who scored higher in Digital Competence and AI Literacy, Group 2 higher scores in Digital Competence and lower scores in AI Literacy, Group 3 lower scores in Digital Competence and higher scores in AI Literacy, and Group 4 lower scores in Digital Competence and AI Literacy. 253 participants were in Group 1, 48 participants in Group 2, 13 participants in Group 3, and 24 participants in Group 4.

Interviews were conducted with 15 of the 334 participants. The students who participated in the interview were given a pseudonym (see Table 15). In Group 1, four participants were interviewed. These participants were Zeynep, Mehmet, Gökhan, and Kerem. In Group 2, five participants were interviewed: Esra, Selin, Mustafa, Ayşe, and Mert. In Group 3, two participants, Gizem and Ebru, were interviewed. Lastly, in Group 4, four participants were interviewed. These participants were Buse, Ece, Alp, and Aslı.

Table 15. Demographic Characteristics of the Interviewees

| Group | N | Participant | Department | Year in College | Gender |
|---|---|---|---|---|---|
| Group 1 | 4 | | | | |
| | | Kerem | Mechanical Engineering | 1 | Male |
| | | Mehmet | Linguistics | 2 | Male |
| | | Gökhan | Mathematics | 4 | Male |
| | | Zeynep | English Language and Literature | 4 | Female |
| Group 2 | 5 | | | | |
| | | Esra | Linguistics | 2 | Female |
| | | Selin | Psychology | 4 | Female |
| | | Ayşe | English Language Education | 4 | Female |
| | | Mustafa | Preschool Education | 4 | Male |
| | | Mert | Preschool Education | 4 | Male |
| Group 3 | 2 | | | | |
| | | Gizem | English Language Education | 3 | Female |
| | | Ebru | English Language Education | 3 | Female |
| Group 4 | 4 | | | | |
| | | Alp | Mechanical Engineering | 1 | Male |
| | | Buse | Preschool Education | 3 | Female |
| | | Ece | English Language and Literature | 3 | Female |
| | | Aslı | Environmental Technology | Postgraduate | Female |

Research Question 2.2: How do higher education students' AI usage relate to their digital competences?

In order to examine how the participants' AI usage varies based on their digital competence and AI literacy scores were investigated in terms of their usage of AI tools, the participants' use of AI for daily and academic purposes, examples from most recent usage, and what problems they found appropriate and meaningful to use AI to solve were explored. In addition, the interviewees were asked if they had the opportunity, what kind of a tool they would design using AI technology for academic purposes. Lastly, their ethical concerns in daily and academic use, what they know about how AI works, and their awareness of AI-related concepts were asked.

#### 4.2.2.1 AI Usage

Daily usage

All groups used AI to do online research for gathering information. They used AI for researching a subject on the web, searching for the answer to an unknown question, looking for a recipe, and doing investigations about leisure activities. For example, Kerem from Group 1 explained his use of AI for accessing information related to his area of interest:

> I am a member of a rocket club. For example, we are sometimes asked to conduct research. Occasionally, we are assigned to research materials. I use ChatGPT when I need materials because it allows me to access sources more quickly, which helps provide examples of materials. Instead of doing a general web search myself to find out which materials are commonly used in a certain part of the rocket, it is faster for me to use ChatGPT.

The participants from Group 1 and Group 2 (both high scorers in DigComp), also used AI for preparing personal planners. Two participants from Group 1 used AI for preparing travel plans. One participant from Group 2 used AI for time

management, to prepare daily plans for work and school. Esra from Group 2 explained:

> I mostly use ChatGPT to plan and create timelines. By timeline, I list the tasks I need to do. I ask it to divide them by day of the week and time slots. It prioritizes the to-do list and gives it to me in order.

Two participants from Group 1 also used AI for problem solving. Gökhan used AI for solving personal problems:

> Whether it's about my classes, workplace, or some problems I have faced in daily life, I prefer to ask AI instead of using Google. If I cannot find sufficient or satisfying answers on Google, I turn to AI.

In addition, Kerem from Group 1 reported that he used AI for programming problems to prepare sample coding studies for coding problems, and added:

> I mostly use AI for coding. I use ChatGPT and DeepSeek quite frequently. In particular, I use ChatGPT extensively for problems related to coding, as it provides useful examples. I use it when creating sample programs for coding purposes and when I want general coding.

In addition, two participants from Group 2 used AI for generating images and visual content, and editing photos. While Mert used AI to generate album cover, Esra used AI for editing the photos she took using AI.

On the other hand, one participant from Group 2 reported that he did not use AI for daily purposes.

Participants in Group 3 stated that they did not use artificial intelligence for their daily needs other than accessing information.

In Group 4, two interviewees indicated that they used AI for translation. They used AI for translating documents, from English to Turkish or vice versa. One interviewee indicated using AI for text editing to improve the quality of the text. Another interviewee said she used AI for text production for preparing official mail for Erasmus applications. She used AI to prepare mail for making applications to

schools. She wrote the mail in daily conversational language and wanted mail in English and formal.

The findings regarding the use of AI in daily life were summarized in terms of four groups in Table 16 below.

Table 16. The Use of AI in Daily Life Based on Groups

| | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| The Use of AI in Daily Life | | | | |
| Accessing information | + | + | + | + |
| Personal planner | + | + | | |
| Image/visual generation | | + | | |
| Text generation | | | | + |
| Photo editing | | + | | |
| Text editing | | | | + |
| Translation | | | | + |
| Programming problems | + | | | |
| Work/school/personal problems | + | | | |

Interviewees used AI in daily life in the areas of information and data literacy, communication and collaboration, digital content creation, and problem-solving. It can be seen that the responses were similar based on competence or literacy levels, in the areas of information and data literacy, and digital content creation. It was observed that all groups used AI for accessing information, and all groups except Group 3 (low DigComp & high AI Lit) used AI for digital content creation such as text generation or image generation. In addition, Group 4 (low DigComp & AI Lit) only used AI for translation, and Group 1 (high DigComp & AI Lit) only used AI for problem-solving in daily life.

Academic Usage

All groups used AI to do online research for academic purposes. They used AI to gain information on a topic they want to know more about, and a unit they covered in their classes or were curious about.

Group 1 (high scorers in DigComp), Group 3, and Group 4 (both low scorers in DigComp) also used AI for help with assignments. All participants in Group 3 had AI explain the tasks and questions to understand the requirements of the assignments. In addition, one participant from Group 1 and one from Group 4 used AI to reach information and related sources, and check information needed when doing an assignment. For example, Aslı from Group 4 explained:

> I use AI to get help with homework. I scan literature. Apps like ChatGPT can help me verify what I read. I often use AI to learn about the topic I'm reading and I verify the accuracy of the source.

Three participants from Group 2, one participant from Group 3 and Group 4 each used AI to prepare a summary about their readings. Ece from Group 4 indicated:

> I do not have much knowledge about AI applications. I only used ChatGPT. Generally, when I ask for a summary of articles, I use it to summarize articles.

In addition to preparing a summary, one participant from Group 1 and Group 4 each used AI for preparing a bibliography. Moreover, one participant from Group 3 and Group 4 each used AI for generating text. While the participant from Group 3 used AI for preparing email messages, the other participant from Group 4 used AI for preparing a statement of purpose for a master's degree application.

All interviewees, except those from Group 3, also used AI for editing digital content. While one participant from Group 1 and one from Group 4 used AI for text

editing to edit content and improve text quality for assignments, one participant from Group 2 used AI for grammar checking.

In addition, one participant from Group 1 (high DigComp & AI Lit) and one from Group 4 (low DigComp & AI Lit) used AI for problem-solving. They both indicate that they used AI for calculations for complex multivariate problems. Gökhan from Group 1 reported:

> I use AI especially when I'm stuck and I cannot solve it myself. I explain the topic to the chatbot, and I try to get help with questions. For example, I am taking an economic course, and I uploaded the Pdf of the course readings. When I'm stuck on a particular question, I upload the Pdf of the topic and say, 'Here's what I've learned so far.' Then I ask, 'Can you help me answer this question based on that?' And it gives me detailed, explanatory answers.

Alp from Group 4 indicated:

> I use AI when dealing with problems with too many variables for us to analyze manually. Using AI for problems with large input or data makes sense. I want it to interpret those things, and I ask AI to make predictions about variables.

Furthermore, two participants from Group 2 used AI to brainstorm to ask for comments and advice from AI. In Ayşe's words from Group 2:

> I want ideas for assignments. If I have a presentation or something, I get ideas for that, too. If I need to plan a lesson, I get ideas from AI again. When I get ideas from AI, I ask questions such as how to start and end things better so that the flow makes more sense.

Moreover, one participant from Group 3 had AI to prepare assignments. The interviewee used it to generate lesson plans to use in teaching practicum.

Two participants from Group 3 indicated that they used AI for translation. They used AI for translating documents, from English to Turkish or vice versa.

On the other hand, one participant from Group 1 said she did not use AI for academic purposes.

The findings regarding the use of AI in academic purposes were summarized in terms of four groups in Table 17 below.

Table 17. The Use of AI in Academic Usage Based on Groups

| | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| The Use of AI in Daily Life | | | | |
| Accessing information | + | + | + | + |
| Help with assignments | + | | + | + |
| Preparing a summary | | + | + | + |
| Preparing bibliography | + | | | + |
| Text production | | | + | + |
| Text Editing | + | | | + |
| Making calculations | + | | | + |
| Grammar Checking | | + | | |
| Have assignments done | | | + | |
| Translation | | | + | |
| Brainstorming | | + | | |

Interviewees used AI in academics in the areas of information and data literacy, communication and collaboration, digital content creation, and problem-solving. It can be seen that the responses were similar based on competence or literacy levels, in the areas of information and data literacy, and digital content creation. It was observed that all groups used AI for accessing information, and digital content creation such as preparing a summary or bibliography. In the communication and collaboration area, Group 3 (low DigComp & high AI Lit) used AI for translation, and Group 2 (high DigComp & low AI Lit) used AI for brainstorming. In addition, Group 1 (high DigComp & AI Lit) and Group 4 (low DigComp & AI Lit) used AI for solving problems.

Examples from most recent usage

The participants' latest use of AI and whether they achieved their aim were investigated. The participants in all groups, except Group 4, used AI most recently to create digital content. In Group 1, one interviewee had AI plan a trip to Paris, and

another generated math questions. The interviewees reported success when asked if they were able to get what they wanted.

In Group 2, one interviewee used AI to generate images for the story he created in a literature class with his classmates, and the other used AI to prepare a planner for studying foreign languages. Moreover, one interviewee's latest use of AI was preparing a statement of purpose for a master's degree application, and another interviewee used AI to check the grammar of the assignments. In addition, Aslı from Group 4 recently used AI for translating documents into English from Turkish. She reported success at getting a solution she aimed at using AI tools. It was observed that all five participants achieved the targeted solution.

Regarding Group 3, one interviewee's most recent AI use involved generating a lesson plan assignment. Another interviewee from the same group most recently used AI to prepare a message to be sent to someone who were not invited to a gathering to politely inform them that they were not among the invitees. The message was prepared in Turkish. The interviewees reported having achieved the intended solution using the AI tools. Ece from Group 4 reported that she recently used AI for accessing information about the chapter of the unit, and she achieved the targeted solution.

In addition, Group 1, Group 2, and Group 3 used solved the problems they encountered the last time they used AI. Kerem from Group 1 used AI for programming problems with Python, AI to create Python-specific code about mobile applications. Selin from Group 2 used AI to calculate her grade point average. Buse from Group 4 used AI for troubleshooting when using a mobile app, to turn off ad blockers in one of the mobile applications with step-by-step explanations from AI. All three participants reported having achieved the targeted solution by using AI.

On the other hand, some participants could not reach the targeted solution in their last attempts using artificial intelligence. Ayşe from Group 2 did not find what she was looking for, as she indicated:

> In my linguistics assignment, I mostly asked questions in Turkish, especially about linguistic topics. The application I used was ChatGPT. It did not help because even though it gave answers, they were often incorrect. I had asked questions mostly about phonetics, and while the responses looked good at first glance, I realized upon reading them carefully that they were wrong. I already knew the correct information so that I could tell the answers were inaccurate.

In addition, Mehmet from Group 1 used AI to simulate a psychology experiment. He mentioned that the experiment required dialogue with AI during class. However, he could not reach the targeted solution as he explained:

> In my most recent attempt, I simulated a psychology experiment where I interacted with ChatGPT. The instructor told us we could talk to ChatGPT about anything we wanted for 10 minutes. I started by asking how it was doing, and then we talked a bit about that. The 10 minutes ended quickly, and the conversation did not lead anywhere. I could not quite reach a conclusion or a specific point within that time. But that was the experiment's goal, just to chat with ChatGPT. They had said you could ask anything, even something you were curious about. My main goal was to have a conversation. I had a few questions, but the 10 minutes were up before I could get clear answers.

Alp from Group 4 used AI to calculate a physics problem, but he did not could not get the solution he targeted. He explained:

> In my last use, our physics instructor asked one question about statistical physics problem including probability. We discussed the problem in the classroom, and then the instructor explained the solution by demonstrating the codes based on sample distributions and graphs. Then I asked this question to ChatGPT, but it did not answer correctly. Already, it was not an easy answer anyway. I asked the AI to estimate. AI answered far from the correct answer, but I was curious because AI had a different estimation from people.

When participants' latest attempt to use AI tools, their goal, and whether they achieved the solution they were aiming for were examined, it was seen that 12 out of the 15 interviewees achieved the targeted solution. Participants frequently used AI to produce digital content. Seven participants used AI to create digital content such as

travel plans, images, personal planners, text, etc. Other participants who achieved their goals using AI's latest attempts were solving problems they encountered or accessing information. On the other hand, three participants did not reach the targeted solution. It was observed that participants who used AI in solving physics problems, linguistics assignments, and simulating a psychology task during the course did not achieve targeted solutions.

#### 4.2.2.2 Problem solving

The interviewees from all groups found appropriate and meaningful use of AI when synthesizing specific, summarized information in a limited time. The interviewees indicated the appropriateness or meaningfulness of using AI when accessing information because AI offered summarized information in a limited time. In Ebru's words from Group 3:

> For example, using AI is practical and makes sense if I'm short on time and want to access a summary or information about a topic quickly. When I search on Google or try to research something, I often go through multiple sources, which can be time-consuming. And if I'm looking for something specific, Google might not be able to present it to me directly.

In addition, Mustafa from Group 2 and Alp from Group 4 reported that solving calculations in complex multivariate mathematics problems was an area where AI usage would be beneficial. Gökhan from Group 1 indicated the appropriateness or meaningfulness of using AI when determining strategy in computer games, Mehmet and Kerem from Group 1 indicated solving programming problems, i.e. writing routine codes, and debugging. In Kerem's words:

> I think that AI is more successful when it comes to problems in virtual environments, like coding, rather than real-life, concrete situations. It is not only faster but also more reliable than a human. No matter how much a person knows, they still have to spend time figuring out where an error might be and go through the debugging process. But AI can do that in just seconds.

> That's why I believe it's much more efficient, especially regarding digital or virtual tasks.

Lastly, digital content creation was one of the other areas that the interviewees emphasized as appropriate or meaningful AI usage to solve problems. Ayşe from Group 2 found the appropriateness or meaningfulness of using AI when preparing a summary of the documents, and Esra from Group 2 pointed out tasks related to personal planning.

#### 4.2.2.3 Future design for tertiary education

The interviewees were asked if they were to design an AI tool for use in education what it would be. Two participants from Group 1, four participants from Group 2, one from Group 3, and two from Group 4 reported that they would design a reliable tool that can review and analyze the literature for the desired topic. They wanted to design a tool to do quality literature review, find related sources, analyze the associated sources, and provide a synthesis of this information. In Esra's words from Group 2:

> The analytical capabilities of AI could be very useful for many students. If I were to develop a tool with AI technologies for academic purposes, I would design one that facilitates literature review by scanning academic articles or academic books and helps students easily access relevant keywords or key topics they are looking for.

Similarly, Zeynep from Group 1 indicated:

> I would design an AI tool that can find academic articles. For example, you're working in a specific field, and this tool can bring you the most recent papers related to that field. So when you ask, it would say, 'Here's a new article that just came out in this area,' and so on.

Zeynep, from Group 1 indicated a question generator to study for exams as a tool that uses AI technology to help with academic work. With such a tool, she

would create examples of exam questions related to the topics covered in each exam so that the students can study on their own.

In addition, one participant from Group 1 and Group 2 each wanted to design a tool that supports complex calculations. Gökhan from Group 1 wished to design a tool that offers reliable complex calculations in math. Mustafa from Group 2 would like to design a statistical analysis and guidance tool, which would analyze problems that required complex mathematical operations by guiding users, and he added:

> Whether it's Excel or SPSS, it could be designed to make those functions easier. It could also be a tool that helps perform analyses and transactions more efficiently and offers better suggestions in those areas.

In addition, Gizem from Group 3 would design a text editor and grammar tool. She aimed to create a tool to edit text and find grammar and punctuation errors to improve students' text.

Additionally, in Group 4, Ece explained to would like to design an AI checker for creating a system that could detect and scan students' use of AI. Buse, said she would like a tool with the capabilities of visual, video, and live support for students when they tackle their assignments. She said:

> I would not want to design a tool that does an assignment directly. I want to design a tool with AI technology that can prepare outlines or, I do not know, intervene at points where students get stuck. I wouldn't want it to prepare an entire assignment for me, down to the last detail. It causes laziness. I would prefer it to be process-oriented rather than result-oriented. I would also prefer it to be visually supported. I could add visual videos and also live support.

#### 4.2.2.4 Ethical concerns (for daily & academic purposes)

When the participants were asked about ethical issues they encountered regarding use of AI in daily tasks, three participants from Group 1, one from Group 2, and two participants from Group 4 were concerned about plagiarism. The participants

reported that plagiarism was directly using text or other media generated by AI without specifying that it was generated by AI.

One participant from Group 2 and two participants from Group 4 were also concerned about privacy and security of personal data as ethical issues for daily purposes. The interviewees pointed out the threat to privacy and security of personal data, explaining that AI applications use individuals' data, such as voice, photos, or other personal information, without informing them, which causes an ethical issue. Alp from Group 4 indicated:

> The ethical issue I see most is where the data is stored, like personal information. There's a question mark around where our data goes. That is the biggest concern because we share information, and AI often predicts more than we've explicitly shared. It learns things from us without us even noticing.

In addition, one participant from Group 2 and one from Group 3 were concerned about the generation of misinformation as an ethical issue. The interviewees were that AI-generated content could contain misinformation, which could lead to an ethical issue. For instance, Mert from Group 2 indicated:

> Because AI collects images and information from the internet, the accuracy of the data cannot always be trusted, and the information may be incorrect.

Two participants from Group 2 were concerned about copyright of AI-generated images. The interviewees indicated that using images produced by others or others' works such as artists' illustrations in AI applications without permissions of their owners could cause copyright problems. For example, Esra from Group 2 reported:

> When ethics comes up, it mostly draws my attention, or I encounter it from an artistic perspective, especially on social media. I mostly use social media to follow artists and people who make illustrations. I come across problems with AI and so on in that respect. Problems like imitation or using their illustrations to run AI without permission.

Two participants from Group 1 indicated ethical concerns regarding personal development. Kerem pointed out possible risk of laziness as an ethical issue. He stated that accessing instant solutions and answers using AI caused a lack of motivation for researching information on one's own. Moreover, Gökhan reported that the lack of real learning was an ethical issue. He explained that reaching directly the product of AI prevents real learning, and added:

> People using applications like ChatGPT can reach the correct answers in a much shorter time, negatively contributing to learning. Or, the use of ChatGPT for studying for exams and doing assignments generally makes learning more difficult and prevents people from understanding the topic.

Lastly, Gizem from Group 3 indicated high energy consumption as an ethical issue, AI use causing devices to use more energy than usual, and added:

> AI uses 10 times more energy, compared to Google search. I use AI very rarely. I ask questions to AI only if it is something only AI can help with. When I get confused about something, I want AI to explain things to me in more detail. For example, I use AI to help me understand the topic better that I need to search.

Ethical considerations about using AI for academic purposes were asked as a separate question. All groups cited plagiarism again as an ethical concern. How they dealt with the risk of plagiarism in the assignments they turned in was also investigated. For example, Kerem from Group 1 explained how to deal with the risk of plagiarism:

> In general, both my university and I are very strict about plagiarism. Even putting ethics aside, from a moral standpoint, I find it disturbing. When I research, I usually ask for proper citations and want to know where the information comes from. Other than that, I do not think I've committed any other ethical violations.

In addition, Zeynep from Group 1 indicated the change in the assessment types of the courses for preventing the risk of plagiarism, and added:

> Since AI has become widespread, our instructors have avoided assigning paper-based homework. They used to give very few in-person exams, but now they hold more written exams due to ethical concerns.

Similarly, Selin from Group 2 added:

> I am careful not to write everything; rather, AI just summarizes things for me. I am careful not to give this text directly to avoid problems in Turnitin, because sometimes it happens. I do not do homework directly with AI. I ask the points where I am stuck in the homework.

Also, Gizem from Group 3 reported:

> Of course, I do not want AI to write my homework. For example, if the homework asks "Can you explain this topic?", and if I don't understand the assignment requirements, I can ask the AI to find just information, otherwise after I investigate it myself from the sources, I write homework.

Lastly, Buse from Group 4 indicated:

> I am trying not to copy-paste. I use AI as a source. ChatGPT is not a place where I can get my homework done. It has become a search engine for me. I can receive more compact answers via ChatGPT than having many pages appear on Google Chrome. I already paraphrase them myself. I take an idea from there and still write my idea. I am careful not to plagiarize.

In addition to plagiarism, Group 1 and Group 2 cited AI-generated misinformation as ethical concern for academic purposes. How the participants dealt with the risk of misinformation or incorrect information provided by AI was investigated. For example, Esra from Group 2 explained how she dealt with the risk of incorrect information provided by AI:

> I do not use the answers I get from AI directly, nor do I take them as completely accurate. Even if I ask the question to AI, I still try to answer it on my own by checking the information through articles and reliable sources on the internet.

Similarly, Gökhan from Group 1 explained:

> I can rarely use AI. I adopt the method AI uses. I do not directly take the answer because it gives generally wrong answers when asked. Like I said, teaching the topics at first makes more sense, and then getting output.

In addition, Mehmet from Group 1 added:

> When AI is used senselessly, for example, if it does demagogy but I do not notice it, there will be a problem. For example, I include some of what the ChatCPT wrote when writing a paper. If the output of AI is very demagogic,

> it can be understood. However, I did not experience such a problem because I did not include the AI's responses, which included demagogy, in my assignment.

Lastly, Mustafa from Group 2 was careful about copyright violation in AI-generated images and texts. He considered the copyright of the AI-generated images. He indicated that AI can access the images on the Internet, the images available on the Internet should not be used to be by AI for providing other users without owners permissions. In addition, he considered the copyright of the AI-generated texts while preparing texts for literature course assignments.

The findings regarding the ethical concerns were summarized in terms of four groups in Table 18.

Table 18. The Ethical Concerns Based on Groups

| | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| The Ethical Concerns | | | | |
| Plagiarism | + | + | + | + |
| Privacy & security of personal data | | + | | + |
| Copyright of AI-generated images/sounds/texts | | + | | |
| Generation of misinformation | + | + | + | |
| Laziness/ lethargy | + | | | |
| Lack of real learning | + | | | |
| High energy consumption | | | + | |

It was observed that all groups were concerned about ethical concerns. All groups concerned about plagiarism, and all groups except Group 4 (low DigComp & AI Lit) concerned about generation of misinformation. In addition, Group 2 (high DigComp & low AI Lit) and Group 4 concerned about copyright of AI-generated

products. Group 1 (high DigComp & AI Lit) also concerned about laziness and lack of real learning. In addition, Group 3 (low DigComp & high AI Lit) only concerned about high energy consumption.

#### 4.2.2.5 Technical understanding

##### How does AI work

To examine the participants' technical understanding about AI, they were asked how AI works. All groups reported that AI works by browsing all databases to gather information on the Internet. The interviewees explained the working logic of AI as providing responses to users based on the information found in the databases. When AI accesses the database, AI would find the user's desired response there and presents it to the user.

In addition, Group 1 and Group 2 indicated that AI systems are dependent on data to learn. They explained that AI systems learn from user data, the information provided to it by users, and this helped in the development of AI systems.

On the other hand, one interviewee from Group 1 and Group 2 and three interviewees from Group 4 did not provide any explanation about AI's working logic.

##### Awareness of AI related concepts

To further prompt technical understanding, the interviewees were asked to comment on three AI-related concepts, namely, neural networks, machine learning, and deep learning. They were asked whether they had heard these concepts before and what they knew about them. All participants from Group 1 (high DigComp & AI Lit) had heard all these technical concepts. In Group 2 (high DigComp & low AI Lit), one interviewee had heard all these technical concepts. While two interviewees had heard

only machine learning, one had heard only deep learning. In addition, one interviewee had not heard any of these concepts before. In Group 3 (low DigComp & high AI Lit), none of the participants had heard these technical concepts. Lastly, in Group 4 (low DigComp & AI Lit), two interviewees had heard all these technical concepts. One interviewee had heard only the concept of deep learning, and one interviewee had not heard all three AI-related concepts.

When the participants' comments on the three concepts were examined, Mehmet from Group 1 and Ayşe from Group 2 reported that the concept of machine learning was using data to learn. For example, Ayşe reported:

> Machine learning could be that it is given a lot of information and then looks at it and gives things according to the information they were given before.

In addition, Kerem from Group 1 explained the concept of deep learning as using data to learn, and added:

> Although I am not sure, deep learning could be that it records everything it sees on memory and interprets data later the user desires based on that memory.

On the other hand, Buse from Group 4 explained deep learning that deep learning was permanent learning. It was stated that deep learning means not just learning something temporarily and forgetting it after it's done but rather having it stay with you to remember it even after some time.

Regarding neural networks, Gökhan from Group 1 only explained the concept of neural networks, and he reported that neural networks were conducting categorization on the data. He said that neural networks means the collection of general data and producing common data by processing data based on similar categories and drawing similar conclusions.

On the other hand, no participant from Group 3 and Group 4 provided explanations for these concepts.

#### 4.2.2.6 Benefits and Risk of AI

##### 4.2.2.6.1 Benefits

All groups stated saving time as a benefit of using AI. The interviewees said that AI saves time in time-consuming tasks such as locating sources, summarizing, performing long computational operations, and translating. For example, Gökhan from Group 1 (high DigComp & AI Lit) reported:

> For people who use AI correctly, especially in research or daily tasks, AI can help complete time-consuming tasks much more quickly. For example, complex calculations that would normally take a long time can be done in a shorter amount of time. In academic research, AI can speed up processes that would otherwise take a lot of time, like paperwork or calculations, and ultimately shorten the overall research timeline.

In addition, all groups except for Group 3 (low DigComp & high AI Lit), pointed out access to multiple and reliable sources as a benefit of using AI. The presentation of different resources researched and provided by AI was regarded as a benefit.

In Group 1, Kerem emphasized making calculations as a benefit of AI. He stated the benefit of AI's solving complex multivariate problems by making correct calculations even if people make mistakes. Zeynep indicated that the accessibility of AI was one of the benefits. She explained the benefits of using AI tools with free and sometimes paid versions in a specific period.

In addition, Mert from Group 2 (high DigComp & low AI Lit) indicated that preparing a summary was a benefit of using AI.

Lastly, Alp from Group 4 (low DigComp & AI Lit) found image generation to be a benefit of using AI. Designing and doing visual designs by using AI technology was found useful. He also reported that using AI was a benefit of simulating situations to support human thinking. He also found using AI beneficial because AI could set up simulations for different scenarios to observe outcomes and

make predictions. The findings regarding the benefits of AI were summarized in terms of four groups in Table 19 below.

Table 19. Benefits of AI

| | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Benefits of AI | | | | |
| Save time in time-consuming tasks | + | + | + | + |
| Access to multiple and reliable sources | + | + | | + |
| Making calculations | + | | | |
| Accessibility | + | | | |
| Image/visual generation | | | | + |
| Simulating situations to support human thinking | | | | + |
| Preparing a summary | | + | | |

It can be seen that the responses did not vary based on competence or literacy levels, all indicated similar benefits regarding AI usage. It was observed that all groups explained saving in time-consuming tasks, and all groups except Group 3 indicated accessing multiple and reliable sources as benefits of AI. Group 4 and Group 2 explained the creation of digital content as a benefit. Group 1 only indicated solving problems and the accessibility feature of AI. In addition, Group 4 only mentioned simulating situations to support human thinking as a benefit of AI.

#### 4.2.2.6.2 Risks

Regarding the risks of AI usage, all groups except Group 3 indicated issues related to privacy and security of personal data and laziness/lethargy as risks of using AI. The participants mentioned the risks of data privacy and the storage of personal data in AI applications. The participants also reported laziness/lethargy as a risk. The

interviewees explained the risk of accessing an instant answer or solution prevents motivation for research on one's own. For example, Mustafa from Group 2 (high DigComp & low AI Lit) added:

> On the downside, AI has the potential to make people lazy. For example, if someone gets used to having AI do tasks that they should do themselves, like literature reviews, this can become a habit and lead to laziness in the long run.

Group 1 (high DigComp & AI Lit) and Group 4 (low DigComp & AI Lit) also found the potential loss of jobs as a risk of using AI. The risk of performing professions by AI instead of people was emphasized. For example, Ece from Group 4 reported:

> From a risk perspective, if I do all my work using ChatGPT, it raises the question: what is the point of studying literature? Many professions could reach a point where students can complete university using ChatGPT. Something needs to be done about fields or professions that AI cannot reach. Departments like mine are at risk. Most academic fields are losing their originality. If AI can do something, why would people study it? That's the risk.

Similarly, Kerem from Group 1 added:

> If, over time, this goes beyond daily tasks and evolves into replacing entire professions, it could have serious consequences. For example, if AI learns to interpret an economic chart, it could cause a major disruption in finance. Similarly, even in engineering, I've seen computer engineers relying on ChatGPT for assistance. In the future, if companies choose ChatGPT over hiring and investing in people, this could lead to adverse outcomes, in my opinion.

In addition, two participants from Group 2 and one from Group 3 indicated misinformation in AI-generated products as a risk of AI. The interviewees explained that AI-generated content could contain misinformation, which could lead to risk. For example, Ebru from Group 3 reported:

> The significant risk is that it does not always provide accurate information. It may not be entirely reliable because it can give incorrect answers. That possibility is always there, so we cannot completely trust it.

Group 3 and Group 4 also mentioned increasing dependency on AI as a risk of using AI. It was explained that there was a risk of performing tasks that needed to be done by students, such as creating ideas for projects or doing assignments.

In Group 2, Selin reported the risk of decreasing social interaction and isolation and added:

> It may weaken communication. After all, humans are social beings, and since I ask everything that comes to my mind to AI instead of the people around me, it weakens the interaction between people.

Lastly, Ayşe from Group 2 found the waste of Earth's resources as a risk of using AI. The risk of Earth's resources being wasted due to high energy consumption by AI tools was emphasized. The findings regarding the risks of AI were summarized in terms of four groups in Table 20 below.

It can be seen that the responses did not vary much based on competence or literacy levels, all indicated disadvantages of AI, and disadvantages for their own use as risks of AI. It was observed that all groups except Group 3 (low DigComp & high AI Lit) explained privacy & security of personal data, laziness as risks of AI. Group 1 (high DigComp & AI Lit) and Group 4 (low DigComp & AI Lit) indicated potential loss of jobs, and Group 2 (high DigComp & low AI Lit) and Group 3 indicated misinformation in AI-generated products and increasing dependency on AI as risks of AI. In addition, Group 2 only indicated decreasing social interaction and isolation, and waste of Earth’s resources as risks of AI.

Table 20. Risks of AI

| | Group 1 | Group 2 | Group 3 | Group 4 |
|---|---|---|---|---|
| Risks of AI | | | | |
| Privacy & Security of personal data | + | + | | + |
| Laziness/Lethargy | + | + | | + |
| Potential loss of jobs | + | | | + |
| Misinformation in AI-generated products | | + | + | |
| Increasing dependency on AI | | + | + | |
| Decreasing social interaction & isolation | | + | | |
| Waste of Earth's resources | | + | | |

## 4.3 Integration of findings

This study investigated the students' AI literacy at one of the top universities in Turkey, and whether or not their AI literacy levels may significantly correlate with their digital competence. In addition, how participants AI usage vary based on their digital competence and AI literacy scores was investigated. The survey results demonstrated that there was a significant and positive correlation between digital competence and AI literacy scores. The findings showed that digital competence and AI literacy were significantly related to each other. The participants who had high scores on one scale tended to score high on the other scale.

The majority of the participants had high digital competence and high AI literacy scorers. The analysis of the quantitiative data showed that 74.9% of the participants were in Group 1 (high DigComp & AI Lit), 14.2% were in Group 2 (high DigComp & low AI Lit), 3.8% were in Group 3 (low DigComp & high AI Lit), and 7.1% were in Group 4 (low DigComp & AI Lit).

When the participants' use of AI tools was examined, the majority of the participants used different AI tools for access information, text editor, image generation, and so on. The most three frequently used AI tools among the participants was ChatGPT, Canva, and Grammarly. Although the majority of the participants had high scorer in AI literacy, the analysis of demographic questionnaire demonstrated that only 57.4% of the total sample followed the recent developments and studies about AI. In addition, the participants were asked whether they attended a workshop, seminar, or a course about AI to get informed about AI, 61.5% of the total sample responded in the negative. The majority of the participants indicated that they had not attend course in AI, seminar, workshop, or other informational activity about AI.

The quantitative data from the surveys were also consistent with the qualitative data in terms of the interviewees' practical application of AI. When the highest scoring items were examined in SNAIL, item thirty, the use of examples of AI in daily life for personal and professional purposes *(M = 5.42 and SD = 1.577),* item twenty two, explaining why AI is important *(M = 5.41 and SD = 1.531),* and item one, explaining the technologies they used supported with AI *(M = 5.42 and SD = 1.434)* were the first three highest scoring items. The findings showed that the participants got the highest scoring item was in the factor of practical application. These findings demonstrated also similarity in the findings of the qualitative data. During the interviews, the participants could explain their AI use examples form daily, academic, and the most recent attempts.

The quantitative data from the surveys were also consistent with the qualitative data in terms of the interviewees' technical understanding of AI. Although interviewees had higher score in AI literacy, both high and low scorers did

not explain the working logic of AI, and the AI-releted concepts. It was observed that participants who heard such AI-releted concepts did not explain the full meanings at all, and none of the interviewees was able to explain all there concepts. These findings demonstrated similarity with the quantitative data. The three questions on the lowest scoring scale was about item thirteen, explaining neural networks *(M = 3.28 and SD = 1.989)*, item eleven, explaining reinforcement learning about machine learning *(M = 3.31 and SD = 1.931)*, and item twelve, explaining deep learning *(M = 3.32 and SD = 1.926)*, respectively in the factor of technical understanding. Therefore, the findings showed that students' technical knowledge about AI was low.

When participants' digital competence scores were examined, the majority of the participants had higher in digital competence. The quantitative data also also consistent with the qualitative data in terms of the interviewees' competencies in the five areas of DigComp framework. When the participants' explanations about the interview questions showed that participants' use of AI, problem solving with AI, future design for academic purposes, and ethical concerns of AI were releted to the areas of DigComp framework. In addition, the findings from the qualitative data showed that interviewees used AI in daily life and education in the areas of information and data literacy, communication and collaboration, digital content creation, and problem-solving. In addition, the interviewees had concerns in the safety area and ethical awareness about the use of AI. Therefore, the interview findings demonstrated that the status of the competencies in the five areas defined by DigComp, seems to have transformed into having AI do the work covered by the competencies today.

Quantitative findings showed that as participants' digital competence levels increase, their AI literacy levels significantly increase. Qualitative findings also supported these findings. It was observed that interviewees used AI tools and provided examples for their uses, which was supported by their competencies within the areas of DigComp framework.

# CHAPTER 5

# DISCUSSION AND CONCLUSION

The study aimed to examine students' AI literacy at one of the top universities in Turkey and whether or not their AI literacy levels may significantly correlate with their digital competence. Also, the study investigated what differentiates high and low AI literacy, and what is involved in becoming highly AI literate, based on the components of UNESCO AI literacy framework, with the hope of providing a guideline for bringing low scorers to a higher level of competence. The explanatory sequential research design was selected to gain more understanding about the research phenomenon. Firstly, the study investigated the digital competence and AI literacy levels and the relationships, then investigated them in more detail through interviews. The digital competence and AI literacy levels were examined quantitatively via survey instruments. Then, the use of AI was investigated qualitatively by the participants at different levels of digital competence and AI literacy. In this chapter, the findings based on the quantitative and qualitative data are discussed, implications and recommendations offered, and the limitations of the study are stated.

The survey results demonstrated that there was a significant and positive correlation between digital competence and AI literacy scores. Both variables were significantly related and that the participants with high scores on one scale tended to be high on the other.

The quantitative data from the surveys were also consistent with the qualitative data in terms of the interviewees' technical understanding of AI. Based on the qualitative data from interviews, one participant among six participants who had

high AI literacy, and four participants among nine participants with low AI literacy did not explain the working logic of AI. Two participants among six who had high AI literacy, and two of nine participants who had low AI literacy had not heard of AI-related technical concepts. It was observed that although participants who heard such technical concepts did not explain the full meanings at all. None of the interviewees was able to explain all the concepts. The interviewees explained only the concepts they were familiar with. When the number of interviewees was examined, machine learning and deep learning were explained by two interviewees. The concept of neural network was explained by only one of the interviewees. The findings of several studies showed that university students' technical understanding of AI was low (Toker Gokce et al., 2024; Laupichler et al., 2024). Therefore, Laupichler et al. (2024) emphasized the necessity of giving students' technical understanding of AI greater importance in higher education curricula, which provides students with better comprehension of AI-based learning environments while balancing their AI literacy.

## 5.1 AI usage

During the interviews, the participants explained their use of AI for daily and academic purposes, and they gave examples of their experiences in various fields, such as accessing information, photo editing, image generation, and preparing travel plans in daily life. Regarding academic purposes, the interviewees used AI again, for accessing information, creating digital content, text editing, and solving problems. For example, preparing a summary, text editing, translation, help with assignments, and brainstorming are examples of areas of use in academic life. Moreover, participants benefited from AI for solving problems they encountered, such as

programming problems, complex math problems, physics problems, and calculations for complex multivariate problems.

These findings are consistent with Chen et al. (2024)'s study carried with 462 students from a public university in the USA. The researchers indicated that most university students used AI to generate ideas for papers, assignments, and projects. Furthermore, students likely considered using AI for brainstorming and the editing feature as tutoring (Chen et al., 2024). In this study, three interviewees used AI to brainstorm, get suggestions, and exchange ideas.

When the participants were examined based on their AI literacy scores, Group 1 and Group 3 were higher in AI literacy, and Group 2 and Group 4 were lower in AI literacy. Both levels of interviewees similarly used AI for academic purposes in the digital competence areas of information and data literacy, digital content creation, and problem-solving. Both levels used AI to access information, make calculations, help with assignments, prepare bibliographies, text, and summaries, and edit texts. While higher scorers used AI tools to complete assignments and translate documents, the lower scorers used AI tools to brainstorm and check grammar.

Regarding the use of AI in education, it was observed that the status of the competencies in the five areas (1. Information and data literacy, 2. Communication and collaboration, 3. Digital content creation, 4. Safety, 5. Problem solving) defined by DigComp, seems to have transformed into having AI do the work covered by the competencies today. For example, while communication and collaboration focus on interaction, sharing, and collaborating through digital technologies, now collaboration seems to be done with AI. Similarly, the dimension of problem solving concentrates on individuals' solving problems by generating innovative processes

through digital tools; now, the direct solution of problems seem to be performed by AI-based digital tools. Therefore, it has been observed that the dimensions of DigComp seem to be transformed from a system where individuals perform several tasks using digital tools to a structure where AI performs targeted tasks. In other words, AI can directly act on tasks individuals need to complete or want to perform. Van Audenhove et al. (2024) indicated that DigComp focused on comprehending data rather than being able to use data. With the development of AI technology, AI takes the role of using data and creating outputs. At this point, Van Audenhove et al. (2024) emphasized knowing how to use AI-generated digital content in one's works. Therefore, the researchers pointed out the use of AI can be controversial regarding who should be credited.

## 5.2 Problem solving with AI

When the participants were also asked what problems they found appropriate and meaningful for AI tools to solve, they answered finding a synthesis of specific information, making calculations in complex multivariate problems, programming problems, determining strategy in computer games, and preparing a personal planner.

It appeared that the tasks the students performed using AI were already the situations they found appropriate and meaningful to solve with AI. Some situations given by interviewees were actually tasks that did not contain a problem situation. For example, finding a synthesis of specific or summarized information was basically related to accessing information, rather than problem solving, though it might be considered an information problem solving situation. In addition, creating digital content included preparing a summary. It was observed that the interviewees'

responses to this question could be categorized as information and data literacy, as well as digital content creation, in addition to the area of problem-solving.

When the high scorers and low scorers responses for areas where they find appropriate and meaningful to solve with AI was examined, the high scorers in AI literacy in Group 1 mostly thought to use AI for the problems they encountered such as determining strategy in computer games, programming problems for debugging, and programming problems for writing routine codes than low scorers in AI literacy because one of the low scorers in AI literacy from Group 2 and Group 4 mentioned for solving complex multivariate problems. Therefore, it was noted that high scorers in AI literacy frequently gave more situations in the dimension of problem-solving in DigComp than lower scorers in AI literacy.

For the problem-solving area in DigComp, Vuorikari et al. (2022) also focused on using digital technologies for innovative processes and products when solving conceptual problems and problems in the digital environment. It was observed that some participants did not also use AI technologies to create innovative products or processes when solving problems interviewees indicated. This may be because participants have not tried AI in solving a different problems before or do not know how to use AI to handle a problem they encountered. Boussioux et al. (2024) emphasized the effectiveness of human AI solutions rather than human solutions in terms of successful implementation, strategic feasibility, and environmental and financial worth. Therefore, Boussioux et al. (2024) indicated that large language models (LLMs) based on large data sets provide a novel aspect for augmenting creative problem-solving by offering interactive collaboration abilities. Choudhary et al. (2023) explained the interactive characteristics of LLMs allow individuals to converse through personalized prompts, allowing new types of

collaboration between humans and AI systems. In addition, Schorcht et al. (2024) explained that using prompt engineering methods, LLMs can also provide explanations that can help with reasoning, directing answers, and personalized learning for users. For improving individuals' problem-solving with AI, Boussioux et al. (2024) focused on training for constructing AI literacy.

### 5.3 Future design for thirtiary education

In response to the AI-tool design for academic purposes, the respondents mostly described a reliable tool for literature review and synthesis, and then reliable complex calculations in Math. In addition, a question generator to study for exams, a text editor and grammar checker tool, an AI checker, statistical analysis and guidance, and lastly, supporting tool for assignments were indicated.

It was observed that the interviewees described their future AI tool design along the lines they were already using AI now. For example, they had explained earlier that they used AI for academic purposes such as accessing reliable sources, solving complex problems, text editor, and grammar checking. When asked about future design for their own use they cited synthesis of literature, solving of complex problems, study support, and text editing. However, there were not design examples of highly futuristic or speculative educational design. This might be because the students are not very familiar with what AI can do, as evident from their answers to the questions regarding technical aspects of AI, even those who scored higher on AI literacy scale. Consequently they could not image what it could have been. These findings seem similar to the findings from Lin et al. (2025) carried out a study to examine higher education students' AI competencies. When the students' creativity in innovative design and development within the field of AI was examined, only

14% of the 300 higher education students were able to design basic AI prototype systems, which showed a deficiency in higher-order capabilities. Lin et al. (2025) emphasized that students' capability is an important sign of their future competitiveness in AI and their higher-order thinking skills.

It could also be speculated that there were not many creative answers can be related to shortcomings in design thinking and creativity. For design thinking, Razzouk & Shute (2012) indicated that design thinking is a creative and analytical way that enables individuals to engage in experiments, develop and prototype models, receive feedback, and make changes. McLaughlin et al. (2022) emphasized design thinking as a human-centered and continuous way of problem-solving that integrates what is sustainable, acceptable, technological, and sustainable. For the shortcoming is creativity, Ritter et al. (2020) addressed that even though the world has changed significantly, the teaching methods remain mostly the same, and learning focuses on rote learning rather than creativity. Similarly, Walter (2024) indicated that AI education places more emphasis on rote learning than promoting students' creative problem-solving, which restricts students' ability for creativity in real-world settings. Therefore, Lin et al. (2025) suggested to bridge the gap in students' capability in creativity, educators need to give importance to enhancing students' creativity and promoting project-based learning.

### 5.4 Ethical concerns (in daily & academic tasks)

Because AI takes place in many different areas in the daily and academic life of students, ethical concerns regarding AI use was of major importance for this study. The ethics dimension is also a part of the UNESCO framework. All groups were aware of the ethical issues regarding AI use, both for daily and academic purposes.

The interviewees frequently cited plagiarism and misinformation as ethical issues. In Group 1, one participant indicated laziness/lethargy and another indicated lack of real learning as ethical issues of using AI in daily life. In addition, one participant from Group 3 indicated high energy consumption. Two participants from Group 2 mentioned copyright of AI-generated products, and two participants from Group 4 and one from Group 2 indicated privacy and security of personal data. In addition, one participant from Group 2 and 3 were concerned about the misinformation in AI-generated content. However, ethical issues of using AI in daily life were not a problem in particular for Buse from Group 4, because she considered the ethical issue of AI as a personal problem for each use. She thought about ethics as differing from person to person, and reported:

> For example, AI retains my previous responses. Sometimes I ask it to write or revise an email draft. Later on, when I ask it to write a new email, it may use information from the earlier draft, like my name, surname, or school, even though I have not provided that information again. I'm not personally uncomfortable with this, whether this is unethical or not, will change from person to person.

The participant's statement showed a lack of knowledge regarding protecting personal data. She thought that personal data protection may vary from person to person. However, the security of personal data does not change from person to person, and it is needed to protect everyone. Similarly, Fuster (2014) emphasized that the right to data protection is a fundamental right in the European Union; everyone has the right to protect personal data.

It is noteworthy that all of the participants in all groups were concerned about plagiarism when using AI for academic purposes, which is also a major concern for instructors. Similarly, Manley (2023) focused on the availability of AI tools, such as essay mills, and paraphrasing tools have facilitated the risk of

plagiarism. Therefore, Cotton et al. (2023) indicated the difficulties instructors face in distinguishing between real work and the work produced with the assistance of AI.

Mohammadkarimi (2023) carried out a study to observe English as foreign language instructors' perception of academic dishonesty with 67 university instructors. The results showed that although teachers thought AI technologies benefited students, it also posed concerns about academic integrity. All teachers agreed that AI has an adverse effect on students' commitment to academic integrity, and thought that AI promotes dishonesty and impedes students' skills development. Therefore, the researchers emphasized the necessity of addressing ethical issues and detecting AI-generated assignments.

One participant from Group 1 and two participants from Group 2 considered the possibility of misinformation in AI-generated products. Similarly, Simon et al. (2023) indicated that AI could produce realistic, but including incorrect or misleading content on a large scale, which could have disastrous effects on individuals' attitudes, actions, and society. Therefore, Karaş (2024) emphasized the misinformation in AI-generated products, and it was indicated that misinformation generated by AI was considered a global risk and significant problem in the AI use areas.

One of the participants had low scorer in AI literacy from Group 2 pointed out the copyright of AI-generated products as distinct from the high scorers in AI literacy. Participant had high AI literacy scores from Group 1 and Group 3 did not indicate their concern about copyright. Although the participant had low scorer in AI literacy, the interviewee had high awareness about the copyright of AI generated products. This can be supported by the findings in Wut et al. (2025), who concluded their study as there was notable awareness of ethical considerations of generative AI

among the university students. On the other hand, there was studies showed that students had lower ethical awareness regarding AI technology. For example, Ghotbi & Ho (2021) carried out a study to observe the college students' moral awareness regarding AI systems with 467 students. The results of the study showed that students' moral awareness regarding AI technologies was fairly low, so including ethics of AI in the curriculum was recommended. In addition, Migdadi et al. (2024) investigated the nursing students' attitudes and intentions about AI technology with the participation of 140 university students. The results showed that nursing students had a moderate level of ethical awareness of AI. Therefore, the researchers emphasized that the integration of comprehensive ethical training programs into the curriculum provides students to enhance their reasoning, critical thinking, self-awareness, and responsible use of AI.

The participants were careful about not getting the output provided by AI and directly using it for assignments, or copying and pasting. In addition, they reported dealing with the risk of plagiarism by taking ideas provided by AI about the assignment, interpreting the output from their own perspective, and changing the structure of the text generated by AI using their own words.

Similarly, the interviewees seemed aware that the responses given by AI may contain wrong information. They dealt with the risk of misinformation or incorrect information by checking the accuracy of the information from the sources and checking whether the output included biased answers. Moreover, one of the interviewees from Group 1 emphasized that getting more accurate answers could be reached by teaching the subject to AI. This particular interviewee first taught AI about a topic he wanted to learn by loading the relevant chapter or documents, and then asking the question he wanted to learn. In this way, he said he was able to

prevent the risk of AI generated misinformation. These findings confirm those from a study conducted by Chen et al. (2024), and the researchers found that university students were skeptical and aware of misleading information and biases in AI products. They took extra steps to check the AI-generated output, including cross-reference or fact check. Similarly, Bobula (2024) suggested informing users of potential hallucinations and inaccuracies and not entirely believing AI-generated outputs to deal with the misinformation generated by AI. Burger et al. (2023) emphasized when requesting reference from AI tools, AI systems can especially generate false responses by giving interesting elaborate titles and authors entirely that are unreal. Therefore, Bobula (2024) emphasized rigorous reference checking. In addition, Chu-Ke & Dong (2024) suggested that cues that show up immediately when users copy and paste operations could also remind users to do fact-checking. Chu-Ke & Dong (2024) emphasized offering useful links by AI tools to websites, governmental agencies, and organizations to verify information.

At this point, Wut et al. (2025) suggested replacing most written assignments with oral presentations and in-class studies to reduce the use of AI for assignment preparation. Similarly, Özer (2024) indicated the transformation of current assessment and evaluation methods to more accurate and reliable ones, and also indicated continuous transformation, not a one-time occurrence. Perkins et al. (2023) suggested a shift toward assessment techniques for higher education such as a substantial number of presentations, invigilated assessments, in-class oral and written examinations to prevent AI-generated assignments. In addition, Cotton et al. (2023) emphasized the assessment, which includes open-ended tasks and enhances students' creativity and originality for preventing plagiarism using AI. Also, Cotton et al.

(2023) suggested that university instructors could develop assessments that students can create their research question and build and advocate their arguments.

### 5.5 Technical understanding

There were participants from all groups who could not explain how AI works or define AI-related concepts, even if at a rudimentary level. While some participants tried to explain how AI works, one interviewee from Group 1 and Group 2 each, and three interviewees from Group 4 did not explain how AI works.

As for AI-related concepts, namely, neural networks, machine learning, and deep learning, only the participants in Group 1 had heard of these concepts before. Some participants had not heard any of these concepts in Groups 2, 3, and 4. In Group 3, none of the participants had heard these concepts. One participant from Group 1 explained machine learning, another explained deep learning, and the other explained neural networks. In addition, one participant from Group 2 partially explained machine learning, and one from Group 4 explained deep learning at a very rudimentary. On the other hand, no participant from Group 3 provided explanations for these concepts.

It was observed that both high and low scorers in AI literacy could not explain all concepts simultaneously. While high scorers had heard of all of these concepts before, they could not describe them as well as those at lower scorers. Three participants from higher scorers and two from low scorers described only one of the concepts.

When students' technical understanding of AI was examined, it was observed that students' technical knowledge about AI was low. Although students had high scores in digital competence and AI literacy, there were students who could not

explain the working logic of AI, and make comments on AI-related concepts. In addition, there were participants who had high level AI literacy but had not heard these three concepts, as well. In fact, high scorers in AI literacy did not even know how AI works technically at an elementary level. Therefore, the findings point to a serious need for training regarding technical aspects of AI. At university level, students are now expected to be knowledgeable in this regard. The findings also show that training should begin at an earlier age for students at university level.

The Artificial Intelligence for K-12 (AI4K12) initiative has developed national guidelines for AI education based on four grades which were K-2, Grades 3-5, Grades 6-8, and Grades 9-12 (Touretzky et al., 2019). The AI4K12 initiative was developed around the Five Big Ideas in AI: Perception, Representation & Reasoning, Learning, Natural Interaction, and Societal Impact (Touretzky et al., 2019). Lim et al. (2025) emphasized that the AI4K12 initiative approach is comprehensive and it focuses on the technical aspects of AI, and its social and ethical effects. In addition, Lim et al. (2025) indicated that the AI4K12 initiative aimed to offer a holistic framework for AI education which handles the ethical and societal issues raised by AI technology and prepares students for future technological challenges. Touretzky et al. (2019) indicated that teaching AI in K12 is the right time because AI has an important role in society, and individuals need to understand the fundamentals of AI because society faces public diplomacy decisions surrounding AI. In addition, Touretzky et al. (2019) explained there is a need for AI-literate workers, so individuals should be encouraged from a younger age to think about STEM careers.

### 5.6 Benefits and risks of AI

When the interviewees' responses for benefits of using AI were examined, participants at all levels mentioned saving time and accessing multiple and reliable

sources. Accessibility and making complex calculations was recounted by the participants who scored high on DigComp and AI literacy scales. Generation of visuals and simulating situations to support human thinking were listed by the participants who scored low on both scales, and preparing a summary was mentioned by a participant who scored high in DigComp and low on AI literacy. It can be seen that the responses did not vary based on competence or literacy levels, all citing similar benefits regarding AI usage.

It is also noteworthy that the participants emphasized the tasks they already carry out using AI as the benefit of AI. They seemed to identify the benefits of AI with the purpose of their own AI use. They did not indicate more general or encompassing benefits other than their own purposes of use, maybe with the exception of a simulating situations to support human thinking, expressed by a low scorer in AI literacy.

On the other hand, when their responses to risks are considered, it can be seen that the participants were able to think of risks more broadly, about the likely disadvantages of AI use, because they listed privacy and security of personal data and loss of jobs as risks involved, in addition to disadvantages for their own use, such as risk of misinformation in AI-generated text, laziness and increasing dependency on AI. Again, there was not much difference in the response from high or low scorers in either of the domains. Only two of the AI low scorers mentioned high energy consumption by AI tools and decreasing in social interaction and isolation as possible risks.

These findings seem similar to the findings from Delello et al. (2023), Pitts et al. (2025), and Özer (2024). For example, Delello et al. (2023) explored the college students' perceived benefits and risks of AI with the participation of 165 students in

the United States. The study demonstrated that the benefits of AI included efficiency and time-saving, assistance in writing, and new teaching strategies such as scenario-based learning. Similarly, Pitts et al. (2025) investigated 262 undergraduate students' perspectives on the benefits and risks of using AI at the University of Florida. The study showed that the benefits of using AI included accessing information, productivity, feedback, and study support, and providing creative support in preparing outlines or brainstorming ideas. Moreover, Özer (2024) emphasized assistance in students' assignments, presentations, and language translation as a benefit of AI.

On the other hand, Delello et al. (2023) explained that students perceived bias, lack of effort, privacy and security issues, a change in workforce, academic dishonesty, and inaccurate data as risks of AI. Similarly, Pitts et al. (2025) explained the risks of using AI were related to academic integrity, accuracy of information, ethical concerns, loss of critical thinking, lack of human elements such as creativity or original ideas, and overreliance on AI. In addition, Özer (2024) indicated inequalities in accessing AI systems among countries as a risk. Moreover, students completing assignments with AI can cause plagiarism, and a lack of learning was indicated.

## 5.7 UNESCO AI competency framework for student

When the interviewees' responses were considered against the UNESCO AI Competency Framework for Students, it was observed that the findings from the interview data were mostly compatible with the competency aspects described in the framework.

The first dimension in the UNESCO AI Competency Framework is human-centered mindset. The participants could explain the interaction of individuals with AI and indicate their beliefs and thoughts about AI systems for safe and responsible use of AI. However, when risks and benefits involved in AI usage were explored, it was observed that interviewees emphasized the examples of use areas of AI as a benefit. It was observed that the participants could not dissociate benefits from their own use, rather they discussed benefits refering to the tasks they already performed using AI. Their lack of refence to a likely future benefit and little mention of possible future risk showed that it is necessary to increase the students' awareness of the human centered dimension in the UNESCO AI Framework.

The second dimension is the Ethics of AI. The participants seemed more aware of the ethical issues involved in AI usage, and could indicate their ethical judgments of AI systems. They seemed aware of the ethical issues regarding safe and responsible use, even if only at an elementary level, except one participant, a low scorer in AI literacy, who considered the ethical issue of using AI a personal problem.

When the participants' responses are considered within AI techniques and applications, the third dimension in the UNESCO AI Framework, it can be seen that the interviewees could explain operational skills regarding use of AI tools. In addition, their responses were compatible with the technical foundation of AI systems at an elementary level, such as browsing all databases to gather information, and using data to learn.

The final dimension in the framework, is AI system design, which entails designing, engineering, and problem-solving skills. While the interviewees could explain the tools with AI technologies, they described features they would like in a

new AI tool for education closely resembled functions they already made use of in the AI tools they already intereacted with. They did not contribute novel and creative features to the tools in the designs they described. In addition, when the interviewees described appropriate problem situations for using AI, again, many interviewees explained tasks where they were already carried out using AI. It was observed that they frequently described the tasks that were not examples of problem situations.

By integrating the UNESCO AI Competency Framework for Students, Lin et al. (2025) carried out a study to examine higher education students' AI competencies. The participants of the study were 300 higher education students from China. The results of the study showed that students had a relatively high understanding of AI, and basic AI concepts such as machine learning, neural networks, and algorithms. On the other hand, students' understanding of the ethics of AI was lower than the technical understanding of AI. When students' problem-solving ability by applying AI was examined, students were proficient in using AI tools to carry out basic tasks such as performing basic text analysis. However, students demonstrated low competence when solving complex tasks by using AI tools. When the creativity capability of students' was examined, only 14% of the participants were able to design basic AI prototype systems. In other words, while students had higher proficiency in technical skills, their ethical reasoning, problem-solving, and creativity were comparatively underdeveloped. Based on the findings, the researchers suggested integrating ethical education into high school curricula. In addition, integrating more hands-on learning tasks into the curriculum was suggested for applying AI knowledge to solve real-world problem scenarios. To enhance students' creativity and innovative thinking skills, researchers emphasized integrating project-based learning and innovation competitions.

## 5.8 Implications and recommendations

This study investigated the students' AI literacy at one of the top universities in Turkey, and whether or not their AI literacy levels may significantly correlate with their digital competence. In addition, the interviews were conducted to observe the difference between what differentiates high and low AI literacy, what is involved in becoming highly AI literate, and understanding the use of AI tools by thirtiary students, and how they evaluate AI technologies. The findings showed that the competencies in the dimensions defined by the DigComp framework appear to have been transformed into having AI do the work covered by the competencies today. It was noted that these dimensions have evolved from a system in which individuals perform several tasks using digital tools to a structure where AI performs targeted tasks within its system. In other words, the users have taken on a passive role, and the system that performs the tasks has become AI.

In addition, when the interview data was considered based on the UNESCO AI Competency Framework for Students, it was observed that the interviewees were unable to provide clear responses with regard to the competency of AI techniques and applications. However, a lack of knowledge was observed regarding conceptual understanding of AI. In addition, the interviewees were unable to provide clear responses for the questions aimed to observe the engineering and design thinking for problem solving, and designing under the competency of AI system design. While the interviewees gave answers to the questions that aimed to investigate the engineering and design thinking for problem solving and designing, their answers were not sufficient or suitable for the questions. This may be because of the complexity of the questions or unfamiliarity with the complexity of the concepts. Therefore, it can be suggested to support the students in the competency areas of AI

techniques and applications, and AI system design to become AI literate individuals, and enhance their awareness of the concepts required in these competencies. While the respondants were able to describe ethical issues and risks involved in using AI, they need to be supported in the competency areas of a human-centered mindset to enhance the required competencies that focus on the effect of AI systems on humans and the interaction between human lives and AI systems and societies.

Furthermore, the participants who scored high in AI literacy seemed to use AI for problem-solving more than those who scored low in AI literacy. Therefore, it can be suggested to support the students who are low AI literate in the use of AI for problem-solving.

In addition, high scorers in AI literacy explained the working logic of AI and the technical concepts more often than lower scorers. However, it has been observed that those with high AI literacy were unable to explain some of the concepts. Therefore, an important implication for education is providing opportunities for all students, those who are high and low scorers in AI literacy to learn about the fundamentals of how AI works.

In addition, Group 3 had not heard of AI-related concepts before, even though they scored high in AI literacy –they had scored low in Digital Competence. They were not able to comment on any of the three fundamental concepts asked. On the other hand, all participants in Group 1 with high digital competence and AI literacy had heard of these concepts before, and some participants were able to define some. There could be a link between the students' technical understanding of AI and their skills in digital competence, which needs to be explored further. The table 21 shows the summary of the key findings, the comparison with literature and, implications for practice and research.

The study contributes to the field in its attempt to explore whether the competencies of AI literacy can be related to the aspects of digital competence as described in the DigComp framework. Because the participants' digital competence and AI literacy levels were highly related, and the interview data demonstrates the transformation of competencies in the DigComp framework to AI. In addition, Bekiaridis & Attwell (2024) indicated that AI demonstrates an essential role for facilitating students' digital competence. Similarly, Bekiaridis & Attwell (2024) emphasized that AI provides a powerful tool for supporting students with the comprehensive digital competence needed to succeed in an increasingly digital world. It is hoped that the academic community of the institution will have a higher awareness of where they stand regarding AI literacy and digital competence, and how these might be related. For future studies, it may be suggested to include a more diverse sample for the qualitative part of the study.

Table 21. Summary of Key Findings and Their Implications

| Key Findings | Comparison with Literature | Implications for Practice and Research |
|---|---|---|
| AI usage<br><br>It was observed that the participants explained their use of AI for daily and academic purposes, and they gave examples of their experiences in various fields. | These findings are consistent with Chen et al. (2024), showing that most university students used AI to generate ideas for papers, assignments, and projects. | It has been observed that the dimensions of DigComp seem to be transformed into a system where AI performs targeted tasks. Future studies may examine student artifacts. |
| Problem-solving with AI<br><br>It was observed that the tasks the students performed using AI were already the situations they found appropriate and meaningful to solve with AI. Some situations given by interviewees did not contain a problem situation. | Boussioux et al. (2024) emphasized the effectiveness of human AI solutions rather than human solutions in terms of successful implementation, strategic feasibility. | For improving individuals' problem-solving with AI, Boussioux et al. (2024) focused on training for constructing AI literacy. |
| Future design for thirtiary education<br><br>The interviewees described their future AI tool design along the lines they were already using AI now. There were not design examples of highly futuristic or speculative educational design. | Lin et al. (2025) found that only 14% of the 300 higher education students were able to design basic AI prototype systems, which showed a deficiency in higher-order capabilities. | Lin et al. (2025) suggested bridging the gap in students' capability in creativity, educators need to give importance to enhancing students' creativity and promoting project-based learning. |
| Ethical concerns<br><br>All groups were aware of the ethical issues regarding AI use, both for daily and academic purposes. | Wut et al. (2025), who concluded their study as there was notable awareness of ethical considerations of generative AI among the university students. On the other hand, Ghotbi & Ho (2021) found students' moral awareness of AI was fairly low. | Ghotbi & Ho (2021) recommended including ethics of AI in the curriculum. Perkins et al. (2023) suggested a shift toward assessment techniques for higher education such as a substantial number of presentations, in-class oral and written examinations. |
| Technical understanding<br><br>Participants' technical understanding of AI was low, although participants who heard such technical concepts related to AI did not explain the full meanings. | The findings of several studies showed that university students' technical understanding of AI was low (Toker Gokce et al., 2024; Laupichler et al., 2024). | A serious need for training regarding technical aspects of AI was found. Laupichler et al. (2024) suggested the need of giving students' technical understanding of AI greater importance in education curricula. |
| Benefits and risks of AI<br><br>The participants emphasized tasks they already perform using AI as benefits. The participants were able to think of risks more broadly, disadvantages of AI use, and for their own use. | These findings seem similar to the findings from Delello et al. (2023), Pitts et al. (2025), and Özer (2024), found benefits of AI such as efficiency and time-saving, assistance in writing, and risks of AI like lack of effort, privacy and security issues, and academic dishonesty. | Participants' lack of refence to a likely future benefit and little mention of possible future risk showed that it is necessary to increase the students' awareness of the human centered dimension. |

In addition, future studies may examine student artifacts, such as their AI-generated texts or images and the kinds of prompts they employed. Therefore, the participants' interaction with AI can be observed.

## 5.9 Limitations of the study

The limitations of the study can be explained below.

One of the limitations was collecting the quantitative data. Because the digital competence questionnaire includes 82 items, the completion time was approximately thirty minutes. Because the questionnaire includes 82 questions that aim to examine 21 competences in five areas of the DigComp framework, participants may have difficulty maintaining attention and engagement while completing the survey, increasing the time it took to complete the survey. Since the test takes a long time to complete, the respondants may experience fatigue by the end of the questionnaire. In addition, because the participants of the study were from Turkish culture, they had difficulty answering the questions about European culture.

Another limit was the distribution of participants by departments. If the majority of students had participated in the study, the distribution of students across departments would have been balanced. Because the rate of participants' return for the interviews was low, the interviews were carried out with those who agreed to participate in the study. Therefore, the interview participants could not be selected according to the criteria with a different sampling method. Because the number of participants was low in the group, including the lower scores in digital competence and higher scores in AI literacy, fewer students were interviewed than in other groups.

In addition, if the interviews were conducted with instructors, it could be investigated how they integrate AI in their own classes and what they pay attention to the use of AI by their students. It could be investigated how instructors take precautions against ethical concerns in the use of AI for academic purposes.

APPENDIX A

SELF-ASSESSMENT TOOL FOR DIGITAL COMPETENCE

The questions that follow refer to your understanding of your knowledge, skills, and attitude to the use of digital technologies. For each question there will be 4 answer options. Please choose the best option that reflects your level of knowledge, understanding and attitude to each statement.

Answer Options:
For Knowledge (K) Items:
0- I have no knowledge of this / I never heard of this
1- I have only a limited understanding of this and need more explanations
2- I have a good understanding of this
3- I fully master this topic/issue and I could explain it to others

For Skill (S) Items:
0- I don't know how to do it
1- I can do it with help
2- I can do it on my own
3- I can do it with confidence and, if needed, I can support/guide others

For Attitude (A) Items:
0- Not at all
1- Not much / very little
2- Yes / Yes I am /Yes I do
3- Very much!

| | | 0 | 1 | 2 | 3 |
|---|---|---|---|---|---|
| Statements | Type | | | | |
| I know that different search engines may give different search results, because they are influenced by commercial factors. | K | | | | |
| I know which words to use in order to find what I need quickly (e.g. to search online or within a document). | K | | | | |

| | | | | | |
|---|---|---|---|---|---|
| When I use a search engine, I can take advantage of its advanced features. | S | | | | |
| I know how to find a website I have visited before. | S | | | | |
| I know how to differentiate promoted content from other content I find or receive online (e.g. recognising an advert on social media or search engines). | S | | | | |
| I know how to identify the purpose of an online information source (e.g. to inform, influence, entertain, or sell). | S | | | | |
| I critically check if the information I find online is reliable. | A | | | | |
| I know that some information on the Internet is false (e.g. fake news). | K | | | | |
| I know about different storage media (e.g. internal or external hard disk, USB memory, pen drive, memory card). | K | | | | |
| I know how to organise digital content (e.g. documents, images, videos) using folders or tagging to find them back later. | S | | | | |
| I know how to copy and move files (e.g. documents, images, videos) between folders, devices, or on the cloud. | S | | | | |
| I know how to manage and analyse data using software (e.g. sorting, filtering, calculations). | S | | | | |
| I know how to send, reply and forward e-mail. | S | | | | |
| I know that many communication services and social media are free of charge because they are paid for by advertising. | S | | | | |
| I know how to use advanced videoconferencing features (e.g. moderating, recording audio and video). | S | | | | |
| I know which communication tools and services (e.g. phone, email, video conference, text message) are appropriate to use in different circumstances. | K | | | | |
| I am open towards sharing digital content that I think might be interesting and useful to others. | A | | | | |

| | | | | | |
|---|---|---|---|---|---|
| I know how to use cloud services (e.g. Google Drive, DropBox and OneDrive) to share my files. | S | | | | |
| I know how to change who I share content with (e.g. friends, friends of friends, everyone). | S | | | | |
| I know how to reference the source of documents (e.g. the author or web address) that I found online. | S | | | | |
| I know how to apply for a job using a digital platform (e.g. fill in a form, upload my CV and photo). | S | | | | |
| I know that many public services are available on the Internet (e.g. booking a health visit, submitting tax declaration, requesting birth, marriage, residence and other certificates). | K | | | | |
| I know how to pay for goods and services that I buy online (e.g. using direct bank transfer, credit/debit cards, other online payment systems). | S | | | | |
| It matters to me to debate social or political issues online (e.g. in online forums, news sites, Facebook, Twitter). | A | | | | |
| I understand the benefits of remote collaboration (e.g. reduced commuting time). | A | | | | |
| I know how to edit a shared, online document. | S | | | | |
| I know how to invite others and give appropriate permissions to collaborate on a shared document. | S | | | | |
| I am aware that I should ask permission from a person before publishing or sharing photos about them. | K | | | | |
| I know how to recognise online messages and behaviors that attack certain groups or individuals (e.g. hate speech). | S | | | | |
| I can take the right measures if someone is doing the wrong thing online (e.g. an offensive comment, threats). | S | | | | |
| I know how to behave online according to the situation (e.g. formal vs informal). | K | | | | |
| I know my digital identity is everything that identifies me in online environments (e.g. | K | | | | |

| | | | | | |
|---|---|---|---|---|---|
| usernames, likes and posts on social media, petitions signed online). | | | | | |
| I know how to create a profile in digital environments for personal or professional purposes. | S | | | | |
| I know that the EU introduced regulation on The Right to Be Forgotten (i.e. to have one's private information removed from the Internet). | K | | | | |
| I know how to configure the settings in my Internet browser to prevent or limit cookies. | S | | | | |
| I know how to create and edit digital text files (e.g. Word, OpenDocument, Google Docs). | S | | | | |
| I know how to express myself by creating digital content on the Internet (e.g. blog post, video on Youtube). | S | | | | |
| I know how to produce a multimedia presentation with text, images, audio and video elements. | S | | | | |
| To express myself, I am careful to choose the right type of digital media depending on the audience and my aim (e.g. using social media to promote a project). | A | | | | |
| I am keen to create new digital content by mixing and modifying existing digital resources (e.g. a presentation with photos and a soundtrack found on the Internet). | A | | | | |
| I know that some digital content can be reused and reworked legally (e.g. public domain or with Creative Commons licences). | K | | | | |
| I know how to edit or make changes to digital content that others have created (e.g. insert a text into an image, edit a wiki). | S | | | | |
| I know how to create something new by mixing different types of content (e.g. text and images) | S | | | | |
| I am careful to follow the rules about copyrights and licenses of digital content that I find. | A | | | | |
| I know that downloading or sharing digital content (e.g. music, software, films) may have ethical or legal consequences. | K | | | | |

| | | | | | |
|---|---|---|---|---|---|
| I can detect when digital content is made available illegally (e.g. software, movies, music, books, TV). | S | | | | |
| I know which different types of licences apply to the use of digital content (e.g. Creative Commons licences). | S | | | | |
| I am interested in understanding how a task can be broken down into steps so that it can be automated, for example in software or by a robot. | A | | | | |
| I know that programming languages (e.g. Python, Visual Basic, Java) are used to provide a digital device instructions to carry out task. | K | | | | |
| I can write scripts, macros and simple applications to automate the execution of a task. | S | | | | |
| I know that there could be different algorithmic solutions to accomplish a specific computational task (e.g. sorting and searching). | K | | | | |
| I understand the benefits and also the safety risks when using Internet-connected devices or systems (e.g. smart watches, smart home devices). | K | | | | |
| I know about the importance of keeping the operating system, antivirus and other software up-to-date in order to prevent security issues. | K | | | | |
| I know how to configure the settings of a firewall on different devices. | S | | | | |
| I know how to recover digital information and other content (e.g. photos, contacts) from a backup. | S | | | | |
| I know how to restrict or refuse access to my geographical location. | S | | | | |
| I know how to identify suspicious e-mail messages that try to obtain my personal data. | S | | | | |
| I know how to check that the website where I am asked to provide personal data is secure (e.g. https sites, safety logo or certificate). | S | | | | |
| I know which personal data I should not share and display online (e.g. on social media). | K | | | | |
| I am careful about checking the privacy policies of | A | | | | |

| | | | | | |
|---|---|---|---|---|---|
| the digital services that I use. | | | | | |
| I am aware that I should manage the time I spend on my digital devices. | A | | | | |
| I know how to protect myself from unwanted and malicious online encounters and materials (e.g. spam messages, identity theft e- mails). | S | | | | |
| I know about digital tools that can help older people or people with special needs. | K | | | | |
| I seek out ways in which digital technologies could help me to live and consume in a more environmentally friendly way. | A | | | | |
| I know that old digital devices and consumables (e.g. computers, smartphones, batteries) must be appropriately disposed to minimise their environmental impact. | K | | | | |
| I know how to reduce the energy consumption of my devices (e.g. change settings, close apps, turn off wifi). | S | | | | |
| I know 'green' behaviours to follow when buying or using digital devices (e.g. purchase devices with Eco-label, restrain from unnecessary printing of digital files, do not leave mobile phones and laptop chargers connected without the device). | K | | | | |
| When I face a technical problem, I try step-by-step to identify the problem. | A | | | | |
| I know some reasons why a digital device may fail to connect online (e.g. wrong wifi password, airplane mode on). | K | | | | |
| When I face a technical problem, I am able to find solutions on the Internet. | S | | | | |
| I am able to edit the configurations of the operating system of my digital devices to solve technical problems (e.g. automatic stop/start of services, modify registry keys) | S | | | | |
| I usually try to find out if there is a technology solution that might help me address a personal or professional need. | A | | | | |
| I know the mail functions of the most common digital devices (computer, tablet, smartphone). | K | | | | |

| | | | | | |
|---|---|---|---|---|---|
| I know how to select the right tool, device or service to perform a given task (e.g. select a smartphone for my needs, choose a tool for a professional videocall). | S | | | | |
| I know technical solutions that can improve the access and use of digital tools such as language translation, magnification or zoom and text-to-voice functionality. | K | | | | |
| I know that digital technology can be used as a powerful tool to innovate processes and products. | K | | | | |
| I am willing to take part in challenges and contests, aimed at solving intellectual, social or practical problems through digital technologies. | A | | | | |
| I can use data tools (e.g. databases, data mining and analysis software) that manage and organize complex information to make decisions and solve problems. | S | | | | |
| I am willing to help people in my community improve their digital skills. | A | | | | |
| I am curious about new digital devices and applications and I am keen to experiment with them whenever I find the opportunity. | A | | | | |
| I know how to use online learning tools to improve my digital skills (e.g. video tutorial, online courses). | S | | | | |
| I know about new trends in the digital world and how they impact on my personal or professional life. | K | | | | |

APPENDIX B

THE SCALE FOR THE ASSESSMENT OF NON-EXPERTS' AI LITERACY

In the questions asked below, you are asked to mark the option closest to you. 1: Strongly disagree, 7: Strongly agree, and you are expected to answer the question on a scale of 1 to 7, taking into account your own situation.

| | Strongly disagree | Disagree | Somewhat disagree | Neutral | Somewhat agree | Agree | Strongly agree |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| I can tell if the technologies I use are supported by artificial intelligence. | | | | | | | |
| I can name examples of technical applications that are supported by artificial intelligence. | | | | | | | |
| I can explain the difference between general (or strong) and narrow (or weak) artificial intelligence. | | | | | | | |
| I can evaluate whether media representations of AI (e.g. , | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| in movies or video games) go beyond the current capabilities of AI technologies. | | | | | | | |
| I can name weaknesses of artificial intelligence. | | | | | | | |
| I can describe risks that may arise when using artificial intelligence systems. | | | | | | | |
| I can explain how AI applications make decisions. | | | | | | | |
| I can explain how machine learning works at general level. | | | | | | | |
| I can describe how machine learning models trained, validated, and tested. | | | | | | | |
| I can explain the difference between 'supervised learning' and 'unsupervised learning' (in the context of machine learning). | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| I can explain how 'reinforcement learning' works on a basic level (in the context of machine learning). | | | | | | | |
| I can explain how deep learning relates to machine learning. | | | | | | | |
| I can explain what the term 'artificial neural network' means. | | | | | | | |
| I can critically evaluate the implications of artificial intelligence applications in at least one subject area. | | | | | | | |
| I can explain why data plays an important role in the development and application of artificial intelligence. | | | | | | | |
| I can describe why humans play an important role in the development of artificial | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| intelligence systems. | | | | | | | |
| I can describe how some artificial intelligence systems can act in their environment and react to their environment. | | | | | | | |
| I can explain how sensors are used by computers to collect data that can be used for AI purposes. | | | | | | | |
| I can name applications in which AI-assisted natural language processing /undestanding is used. | | | | | | | |
| I can identify ethical issues surrounding artificial intelligence. | | | | | | | |
| I can critically reflect on the potential impact of artificial intelligence on individuals and society. | | | | | | | |
| I can explain why AI has recently | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| become increasingly important. | | | | | | | |
| I can explain how rule-based systems differ from machine learning systems. | | | | | | | |
| I can assess if a problem in my field can and should be solved with artificial intelligence methods. | | | | | | | |
| I can describe what artificial intelligence is. | | | | | | | |
| I can describe the concept of explainable AI. | | | | | | | |
| I can explain why data security must be considered when developing and using artificial intelligence applications. | | | | | | | |
| I can explain why data privacy must be considered when developing and using artificial intelligence applications. | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| I can describe the concept of big data. | | | | | | | |
| I can give examples from my daily life (personal and professional) where I might be in contact with artificial intelligence. | | | | | | | |
| I can describe potential legal problems that may arise when using artificial intelligence. | | | | | | | |

# APPENDIX C

## DEMOGRAPHIC QUESTIONNAIRE

1. Yaşınız:

- o 18-24
- o 25-34
- o 35-44

2. Cinsiyetiniz:

    - o Kadın
    - o Erkek
    - o Söylemek istemiyorum.

3. Bölümünüz:

4. Bölümde kaçıncı sınıftasınız?

- o Hazırlık
- o 1
- o 2
- o 3
- o 4
- o Lisansüstü

5. Aşağıda yer alan AI araçlarından en az 1 kez kullandıklarınızı seçin. Birden fazla AI aracını işaretleyebilirsiniz.

- o ChatGPT
- o Geminİ
- o Copilot
- o Canva
- o Sora

- Slides AI
- Quillbot
- Grammarly
- Scribe
- Dall-E 2
- Diğer
  _____

6. Yapay zeka alanında yer alan çalışmaları ve gelişmeleri takip ediyor musunuz?

- Evet
- Hayır

7. Yapay zeka ile ilgili bir atölye çalışmasına veya seminere katıldınız mı, veya yapay zeka ile ilgili bir ders aldınız mı?

- Evet
- Hayır

## APPENDIX D

## THE INTERVIEW PROTOCOL

Time of Interview:
Date:
Place:
Interviewer:
Interviewee:
Position of Interviewee:

1. Günlük hayatınızda yapay zekayı kullanıyor musunuz? Nasıl?
2. Yapay zeka uygulamalarından dersleriniz ve ödevleriniz için yararlanıyor musunuz? Nasıl?
3. En son denemelerinizden bir örnek tarif edebilir misiniz? Amacınız neydi, hedeflediğiniz çözüme ulaştınız mı? Nasıl?
4. Günlük hayatınızda Yapay Zeka kullanırken ne gibi etik sorunlarla karşılaşıyorsunuz/karşılaşabilirsiniz?
5. Yapay zekayı dersleriniz için kullanırken etik açıdan nelere dikkat ediyorsunuz?
6. Sizin için ne tür problemlerin çözümünde yapay zekayı işe koşmak uygun veya anlamlı oluyor?
7. Akademik amaçlı bir AI aracı tasarlayacak olsanız nasıl bir araç tasarlarsınız? Yapay zekanın hangi özelliklerini göz önünde bulundurursunuz?
8. Yapay zeka kullanımının, ne gibi fayda ve risk taşıdığını düşünüyorsunuz?
9. Sizce yapay zeka uygulamaları nasıl çalışıyor? Çalışma mantığı hakkında ne biliyorsunuz?
10. Yapay sinir ağı, makine öğrenimi ve derin öğrenme kelimelerini duydunuz mu? Bu kavramlar hakkında ne biliyorsunuz?

## APPENDIX E

## CONSENT FORM FOR THE QUANTITATIVE PART OF THE STUDY

T.C.
BOĞAZİÇİ ÜNİVERSİTESİ
SOSYAL VE BEŞERI BILIMLER İNSAN ARAŞTIRMALARI ETIK KURULU
KATILIMCI BİLGİ ve ONAM FORMU

Araştırmayı destekleyen kurum: Boğaziçi Üniversitesi
Araştırmanın adı: Öğrencilerin Dijital Yetkinlik ve Yapay Zeka Okuryazarlık Düzeylerinin Araştırılması
Proje Yürütücüsü/Araştırmacının adı: Assoc. Prof. Günizi Kartal/ Elif Naz Çelik
Adresi: Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü/ Boğaziçi Üniversitesi
E-mail adresi:
Telefonu:

Sayın Öğrenci,

Boğaziçi Üniversitesi Eğitim Teknolojisi yüksek lisans öğrencisi Elif Naz Çelik "Öğrencilerin Dijital Yetkinlik ve Yapay Zeka Okuryazarlık Düzeylerinin Araştırılması" adı altında bilimsel bir araştırma projesi yürütmektedir. Bu araştırmanın amacı Türkiye'nin en iyi üniversitelerinden birinde öğrenim gören öğrencilerin ve öğretim üyelerinin yapay zeka kullanım biçimlerini araştırmak, yapay zeka okuryazarlık düzeyleri ile dijital yeterlilikleri arasında anlamlı bir ilişki olup olmadığını tespit etmektir. Bu çalışma ile katılımcıların yapay zeka ile ilgili farkındalıklarının artması ve yükseköğretim kurum düzeyinde yapay zeka okuryazarlığının geliştirilmesi beklenmektedir. Sizi bu araştırmaya katılmaya davet ediyoruz. Kararınızdan önce araştırma hakkında sizi bilgilendirmek istiyoruz.

Bu araştırmaya katılmayı kabul ettiğiniz takdirde nicel ve nitel olmak üzere iki farklı veri toplama aşamasına katılımınız istenebilir. Birinci aşama olarak nicel veri toplanacaktır. Yapay zeka okuryazarlığı testini tamamlamanız beklenmektedir. Tamamlanan test sonunda yapay zeka okuryazarlık seviyeniz hakkında bilgi sahibi olacaksınız. Testi tamamlamak yaklaşık olarak 20 dakika sürecektir. Ardından, dijital yeterlilik seviyesini gösteren ölçeği tamamlamanız beklenmektedir. Bu ölçeğin tamamlanması yaklaşık olarak 30 dakika sürecektir. Birinci aşamayı tamamlamanız durumunda, ikinci aşama için sizlere yine davet iletilebilir.

Bu araştırma bilimsel bir amaçla yapılmaktadır ve katılımcı bilgilerinin gizliliği esas tutulmaktadır. Katılımcılardan toplanan veriler araştırmacının bilgisayarında ve şifreli bulut hesabında tutulacak, araştırmacının tez danışmanı

dışında kimseyle paylaşılmayacaktır. Toplanan veriler araştırma ve yayınlama süreci tamamlandığında silinecektir.

Bu araştırmaya katılmak tamamen isteğe bağlıdır. Katıldığınız takdirde çalışmanın herhangi bir aşamasında herhangi bir sebep göstermeden onayınızı çekebilirsiniz. Araştırma projesi hakkında ek bilgi almak istediğiniz takdirde Boğaziçi Üniversitesi Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü Öğretim Üyesi Doç. Dr. Günizi Kartal ile temasa geçiniz. Araştırmayla ilgili haklarınız konusunda Boğaziçi Üniversitesi Sosyal ve Beşeri Bilimler İnsan Araştırmaları Etik Kurulu'na (sbinarek@bogazici.edu.tr) da danışabilirsiniz.

Ben, (katılımcının adı) ....., yukarıdaki metni okudum ve katılmam istenen çalışmanın kapsamını ve amacını, gönüllü olarak üzerime düşen sorumlulukları tamamen anladım. Çalışma hakkında soru sorma imkanı buldum. Bu çalışmayı istediğim zaman ve herhangi bir neden belirtmek zorunda kalmadan bırakabileceğimi ve bıraktığım takdirde herhangi bir olumsuzluk ile karşılaşmayacağımı anladım.

Bu koşullarda söz konusu araştırmaya kendi isteğimle, hiçbir baskı ve zorlama olmaksızın katılmayı kabul ediyorum.

____ Araştırmaya katılmayı kabul ediyorum.

Formun bir örneğini aldım / almak istemiyorum (bu durumda araştırmacı bu kopyayı saklar).

Katılımcının Adı-
Soyadı:.....
İmzası:.....
Tarih (gün/ay/yıl): ...../...../.....

Araştırmacının Adı-
Soyadı:.....
İmzası:.....
Tarih (gün/ay/yıl): ...../...../.....

## APPENDIX F

## CONSENT FORM FOR THE QUALITATIVE PART OF THE STUDY

T.C.
BOĞAZİÇİ ÜNİVERSİTESİ
SOSYAL VE BEŞERI BILIMLER İNSAN ARAŞTIRMALARI ETIK KURULU
KATILIMCI BİLGİ ve ONAM FORMU

Araştırmayı destekleyen kurum: Boğaziçi Üniversitesi
Araştırmanın adı: Öğrencilerin Dijital Yetkinlik ve Yapay Zeka Okuryazarlık Düzeylerinin Araştırılması
Proje Yürütücüsü/Araştırmacının adı: Assoc. Prof. Günizi Kartal/ Elif Naz Çelik
Adresi: Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü/ Boğaziçi Üniversitesi
E-mail adresi:
Telefonu:

Sayın Öğrenci,

Boğaziçi Üniversitesi Eğitim Teknolojisi yüksek lisans öğrencisi Elif Naz Çelik "Öğrencilerin Dijital Yetkinlik ve Yapay Zeka Okuryazarlık Düzeylerinin Araştırılması" adı altında bilimsel bir araştırma projesi yürütmektedir. Bu araştırmanın amacı Türkiye'nin en iyi üniversitelerinden birinde öğrenim gören öğrencilerin ve öğretim üyelerinin yapay zeka kullanım biçimlerini araştırmak, yapay zeka okuryazarlık düzeyleri ile dijital yeterlilikleri arasında anlamlı bir ilişki olup olmadığını tespit etmektir. Bu çalışma ile katılımcıların yapay zeka ile ilgili farkındalıklarının artması ve yükseköğretim kurum düzeyinde yapay zeka okuryazarlığının geliştirilmesi beklenmektedir. Bu araştırmanın nicel veri toplama aşamasına katılımınızdan dolayı teşekkür ederiz. Sizi bu araştırmanın ikinci ayağı olan görüşmelere davet ediyoruz. Kararınızdan önce araştırma hakkında sizi bilgilendirmek istiyoruz.

Görüşmeyi kabul ettiğiniz takdirde katılımcıların yapay zeka okuryazarlık seviyelerine göre birbirlerinden nasıl farklılaştıklarını tespit etmeye yönelik sorular sorulacaktır. Görüşmeler, Microsoft Teams uygulaması üzerinden çevrimiçi olarak gerçekleştirilecektir ve yaklaşık 20 dakika sürmesi beklenmektedir.

Bu araştırma bilimsel bir amaçla yapılmaktadır ve katılımcı bilgilerinin gizliliği esas tutulmaktadır. Katılımcılardan toplanan veriler araştırmacının bilgisayarında ve şifreli bulut hesabında tutulacak, araştırmacının tez danışmanı dışında kimseyle paylaşılmayacaktır. Toplanan veriler araştırma ve yayınlama süreci tamamlandığında silinecektir.

Bu araştırmaya katılmak tamamen isteğe bağlıdır. Katıldığınız takdirde çalışmanın herhangi bir aşamasında herhangi bir sebep göstermeden onayınızı çekebilirsiniz. Araştırma projesi hakkında ek bilgi almak istediğiniz takdirde Boğaziçi Üniversitesi Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü Öğretim Üyesi Doç. Dr. Günizi Kartal ile temasa geçiniz. Araştırmayla ilgili haklarınız konusunda Boğaziçi Üniversitesi Sosyal ve Beşeri Bilimler İnsan Araştırmaları Etik Kurulu'na (sbinarek@bogazici.edu.tr) da danışabilirsiniz.

Ben, (katılımcının adı) ....., yukarıdaki metni okudum ve katılmam istenen çalışmanın kapsamını ve amacını, gönüllü olarak üzerime düşen sorumlulukları tamamen anladım. Çalışma hakkında soru sorma imkanı buldum. Bu çalışmayı istediğim zaman ve herhangi bir neden belirtmek zorunda kalmadan bırakabileceğimi ve bıraktığım takdirde herhangi bir olumsuzluk ile karşılaşmayacağımı anladım.

Bu koşullarda söz konusu araştırmaya kendi isteğimle, hiçbir baskı ve zorlama olmaksızın katılmayı kabul ediyorum.

___ Araştırmaya katılmayı kabul ediyorum.

___ Görüşme sırasında kayıt alınmasını kabul ediyorum

Formun bir örneğini aldım / almak istemiyorum (bu durumda araştırmacı bu kopyayı saklar).

Katılımcının Adı-
Soyadı:.....
İmzası:.....
Tarih (gün/ay/yıl): ...../...../.....

Araştırmacının Adı-
Soyadı:.....
İmzası:.....
.....
Tarih (gün/ay/yıl): ...../...../.....

APPENDIX G

THE MEAN AND STD. DEVIATION OF ITEMS OF DIGITAL COMPETENCE

| | Mean | Std. Deviation |
|---|---|---|
| Digital Competence Scale Item Number | | |
| DC1 | 1.74 | .724 |
| DC2 | 2.08 | .640 |
| DC3 | 1.89 | .780 |
| DC4 | 2.50 | .578 |
| DC5 | 2.25 | .702 |
| DC6 | 2.17 | .645 |
| DC7 | 2.05 | .683 |
| DC8 | 2.38 | .586 |
| DC9 | 1.91 | .786 |
| DC10 | 2.32 | .679 |
| DC11 | 2.59 | .538 |
| DC12 | 1.59 | .940 |
| DC13 | 2.79 | .431 |
| DC14 | 2.55 | .625 |
| DC15 | 2.07 | .814 |
| DC16 | 2.42 | .567 |
| DC17 | 2.09 | .792 |
| DC18 | 2.27 | .712 |
| DC19 | 2.44 | .666 |
| DC20 | 2.02 | .819 |
| DC21 | 2.28 | .770 |
| DC22 | 2.36 | .676 |
| DC23 | 2.64 | .545 |
| DC24 | 1.33 | .969 |
| DC25 | 2.15 | .707 |
| DC26 | 2.42 | .673 |
| DC27 | 2.39 | .694 |
| DC28 | 2.56 | .590 |
| DC29 | 2.42 | .622 |

| | | |
|---|---|---|
| DC30 | 2.17 | .755 |
| DC31 | 2.37 | .633 |
| DC32 | 2.28 | .650 |
| DC33 | 2.40 | .628 |
| DC34 | 1.03 | .963 |
| DC35 | 1.83 | .905 |
| DC36 | 2.52 | .608 |
| DC37 | 2.12 | .797 |
| DC38 | 2.24 | .745 |
| DC39 | 2.09 | .723 |
| DC40 | 1.88 | .888 |
| DC41 | 1.71 | .835 |
| DC42 | 1.86 | .884 |
| DC43 | 2.20 | .746 |
| DC44 | 1.73 | .820 |
| DC45 | 2.07 | .702 |
| DC46 | 1.84 | .867 |
| DC47 | 1.08 | .965 |
| DC48 | 1.56 | .955 |
| DC49 | 1.59 | .918 |
| DC50 | 1.10 | .990 |
| DC51 | 1.54 | .895 |
| DC52 | 1.99 | .731 |
| DC53 | 1.91 | .780 |
| DC54 | 1.22 | .951 |
| DC55 | 1.58 | .916 |
| DC56 | 1.99 | .812 |
| DC57 | 2.07 | .841 |
| DC58 | 1.80 | .913 |
| DC59 | 2.19 | .700 |
| DC60 | 1.40 | .897 |
| DC61 | 2.13 | .772 |
| DC62 | 1.92 | .787 |
| DC63 | 1.56 | .897 |
| DC64 | 1.67 | .873 |

| | | |
|---|---|---|
| DC65 | 1.86 | .805 |
| DC66 | 2.12 | .784 |
| DC67 | 1.55 | .898 |
| DC68 | 2.07 | .734 |
| DC69 | 2.20 | .645 |
| DC70 | 2.28 | .697 |
| DC71 | 1.53 | .956 |
| DC72 | 2.02 | .797 |
| DC73 | 2.17 | .689 |
| DC74 | 2.24 | .700 |
| DC75 | 2.06 | .768 |
| DC76 | 2.18 | .706 |
| DC77 | 1.58 | .938 |
| DC78 | 1.33 | 1.027 |
| DC79 | 1.66 | .850 |
| DC80 | 1.75 | .891 |
| DC81 | 2.25 | .715 |
| DC82 | 1.95 | .759 |

APPENDIX H

THE MEAN AND STD. DEVIATION OF ITEMS OF AI LITERACY SCALE

| | Mean | Std. Deviation |
|---|---|---|
| AI Literacy Scale Item Number | | |
| AI1 | 5.32 | 1.434 |
| AI2 | 5.17 | 1.552 |
| AI3 | 4.14 | 1.836 |
| AI4 | 4.86 | 1.672 |
| AI5 | 5.18 | 1.454 |
| AI6 | 5.23 | 1.437 |
| AI7 | 4.22 | 1.630 |
| AI8 | 4.12 | 1.807 |
| AI9 | 3.81 | 1.856 |
| AI10 | 3.45 | 1.958 |
| AI11 | 3.31 | 1.931 |
| AI12 | 3.32 | 1.926 |
| AI13 | 3.28 | 1.989 |
| AI14 | 4.27 | 1.842 |
| AI15 | 4.90 | 1.728 |
| AI16 | 5.25 | 1.470 |
| AI17 | 4.17 | 1.697 |
| AI18 | 3.79 | 1.880 |
| AI19 | 4.00 | 1.846 |
| AI20 | 5.09 | 1.513 |
| AI21 | 5.07 | 1.520 |
| AI22 | 5.41 | 1.531 |
| AI23 | 3.80 | 1.927 |
| AI24 | 4.78 | 1.614 |
| AI25 | 5.13 | 1.514 |
| AI26 | 4.25 | 1.782 |
| AI27 | 4.95 | 1.576 |
| AI28 | 5.00 | 1.613 |

| | | |
|---|---|---|
| AI29 | 3.80 | 1.884 |
| AI30 | 5.42 | 1.577 |
| AI31 | 5.13 | 1.546 |

# APPENDIX I

## ETHICS COMMITTEE APPROVAL

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

Sayı : E-84391427-050.04-212457 23.12.2024
Konu : 2024-53T Kayıt Numaralı Başvurunuz Hakkında

Sayın Doç. Dr. Günizi KARTAL

Tez danışmanlığını yürüttüğünüz öğrenciniz Elif Naz Çelik'in "Exploring digital competence and AI literacy at the tertiary level" başlıklı projesi ile Boğaziçi Üniversitesi Sosyal ve Beşeri Bilimler İnsan Araştırmaları Etik Kurulu (SBİNAREK)'e yaptığınız 2024-53T kayıt numaralı başvuru 03.12.2024 tarih ve 2024/09 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.

# REFERENCES


Akgun, S., & Greenhow, C. (2021). Artificial Intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics*, *2*(3), 431–440. https://doi.org/10.1007/s43681-021-00096-7

Ala-Mutka, K., Punie, Y., & Redecker, C. (2008). Digital competence for lifelong learning. *Institute for Prospective Technological Studies (IPTS), European Commission, Joint Research Centre. Technical Note: JRC, 48708*, 271-282.

Alarcón, R., del Pilar Jiménez, E., & de Vicente- Yagüe, M. I. (2020). Development and validation of the DIGIGLO, a tool for assessing the digital competence of educators. *British Journal of Educational Technology*, *51*(6), 2407–2421. https://doi.org/10.1111/bjet.12919

Azevedo, L., Mallinson, D. J., Wang, J., Robles, P., & Best, E. (2024). AI policies, equity, and morality and the implications for faculty in Higher Education. *Public Integrity*, 1–16. https://doi.org/10.1080/10999922.2024.2414957

Bakiner, O. (2023). What do academics say about Artificial Intelligence Ethics? an overview of the scholarship. *AI and Ethics*, *3*(2), 513–525. https://doi.org/10.1007/s43681-022-00182-4

Barboutidis, G., & Stiakakis, E. (2023). Identifying the factors to enhance digital competence of students at Vocational Training Institutes. *Technology, Knowledge and Learning*, *28*(2), 613–650. https://doi.org/10.1007/s10758-023-09641-1

Bekiaridis, G., & Attwell, G. (2024). Supplement to the DigCompEDU Framework Introduction to AI in Education. *AI Pioneers*.

Bobula, M. (2024). Generative Artificial Intelligence (AI) in Higher Education: A comprehensive review of challenges, opportunities, and implications. *Journal of Learning Development in Higher Education*, (30). https://doi.org/10.47408/jldhe.vi30.1137

Borenstein, J., & Howard, A. (2021). Emerging challenges in AI and the need for AI ethics education. *AI and Ethics*, *1*, 61-65.

Boussioux, L., Lane, J. N., Zhang, M., Jacimovic, V., & Lakhani, K. R. (2024). The crowdless future? Generative AI and creative problem-solving. *Organization Science*, *35*(5), 1589–1607. https://doi.org/10.1287/orsc.2023.18430

Bozkurt, V., & Gursoy, D. (2023). The artificial intelligence paradox: Opportunity or threat for humanity? *International Journal of Human–Computer Interaction*, *41*(1), 174–187. https://doi.org/10.1080/10447318.2023.2297114

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Brinkmann, S. (2014). 14 Unstructured and Semi-Structured Interviewing. *The Oxford handbook of qualitative research*, 277.

Budai, B. B., Csuhai, S., & Tózsa, I. (2023). Digital Competence Development in Public Administration Higher Education. *Sustainability*, *15*(16), 12462. https://doi.org/10.3390/su151612462

Burger, B., Kanbach, D. K., Kraus, S., Breier, M., & Corvello, V. (2023). On the use of AI-based tools like CHATGPT to support management research. *European Journal of Innovation Management*, *26*(7), 233–241. https://doi.org/10.1108/ejim-02-2023-0156

Calvani, A., Fini, A., Ranieri, M., & Picci, P. (2012). Are young generations in secondary school digitally competent? A study on Italian teenagers. *Computers & Education*, *58*(2), 797–807. https://doi.org/10.1016/j.compedu.2011.10.004

Carolus, A., Koch, M. J., Straka, S., Latoschik, M. E., & Wienrich, C. (2023). Mails - meta ai literacy scale: Development and testing of an AI literacy questionnaire based on well-founded competency models and psychological change- and meta-competencies. *Computers in Human Behavior: Artificial Humans*, *1*(2), 100014. https://doi.org/10.1016/j.chbah.2023.100014

Chang, H. J., Huang, K., & Wu, C. (2006). Determination of sample size in using central limit theorem for weibull distribution. International journal of information and management sciences, 17(3), 31.

Chaudhry, M. A., Cukurova, M., & Luckin, R. (2022). *A Transparency Index Framework for AI in Education*. https://doi.org/10.35542/osf.io/bstcf

Chen, K., Tallant, A. C., & Selig, I. (2024). Exploring generative AI literacy in Higher Education: Student adoption, interaction, Evaluation and Ethical Perceptions. *Information and Learning Sciences*, *126*(1/2), 132–148. https://doi.org/10.1108/ils-10-2023-0160

Chen, X., Xie, H., Zou, D., & Hwang, G. J. (2020). Application and theory gaps during the rise of artificial intelligence in education. *Computers in Education: Artificial Intelligence*, *1*, 100002. https://doi.org/10.1016/j.caeai.2020.100002

Chen, X., Zou, D., Xie, H., Cheng, G., & Liu, C. (2022). Two decades of artificial intelligence in education: Contributors, collaborations, research topics, challenges, and future directions. *Educational Technology & Society*, *25*(1), 28–47.

Chiu, T. K. F., Ahmad, Z., Ismailov, M., & Sanusi, I. T. (2024). What are Artificial Intelligence Literacy and competency? A comprehensive framework to support them. *Computers and Education Open*, *6*, 100171. https://doi.org/10.1016/j.caeo.2024.100171

Chiu, T. K. F., Chen, Y., Yau, K. W., Chai, C., Meng, H., King, I., Wong, S., & Yam, Y. (2024). Developing and validating measures for AI literacy tests: From self-reported to objective measures. *Computers and Education: Artificial Intelligence*, *7*, 100282. https://doi.org/10.1016/j.caeai.2024.100282

Choudhary V, Marchetti A, Shrestha YR, Puranam P (2023) Human- AI ensembles: When can they work? *J. Management*, ePub ahead of print October 3, https://doi.org/10.1177/0149206331194968.

Chu-Ke, C., & Dong, Y. (2024). Misinformation and literacies in the era of Generative Artificial Intelligence: A brief overview and a call for future research. *Emerging Media*, *2*(1), 70–85. https://doi.org/10.1177/27523543241240285

Clifford, I., Kluzer, S., Troia, S., Jakobsone, M., Zandbergs, U., Vuorikari, R., ... & O'Keeffe, W. (2020). DigCompSat. A Self-reflection Tool for the European Digital Competence Framework for Citizens. *Publications Office of the European Union*.

Cotton, D. R., Cotton, P. A., & Shipway, J. R. (2023). Chatting and cheating: Ensuring academic integrity in the era of ChatGPT. *Innovations in Education and Teaching International*, 1-12. https://doi.org/10.1080/14703297.2023.2190148

Creswell, J. W. (2014, March 1). Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research.

Çebi, A., & Reisoğlu, İ. (2020). Digital Competence: A study from the perspective of pre-service teachers in Turkey. *Journal of New Approaches in Educational Research*, *9*(2), 294–308. https://doi.org/10.7821/naer.2020.7.583

Çelebi, C., Yılmaz, F., Demir, U., & Karakuş, F. (2023). Artificial intelligence literacy: An adaptation study. *Instructional Technology and Lifelong Learning*, *4*(2), 291-306.

Celik, I., Dindar, M., Muukkonen, H., & Järvelä, S. (2022). The promises and challenges of artificial intelligence for teachers: A systematic review of Research. *TechTrends*, *66*(4), 616–630. https://doi.org/10.1007/s11528-022-00715-y

Daniels, U.-D., Lindner. M., Sommer, S., & Rauch, E. AICOMP - Future Skills in a World Increasingly Shaped By AI 2023 *Ubiquity Proceedings*, 3(1): 230-239. DOI: https://doi.org/10.5334/uproc.91

Delello, J. A., Sung, W., Mokhtari, K., & De Giuseppe, T. (2023). Exploring College Students' Awareness of AI and ChatGPT: Unveiling Perceived Benefits and Risks. *Journal of Inclusive Methodology and Technology in Learning and Teaching*, *3*(4).

Deveci Topal, A., Toker Gokce, A., Dilek Eren, C., Kolburan Geçer, A. (2025). Artificial intelligence literacy scale: A study of reliability and validity in

Turkish university students. *Journal of Learning and Teaching in Digital Age*. In press.

*Digital Competence Framework*. Hwb. (2019). https://hwb.gov.wales/curriculum-for-wales/cross-curricular-skills-frameworks/digital-competence-framework/

Ding, A.-C. E., Shi, L., Yang, H., & Choi, I. (2024). Enhancing teacher AI literacy and integration through different types of cases in teacher professional development. *Computers and Education Open*, *6*, 100178. https://doi.org/10.1016/j.caeo.2024.100178

Edvard Hatlevik, O., Björk Guðmundsdóttir, G., & Loi, M. (2015). Examining factors predicting students' digital competence. *Journal of Information Technology Education: Research*, *14*, 123–137. https://doi.org/10.28945/2126

Ferrari, A. (2012). *Digital competence in practice: An analysis of frameworks* (Vol. 10, p. 82116). Luxembourg: Publications Office of the European Union.

Ferrari, A., & Punie, Y. (2013). DIGCOMP: A framework for developing and understanding digital competence in Europe.

Fuster, G. G. (2014). *The emergence of personal data protection as a fundamental right of the EU* (Vol. 16). Springer Science & Business.

Gallardo-Echenique, E. E., de Oliveira, J. M., Marqués-Molias, L., Esteve-Mon, F., Wang, Y., & Baker, R. (2015). Digital competence in the knowledge society. *MERLOT Journal of Online Learning and Teaching*, *11*(1).

Gedrimiene, E., Celik, I., Kaasila, A., Mäkitalo, K., & Muukkonen, H. (2023). Artificial Intelligence (ai)-enhanced learning analytics (LA) for supporting career decisions: Advantages and challenges from User Perspective. *Education and Information Technologies*, *29*(1), 297–322. https://doi.org/10.1007/s10639-023-12277-4

Ghotbi, N., & Ho, M. T. (2021). Moral awareness of college students regarding Artificial Intelligence. *Asian Bioethics Review*, *13*(4), 421–433. https://doi.org/10.1007/s41649-021-00182-2

Gökçearslan, Ş., Durak, H., Günbatar, M., Atman Uslu, N., & Elçi, A. (2024). Generative Artificial Intelligence (GenAI) Literacy Scale: Validity and Reliability.

Graesser, A. C., Hu, X., Sabatini, J. P., & Carmon, C. M. (2023). Where is ethics in the evolution of AIED's future? *International Journal of Artificial Intelligence in Education*, *34*(1), 92–96. https://doi.org/10.1007/s40593-023-00353-2

Guarini, P., & Peconio, G. (2023). Special needs pre-service teachers digital competencies: An exploratory study at the University of Foggia. *9th International Conference on Higher Education Advances (HEAd'23)*, 75–

82. https://doi.org/10.4995/head23.2023.16237

Halász, G., & Michel, A. (2011). Key competences in Europe: Interpretation, policy formulation and implementation. *European Journal of Education, 46*(3), 289–306. https://doi.org/10.1111/j.1465-3435.2011.01491.x

Hao, X., & Cukurova, M. (2023). Exploring the Effects of "AI-Generated" Discussion Summaries on Learners' Engagement in Online Discussions. In *International Conference on Artificial Intelligence in Education* (pp. 155-161). Cham: Springer Nature Switzerland.

Hazari, S. (2024). Justification and roadmap for Artificial Intelligence (AI) literacy courses in higher education. Journal of Educational Research and Practice, 14(1), 106–118. https://doi.org/10.5590/JERAP.2024.14.1.07

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S. B., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2021). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education, 32*(3), 504–526. https://doi.org/10.1007/s40593-021-00239-1

Hornberger, M., Bewersdorff, A., & Nerdel, C. (2023). What do university students know about artificial intelligence? development and validation of an AI literacy test. *Computers and Education: Artificial Intelligence, 5*, 100165. https://doi.org/10.1016/j.caeai.2023.100165

Hwang, G.-J., Xie, H., Wah, B. W., & Gašević, D. (2020). Vision, challenges, roles and research issues of Artificial Intelligence in Education. *Computers and Education: Artificial Intelligence, 1*, 100001. https://doi.org/10.1016/j.caeai.2020.100001

Ikramovich, K. H. (2023). CRITERIA FOR DEVELOPMENT OF DIGITAL COMPETENCE IN HIGHER EDUCATION. *Galaxy International Interdisciplinary Research Journal, 11*(11), 852-855.

Ilomäki, L., Kantosalo, A., & Lakkala, M. (2011). What is digital competence?. In *Linked portal* (pp. 1-12). European Schoolnet (EUN).

International Society for Technology in Education. (2024). *ISTE standards for students*. https://iste.org/standards/students

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using mixed-methods sequential explanatory design: From theory to practice. *Field Methods, 18*(1), 3–20. https://doi.org/10.1177/1525822x05282260

Karaca, O., Çalıs¸kan, S. A., & Demir, K. (2021). Medical artificial intelligence readiness scale for medical students (MAIRS-MS) – development, validity and reliability study. BMC Medical Education, 21(1), 112. https://doi.org/10.1186/s12909-021-02546-6

Karaca, O., Çalışkan, S. A., & Demir, K. (2021). Medical Artificial Intelligence Readiness Scale for medical students (Mairs-MS) – development, validity

and Reliability Study. *BMC Medical Education*, *21*(1). https://doi.org/10.1186/s12909-021-02546-6

Karaoğlan Yılmaz, F. G. & Yılmaz, R. (2023). Adaptation of artificial intelligence literacy scale into Turkish. *Journal of Information and Communication Technologies*, *5*(2), 172-190. https://doi.org/10.53694/bited.1376831

Karaş, Z. (2024). Effects of ai-generated misinformation and disinformation on the economy. *Düzce Üniversitesi Bilim ve Teknoloji Dergisi*, *12*(4), 2349–2360. https://doi.org/10.29130/dubited.1537268

Kasinidou, M. (2023). Ai literacy for all: A Participatory approach. *Proceedings of the 2023 Conference on Innovation and Technology in Computer Science Education V. 2*. https://doi.org/10.1145/3587103.3594135

Kathala, K. C., & Palakurthi, S. (2024). Ai Literacy Framework and strategies for implementation in developing nations. *Proceedings of the 2024 16th International Conference on Education Technology and Computers*, 418–422. https://doi.org/10.1145/3702163.3702449

Kathala, K. C., & Palakurthi, S. (2024). Ai Literacy Framework and strategies for implementation in developing nations. *Proceedings of the 2024 16th International Conference on Education Technology and Computers*, 418–422. https://doi.org/10.1145/3702163.3702449

Keefe, E. B., & Copeland, S. R. (2011). What is literacy? the power of a definition. *Research and Practice for Persons with Severe Disabilities*, *36*(3–4), 92–99. https://doi.org/10.2511/027494811800824507

Kluzer, S., & Priego, L. P. (2018). *DigComp into Action: Get inspired, make it happen. A user guide to the European Digital Competence Framework* (No. JRC110624). Joint Research Centre.

Kluzer, S., & Priego, L. P. (2018). *DigComp into Action: Get inspired, make it happen. A user guide to the European Digital Competence Framework* (No. JRC110624). Joint Research Centre.

Kong, S.-C., Cheung, M.-Y. W., & Tsang, O. (2024). Developing an artificial intelligence literacy framework: Evaluation of a literacy course for senior secondary students using a project-based learning approach. *Computers and Education: Artificial Intelligence*, *6*, 100214. https://doi.org/10.1016/j.caeai.2024.100214

Kong, S.-C., Korte, S.-M., Burton, S., Keskitalo, P., Turunen, T., Smith, D., Wang, L., Lee, J. C.-K., & Beaton, M. C. (2024). Artificial Intelligence (AI) literacy – an argument for AI literacy in Education. *Innovations in Education and Teaching International*, *62*(2), 477–483. https://doi.org/10.1080/14703297.2024.2332744

Kong, S.-C., Man-Yin Cheung, W., & Zhang, G. (2021). Evaluation of an artificial intelligence literacy course for university students with diverse study

backgrounds. *Computers and Education: Artificial Intelligence, 2*, 100026. https://doi.org/10.1016/j.caeai.2021.100026

Laupichler, M. C., Aster, A., Haverkamp, N., & Raupach, T. (2023). Development of the "scale for the assessment of non-experts' ai literacy" – an exploratory factor analysis. *Computers in Human Behavior Reports, 12*, 100338. https://doi.org/10.1016/j.chbr.2023.100338

Laupichler, M. C., Aster, A., Meyerheim, M., Raupach, T., & Mergen, M. (2024). Medical students' ai literacy and attitudes towards AI: A cross-sectional two-center study using pre-validated assessment instruments. *BMC Medical Education*, *24*(1). https://doi.org/10.1186/s12909-024-05400-7

Laupichler, M. C., Aster, A., Perschewski, J.-O., & Schleiss, J. (2023). Evaluating AI courses: A valid and reliable instrument for assessing artificial-intelligence learning through comparative self-assessment. *Education Sciences*, *13*(10), 978. https://doi.org/10.3390/educsci13100978

Laupichler, M. C., Aster, A., Schirch, J., & Raupach, T. (2022). Artificial Intelligence Literacy in higher and Adult Education: A scoping literature review. *Computers and Education: Artificial Intelligence*, *3*, 100101. https://doi.org/10.1016/j.caeai.2022.100101

Lee, Y.-J., Oh, J., & Hong, C. (2024). Exploratory research on Understanding University Students' Artificial Intelligence Literacy in a Korean University. *Online Journal of Communication and Media Technologies*, *14*(3). https://doi.org/10.30935/ojcmt/14711

Lérias, E., Guerra, C., & Ferreira, P. (2024). Literacy in Artificial Intelligence as a Challenge for Teaching in Higher Education: A Case Study at Portalegre Polytechnic University. https://doi.org/10.20944/preprints202403.0754.v1

Lim, H., Boulden, D., Vandenberg, J., Cateté, V., Min, W., & Mott, B. (2025). Shaping AI interest in rural middle schools with unplugged learning: Gender differences and teacher insights. *Proceedings of the AAAI Conference on Artificial Intelligence*, *39*(28), 29153–29161. https://doi.org/10.1609/aaai.v39i28.35188

Lin, D., Xu, X., & Liu, J. (2025). Chinese high school students AI competency survey: Based on the UNESCO students' ai competency framework. *Journal of Educational Technology and Innovation*, *7*(1). https://doi.org/10.61414/0y6gsj74

Lintner, T. (2024). A systematic review of Ai Literacy Scales. *Npj Science of Learning*, *9*(1). https://doi.org/10.1038/s41539-024-00264-4

Liu, S., & Xie, X. (2021). Ai quality cultivation and application ability training for Normal University students. *2021 7th Annual International Conference on Network and Information Systems for Computers (ICNISC)*. https://doi.org/10.1109/icnisc54316.2021.00030

Liu, Z. (2023). The digital competence of Chinese University Students: A Survey Study. *Journal of Education and Educational Research, 2*(1), 35–38. https://doi.org/10.54097/jeer.v2i1.5132

Long, D., & Magerko, B. (2020). What is ai literacy? competencies and design considerations. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. https://doi.org/10.1145/3313831.3376727

Ma, S., & Lei, L. (2024). The factors influencing teacher education students' willingness to adopt artificial intelligence technology for information-based teaching. *Asia Pacific Journal of Education, 44*(1), 94–111. https://doi.org/10.1080/02188791.2024.2305155

Magrill, J., & Magrill, B. (2024). Preparing Educators and Students at Higher Education Institutions for an AI-Driven World. Teaching and Learning Inquiry, 12, 1-9.

Maguire, M., & Delahunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. *All Ireland journal of higher education*, *9*(3).

Manley, S. (2023). The use of text-matching software's similarity scores. *Accountability in Research, 30*(4), 219-245. https://doi.org/10.1080/08989621.2021.1986018

McLaughlin, J. E., Chen, E., Lake, D., Guo, W., Skywark, E. R., Chernik, A., & Liu, T. (2022). Design thinking teaching and learning in higher education: Experiences across four universities. *Plos one*, *17*(3), e0265902.

McMillan, S. 1996. "Literacy and Computer Literacy: Definitions and Comparisons." Computers & Education 27 (3-4): 161–170.

Mertala, P., Fagerlund, J., & Calderon, O. (2022). Finnish 5th and 6th grade students' pre-instructional conceptions of artificial intelligence (AI) and their implications for AI Literacy Education. *Computers and Education: Artificial Intelligence*, *3*, 100095. https://doi.org/10.1016/j.caeai.2022.100095

Miao, F., Shiohira, K., & Lao, N. (2024). *AI competency framework for Students*. UNESCO.

Migdadi, M. K., Oweidat, I. A., Alosta, M. R., Al-Mugheed, K., Saeed Alabdullah, A. A., & Farghaly Abdelaliem, S. M. (2024). The Association of Artificial Intelligence Ethical Awareness, attitudes, anxiety, and intention-to-use artificial intelligence technology among nursing students. *DIGITAL HEALTH*, *10*. https://doi.org/10.1177/20552076241301958

Ministère de l'Éducation du Québec. (2022). *Digital Competency Framework*. Gouvernement du Québec.https://www.education.gouv.qc.ca/fileadmin/site_web/documents/ministere/Cadre-reference-competence-num-AN.pdf

Mohammadkarimi, E. (2023). Teachers' reflections on academic dishonesty in EFL students' writings in the era of artificial intelligence. *Journal of Applied Learning and Teaching*, *6*(2), 105-113.

Ng, D. T. K., Leung, J. K. L., Chu, K. W. S., & Qiao, M. S. (2021). AI literacy: Definition, teaching, evaluation and ethical issues. *Proceedings of the Association for Information Science and Technology*, *58*(1), 504-509.

Ng, D. T., Leung, J. K., Chu, S. K., & Qiao, M. S. (2021). Conceptualizing ai literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, *2*, 100041. https://doi.org/10.1016/j.caeai.2021.100041

Ng, D. T., Luo, W., Chan, H. M., & Chu, S. K. (2022). Using digital story writing as a pedagogy to develop AI literacy among primary students. *Computers and Education: Artificial Intelligence*, *3*, 100054. https://doi.org/10.1016/j.caeai.2022.100054

Nguyen, T. Q., Ngoc, P. T., Phuong, H. A., Duy, D. P., Hiep, P. C., McClelland, R., & Noroozi, O. (2024). Digital competence of Vietnamese citizens: An application of digcomp framework and the role of individual factors. *Education and Information Technologies*, *29*(15), 19267–19298. https://doi.org/10.1007/s10639-024-12585-3

Özer, M. (2024). Potential benefits and risks of Artificial Intelligence in Education. *Bartın Üniversitesi Eğitim Fakültesi Dergisi*, *13*(2), 232–244. https://doi.org/10.14686/buefad.1416087

Perkins, M., Roe, J., Postma, D., McGaughran, J., & Hickerson, D. (2023). Detection of GPT-4 generated text in Higher Education: Combining Academic Judgement and software to identify Generative AI Tool Misuse. *Journal of Academic Ethics*, *22*(1), 89–113. https://doi.org/10.1007/s10805-023-09492-6

Pettersson, F. (2017). On the issues of digital competence in educational contexts – A review of literature. *Education and Information Technologies*, *23*(3), 1005–1021. https://doi.org/10.1007/s10639-017-9649-3

Pinski, M., & Benlian, A. (2023). AI literacy-towards measuring human competency in artificial intelligence.

Pinski, M., & Benlian, A. (2023). AI literacy-towards measuring human competency in artificial intelligence.

Pitts, G., Marcus, V., & Motamedi, S. (2025). Student Perspectives on the Benefits and Risks of AI in Education. *arXiv preprint arXiv:2505.02198*.

Polatgil, M. & Güler, A. Bilim. Nicel Araştırmalar Derg. 3, 99–114, https://sobinarder.com/index.php/sbd/article/view/65. (2023).

Punie, Y. (2007). Learning spaces: an ICT-enabled model of future learning in the knowledge-based Society. European Journal of Education, 42, 185–199.

Razzouk, R., & Shute, V. (2012). What is design thinking and why is it important? *Review of Educational Research, 82*(3), 330–348. https://doi.org/10.3102/0034654312457429

Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu

Redecker, C., & Punie, Y. (2017). *European Framework for the digital competence of educators: Digcompedu*. Publications Office.

Ritter, S. M., Gu, X., Crijns, M., & Biekens, P. (2020). Fostering students' creative thinking skills by means of a one-year creativity training program. *PLOS ONE, 15*(3). https://doi.org/10.1371/journal.pone.0229773

Røkenes, F. M., & Krumsvik, R. (2014). Development of Student Teachers' Digital Competence in Teacher Education - A Literature Review, Nordic Journal of Digital Literacy, 4 (9). 250-280.

Różewski, P., Kieruzel, M., Lipczyński, T., & Prys, M. (2021). Framework of visual literacy competences for engineering education discussed in the scope of DigComp framework with examples from educational R&D projects. *Procedia Computer Science, 192,* 4441-4447.

Santos, C. C., Mattar, J., & Pedro, N. S. (2021). Uso dos Quadros de Competãancia Digital digcomp E digcompedu EM educaã§ã£o: Revisã£o de Literatura. *Cadernos de Educação Tecnologia e Sociedade, 14*(2), 311–327. https://doi.org/10.14571/brajets.v14.n2.311-327

Schiff, D. (2022). Education for AI, not AI for education: The role of education and ethics in national AI policy strategies. *International Journal of Artificial Intelligence in Education, 32*(3), 527–563. https://doi.org/10.1007/s40593-021-00270-2

Schorcht, S., Buchholtz, N., & Baumanns, L. (2024). Prompt the problem – investigating the mathematics educational quality of AI-supported problem solving by comparing prompt techniques. *Frontiers in Education, 9*. https://doi.org/10.3389/feduc.2024.1386075

Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education, 36,* 111–139. https://doi.org/10.1007/s11165-005-3917-8

Schwarz, S., Bieg, T., Svecnik, E., Schmölz, A., Geppert, C., & Gerdenitsch, C. (2024). Digital Competence Scale (DCS) A Short Self-Assessment Instrument for Measuring Digital Competences. *Nordic Journal of Digital Literacy,* (3), 126-143.

Sillat, L. H., Tammets, K., & Laanpere, M. (2021). Digital Competence Assessment Methods in Higher Education: A systematic literature review. *Education Sciences, 11*(8), 402. https://doi.org/10.3390/educsci11080402

Simon, F. M., Altay, S., & Mercier, H. (2023). Misinformation reloaded? fears about the impact of generative AI on misinformation are overblown. *Harvard Kennedy School Misinformation Review*. https://doi.org/10.37016/mr-2020-127

Sindermann, C., Sha, P., Zhou, M., Wernicke, J., Schmitt, H. S., Li, M., ... & Montag, C. (2021). Assessing the attitude towards artificial intelligence: Introduction of a short measure in German, Chinese, and English language. *KI-Künstliche intelligenz*, *35*(1), 109-118.

Smyrnaiou, Z., Liapakis, A., & Bougia, A. (2023). Ethical use of Artificial Intelligence and new technologies in Education 5.0. *Journal of Artificial Intelligence, Machine Learning and Data Science*, *1*(4), 119–124. https://doi.org/10.51219/jaimld/anastasios-liapakis/15

Soto-Sanfiel, M. T., Angulo-Brunet, A., & Lutz, C. (2024). *The Scale of Artificial Intelligence Literacy for All (SAIL4ALL): A Tool for Assessing Knowledge on Artificial Intelligence in All Adult Populations and Settings*. https://doi.org/10.31235/osf.io/bvyku

Stolpe, K., & Hallström, J. (2024). Artificial Intelligence Literacy for Technology Education. *Computers and Education Open*, *6*, 100159. https://doi.org/10.1016/j.caeo.2024.100159

Su, J., & Yang, W. (2022). Artificial intelligence in early childhood education: A scoping review. *Computers and Education: Artificial Intelligence*, *3*, 100049.

Su, J., & Yang, W. (2023). Digital competence in early childhood education: A systematic review. *Education and Information Technologies*, *29*(4), 4885–4933. https://doi.org/10.1007/s10639-023-11972-6

Subedi, D. (2016). Explanatory sequential mixed method design as the third research community of knowledge claim. American Journal of Educational Research, 4(7), 570-577.

Toker Gokce, A., Deveci Topal, A., Kolburan Geçer, A., & Dilek Eren, C. (2024). Investigating the level of artificial intelligence literacy of university students using decision trees. *Education and Information Technologies*. https://doi.org/10.1007/s10639-024-13081-4

Touretzky, D. S., Gardner-McCune, C., Martin, F., & Seehorn, D. (2019). K-12 guidelines for artificial intelligence: what students should know. In *Proc. of the ISTE Conference* (Vol. 53).

Touretzky, D., Gardner- McCune, C., Breazeal, C., Martin, F., & Seehorn, D. (2019). A year in K–12 AI Education. *AI Magazine*, *40*(4), 88–90. https://doi.org/10.1609/aimag.v40i4.5289

Tzafilkou, K., Perifanou, M., & Economides, A. A. (2022). Development and validation of Students' Digital Competence Scale (sdicos). *International*

*Journal of Educational Technology in Higher Education*, *19*(1). https://doi.org/10.1186/s41239-022-00330-0

Tzirides, A. O., Zapata, G., Kastania, N. P., Saini, A. K., Castro, V., Ismael, S. A., You, Y., Santos, T. A., Searsmith, D., O'Brien, C., Cope, B., & Kalantzis, M. (2024). Combining human and artificial intelligence for enhanced AI literacy in Higher Education. Computers and Education Open, 6, 100184. https://doi.org/10.1016/j.caeo.2024.100184

Tzirides, A. O., Zapata, G., Kastania, N. P., Saini, A. K., Castro, V., Ismael, S. A., You, Y., Santos, T. A., Searsmith, D., O'Brien, C., Cope, B., & Kalantzis, M. (2024). Combining human and artificial intelligence for enhanced AI literacy in Higher Education. Computers and Education Open, 6, 100184. https://doi.org/10.1016/j.caeo.2024.100184

Van Audenhove, L., Vermeire, L., Van den Broeck, W., & Demeulenaere, A. (2024). Data Literacy in the new EU DIGCOMP 2.2 framework how DIGCOMP defines competences on artificial intelligence, internet of things and Data. *Information and Learning Sciences*, *125*(5/6), 406–436. https://doi.org/10.1108/ils-06-2023-0072

Verdú-Pina, M., Usart, M., Grimalt-Álvaro, C., & Ortega-Torres, E. (2023). Students' and teachers' digital competence in a Valencian network of cooperative schools. *Aloma*, *41*(1), 71-82.

Vieru, D. (2014). Towards a multi-dimensional model of digital competence in small- and medium-sized enterprises. *Advances in Information Quality and Management*, 6715–6725. https://doi.org/10.4018/978-1-4666-5888-2.ch660

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The Digital Competence Framework for Citizens-With new examples of knowledge, skills and attitudes.*

Walter, Y. (2024). Embracing the future of artificial intelligence in the classroom: The relevance of AI literacy, Prompt Engineering, and critical thinking in modern education. *International Journal of Educational Technology in Higher Education*, *21*(1). https://doi.org/10.1186/s41239-024-00448-3

Wang, B., Rau, P.-L. P., & Yuan, T. (2022). Measuring user competence in using artificial intelligence: Validity and reliability of Artificial Intelligence Literacy Scale. *Behaviour & Information Technology*, *42*(9), 1324–1337. https://doi.org/10.1080/0144929x.2022.2072768

Wong, G. K., Ma, X., Dillenbourg, P., & Huan, J. (2020). Broadening artificial intelligence education in K-12. *ACM Inroads*, *11*(1), 20–29. https://doi.org/10.1145/3381884

Wut, T. M., Chan, E. A., Wong, H. S., & Chan, J. K. (2025). Perceived Artificial Intelligence Literacy and employability of university students. *Education + Training*. https://doi.org/10.1108/et-06-2024-0272

Yang, W. (2022). Artificial Intelligence Education for young children: Why, what, and how in curriculum design and implementation. *Computers and Education: Artificial Intelligence*, *3*, 100061. https://doi.org/10.1016/j.caeai.2022.100061

Yi, Y. (2021). Establishing the concept of AI literacy. *JAHR*, *12*(2), 353–368. https://doi.org/10.21860/j.12.2.8

Zhang, H., Lee, I., Ali, S., DiPaola, D., Cheng, Y., & Breazeal, C. (2023). Integrating ethics and career futures with technical learning to promote AI literacy for middle school students: An exploratory study. *International Journal of Artificial Intelligence in Education*, *33*(2), 290-324.

Zhao, Y., Pinto Llorente, A. M., & Sánchez Gómez, M. C. (2021). Digital competence in Higher Education Research: A systematic literature review. *Computers & Education*, *168*, 104212. https://doi.org/10.1016/j.compedu.2021.104212