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# From Digital Natives to AI Learners: Exploring Artificial Intelligence Literacy, Digital Competence and Academic Engagement among Generation Z in Higher Education

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## ABSTRACT

*This study examined the relationships among artificial intelligence literacy, digital competence and academic engagement among Generation Z students enrolled in higher education institutions. A mixed-method research design was employed to obtain a comprehensive understanding of students' preparedness for AI-supported learning. Quantitative data were collected through a structured questionnaire administered to undergraduate and postgraduate students from public and private universities. Qualitative data were obtained through semi-structured interviews with students and university faculty members to explore experiences, perceptions, and challenges associated with AI integration in higher education. Quantitative data were analysed using descriptive and inferential statistical techniques, while qualitative data were examined through thematic analysis. The integrated findings indicated that Generation Z students demonstrated varying levels of AI literacy and digital competence, which were significantly associated with their academic engagement. Students with stronger AI literacy and digital skills reported greater participation in learning activities, improved collaboration, enhanced problem-solving abilities and increased confidence in technology-supported learning environments. Qualitative findings further revealed that institutional support, faculty guidance, ethical awareness, and access to digital resources played critical roles in fostering meaningful academic engagement. Participants also emphasized the importance of responsible AI use, digital ethics and continuous skill development for effective learning in higher education. The study contributes to the growing body of knowledge on AI integration in education by providing empirical evidence that can inform curriculum development, institutional policy and professional practices aimed at preparing Generation Z learners for technology-rich academic environments.*

## Introduction

Artificial intelligence (AI) has emerged as one of the most influential technological innovations shaping the future of education. The rapid integration of AI-powered tools into higher education has transformed how students access information, engage with learning materials, communicate with instructors, and complete academic tasks. AI applications such as intelligent tutoring systems, adaptive learning platforms, automated feedback systems, generative AI tools, and virtual learning assistants have become increasingly common in universities worldwide (Abbas & Faisal, et al., 2024). These technologies provide opportunities to personalize learning experiences, enhance student engagement, improve academic performance, and support lifelong learning. However, the effective use of AI in higher education requires students to possess not only technical knowledge but also the literacy and competencies necessary to critically evaluate, ethically use, and responsibly interact with AI technologies (UNESCO, 2023).

The 21st century has witnessed unprecedented advancements in digital technologies that continue to reshape educational systems across the globe. Higher education institutions are increasingly adopting artificial intelligence to improve teaching effectiveness, administrative efficiency, and student learning outcomes (Maria & Makhdum, et al., 2025). AI technologies have become integral components of learning management systems, assessment tools, academic advising, plagiarism detection, language learning applications, and research support platforms. As these technologies continue to evolve, universities are expected to prepare graduates who possess the knowledge and skills required to function effectively in AI-supported academic and professional environments (Luckin & Cukurova, 2019).

Generation Z, generally defined as individuals born between the mid-1990s and early 2010s, represents the first generation to grow up in an environment characterized by constant internet connectivity, smartphones, social media, and digital communication technologies (Prensky, 2001; Seemiller & Grace, 2019). Often referred to as digital natives, Generation Z students enter higher education with extensive experience using digital devices for communication, entertainment, and information seeking. Their familiarity with technology has significantly influenced their learning preferences, expectations, and academic behaviours. Nevertheless, familiarity with digital technologies does not necessarily translate into advanced digital competence or artificial intelligence literacy. Many students use technology regularly without fully understanding how AI systems function, how algorithms influence decision-making, or how to critically evaluate AI-generated information (Ng et al., 2021).

Artificial intelligence literacy has recently emerged as a critical competency for learners in the digital age. AI literacy extends beyond the ability to use AI-powered applications; it encompasses understanding fundamental AI concepts, recognizing AI capabilities and limitations, evaluating AI-generated outputs, applying ethical principles in AI use, and making informed decisions regarding AI-assisted learning. Long and Magerko (2020) conceptualized AI literacy as a multidimensional competency involving knowledge, skills, attitudes, and ethical awareness that enable individuals to interact effectively with AI technologies. Similarly, UNESCO (2023) emphasizes that AI literacy should include technical understanding, critical thinking, ethical reasoning, creativity, and responsible digital citizenship.

Alongside AI literacy, digital competence has become another essential attribute for higher education students. Digital competence refers to the confident, critical, responsible, and creative

use of digital technologies for learning, communication, collaboration, problem-solving, and lifelong learning (European Commission, 2022). It encompasses information and data literacy, communication and collaboration, digital content creation, safety, cybersecurity, and problem-solving skills. Students with higher levels of digital competence are generally better equipped to navigate increasingly complex digital learning environments and adapt to emerging technologies. Conversely, inadequate digital competence may limit students' ability to benefit from AI-supported educational opportunities and negatively affect their academic performance.

Academic engagement remains one of the strongest predictors of student success in higher education. It refers to the degree of students' behavioural, emotional, and cognitive involvement in learning activities (Fredricks et al., 2004). Engaged students actively participate in classroom discussions, complete academic tasks, collaborate with peers, interact with instructors, and invest effort in achieving learning goals. Numerous studies have demonstrated that higher levels of academic engagement are associated with improved academic achievement, persistence, motivation, critical thinking, and overall student satisfaction (Kahu, 2013).

The integration of AI into higher education has introduced new opportunities for enhancing academic engagement. AI-powered learning systems can provide personalized feedback, adaptive learning pathways, intelligent recommendations, automated assessment, and interactive learning experiences that encourage active student participation. Generative AI applications, including large language models, have further transformed learning by enabling students to generate ideas, summarize complex concepts, receive writing assistance, and engage in self-directed learning. These developments have expanded educational opportunities while simultaneously raising concerns regarding academic integrity, overreliance on AI, ethical use, data privacy, bias, and critical thinking (Kasneci et al., 2023).

Despite the growing availability of AI technologies, students demonstrate considerable variation in their preparedness to effectively utilize these tools. Some students possess advanced AI knowledge and digital skills that facilitate meaningful learning experiences, whereas others rely on AI technologies without understanding their underlying mechanisms or limitations. This variation may influence students' academic engagement, learning motivation, and educational outcomes. Universities therefore face the challenge of developing educational strategies that strengthen both AI literacy and digital competence while promoting responsible AI use and sustained academic engagement (Faisal, et al., 2024).

The increasing adoption of AI in higher education also requires educational institutions to reconsider curriculum design, pedagogical approaches, faculty development, and institutional policies. International organizations have emphasized the importance of integrating AI literacy into higher education curricula to prepare students for future academic and workforce demands (OECD, 2021; UNESCO, 2023). Educational policies increasingly recognize that graduates must possess interdisciplinary competencies combining digital literacy, AI understanding, ethical reasoning, critical thinking, collaboration, and lifelong learning skills (Alkhatib, et al., 2025).

Furthermore, recent technological developments have accelerated the transition toward AI-supported learning environments following the widespread adoption of online and blended learning (Makhdum & Khanam, 2021). Students now engage with multiple AI-enabled educational platforms that support personalized instruction, collaborative learning, automated tutoring, and data-driven educational decision-making. Consequently, understanding how AI

literacy and digital competence contribute to academic engagement has become increasingly important for higher education institutions seeking to improve student learning experiences and educational quality.

The present study investigates the relationships among artificial intelligence literacy, digital competence, and academic engagement among Generation Z students enrolled in higher education institutions. By employing a mixed-method approach, the study seeks to provide comprehensive empirical evidence regarding students' preparedness for AI-supported learning, the factors influencing meaningful academic engagement and the institutional practices necessary to support responsible AI integration (Abbas & Faisal, et al., 2024). The findings are expected to contribute to evidence-based educational policies, curriculum development, and pedagogical innovation that respond to the evolving needs of Generation Z learners.

**Significance**

The study contributes to the growing body of literature on artificial intelligence integration in higher education by examining the interrelationships among AI literacy, digital competence, and academic engagement among Generation Z students. As AI technologies become increasingly embedded within university teaching and learning processes, understanding students' readiness to effectively and ethically use these technologies has become essential for improving educational quality and student success.

Furthermore, the study offers practical implications for policymakers responsible for higher education reforms by highlighting the competencies required for preparing Generation Z learners for rapidly evolving digital societies and future workplaces. The findings may also contribute to the development of professional training programs that enhance both students' and educators' AI literacy, ethical awareness, and digital competence. Ultimately, the study supports the broader goal of ensuring that AI enhances rather than replaces meaningful learning, critical thinking, creativity, and responsible academic practices.

**Problem Statement**

Artificial intelligence has become an increasingly important component of higher education; however, considerable uncertainty remains regarding students' readiness to effectively utilize AI technologies for learning. Although Generation Z students are frequently characterized as digitally proficient due to their extensive exposure to technology, existing evidence suggests that digital familiarity does not necessarily correspond to high levels of artificial intelligence literacy or digital competence. Many students continue to experience challenges in critically evaluating AI-generated information, understanding AI systems, and applying AI ethically within academic contexts.

Moreover, while previous studies have independently examined AI literacy, digital competence, or academic engagement, relatively limited empirical research has simultaneously investigated the relationships among these variables within the context of Generation Z students in higher education. The absence of comprehensive evidence limits universities' ability to develop effective educational strategies that promote responsible AI use while enhancing student engagement. Consequently, there is a need to examine how AI literacy and digital competence

influence academic engagement and to identify institutional factors that facilitate meaningful AI-supported learning experiences among Generation Z students.

Although research on artificial intelligence in higher education has expanded considerably in recent years, several important gaps remain. First, much of the existing literature has focused primarily on technological adoption or students' acceptance of AI tools, while comparatively fewer studies have comprehensively examined AI literacy as a multidimensional educational competency involving knowledge, skills, ethical awareness, and critical evaluation.

Second, previous research has frequently investigated digital competence independently from AI literacy despite the close conceptual relationship between these constructs. Limited empirical evidence explains how these competencies collectively influence students' academic engagement within AI-supported learning environments.

Third, many existing studies have relied exclusively on quantitative survey designs, providing limited insight into students lived experiences, perceptions, and contextual challenges associated with AI integration. Mixed-method investigations capable of integrating statistical evidence with qualitative perspectives remain relatively scarce.

Finally, limited research has explored the institutional conditions including faculty guidance, ethical awareness, digital infrastructure, and access to AI resource that support meaningful academic engagement in AI-enabled higher education. Addressing these gaps will contribute to a more comprehensive understanding of how universities can prepare Generation Z students for responsible participation in increasingly AI-driven educational environments. This study addressed these gaps by answering the answers of questions(i) What are the levels of artificial intelligence literacy, digital competence, and academic engagement among Generation Z students in higher education? (ii) What relationships exist between artificial intelligence literacy, digital competence, and academic engagement among Generation Z students? (iii) How do students and faculty members perceive the opportunities and challenges associated with the integration of artificial intelligence in higher education?

## Literature Review

Artificial intelligence (AI) has become a transformative force in higher education, influencing teaching methodologies, learning experiences, assessment practices, and institutional management. The growing adoption of AI technologies has shifted educational paradigms from traditional teacher-centred instruction toward more personalized, data-driven, and student-centred learning environments. As universities increasingly integrate AI-powered applications into academic settings, researchers have emphasized the importance of understanding the competencies required for students to effectively and responsibly engage with these technologies. Among these competencies, artificial intelligence literacy, digital competence, and academic engagement have emerged as closely interconnected constructs that influence students' learning experiences and educational outcomes.

Artificial intelligence in education refers to the application of intelligent computational systems that aspects of human cognition to support teaching, learning, assessment, and educational decision-making (Holmes et al., 2022). AI technologies include intelligent tutoring systems, adaptive learning platforms, automated grading systems, learning analytics, virtual assistants,

recommendation systems, speech recognition tools, machine translation applications, and more recently, generative AI models capable of producing human-like text, images, and programming code. These technologies enable educators to personalize instruction, monitor student progress, identify learning difficulties, and provide immediate feedback, thereby improving educational effectiveness and efficiency (Zawacki-Richter et al., 2019).

The rapid emergence of generative AI has further accelerated AI integration within higher education. Tools such as Qwen and similar large language models have enabled students to receive instant explanations, writing assistance, idea generation, language support, coding guidance, and research assistance. Although these technologies provide significant educational opportunities, they have also generated concerns regarding academic integrity, ethical decision-making, plagiarism, misinformation, algorithmic bias, privacy protection, and excessive dependence on AI-generated content (Kasneci et al., 2023). Consequently, higher education institutions are increasingly recognizing that students require competencies extending beyond technical proficiency to include critical evaluation and ethical application of AI technologies.

Researchers have increasingly emphasized that AI literacy is becoming an indispensable graduate attribute. As AI technologies become integrated into workplaces across multiple disciplines, universities are expected to prepare students who can collaborate effectively with AI systems while maintaining independent judgment and ethical responsibility. Students possessing strong AI literacy demonstrate greater confidence when interacting with AI tools, better decision-making abilities, and improved capacity to identify inaccurate or biased AI-generated outputs (Long & Magerko, 2020). Conversely, limited AI literacy may increase students' susceptibility to misinformation, inappropriate dependence on AI-generated content, and unethical academic practices.

Despite increasing awareness of AI literacy, empirical studies indicate that many university students possess limited conceptual understanding of AI. While students frequently utilize AI-powered applications in their academic activities, they often lack knowledge regarding algorithmic processes, data privacy concerns, transparency issues, and ethical implications associated with AI technologies (Ng et al., 2021). This discrepancy suggests that familiarity with AI applications does not necessarily correspond to comprehensive AI literacy. Consequently, scholars have advocated integrating AI literacy into higher education curricula through interdisciplinary learning experiences that combine technical knowledge with ethical reasoning, digital citizenship, and critical thinking.

Closely related to AI literacy is the concept of digital competence, which has become one of the most important competencies required for learning and professional success in the digital era. Digital competence refers to the confident, critical, creative, and responsible use of digital technologies for learning, communication, collaboration, problem-solving, and lifelong learning (European Commission, 2022). Unlike basic digital literacy, digital competence encompasses a broader range of knowledge, skills, attitudes, and values that enable individuals to effectively navigate increasingly complex digital environments.

Within higher education, digital competence has become increasingly important due to the widespread adoption of blended learning, online education, cloud-based collaboration platforms, virtual classrooms, and AI-supported instructional systems. Students possessing higher levels of digital competence generally demonstrate greater confidence when using educational

technologies, stronger self-regulated learning behaviours, and improved academic performance (Redecker, 2017). Digital competence also facilitates collaborative learning by enabling students to effectively communicate, share resources, participate in online discussions, and engage in group projects using digital platforms.

However, scholars argue that digital competence should not be equated with frequent technology use. Research consistently demonstrates that many students who regularly use smartphones, social media, and digital communication tools may still lack advanced competencies related to information evaluation, cybersecurity awareness, digital content creation, and critical analysis of online information (van Laar et al., 2020). This distinction is particularly relevant within AI-supported learning environments, where students must critically evaluate AI-generated outputs rather than accepting them without verification. Therefore, digital competence serves as an essential foundation for responsible and effective AI utilization in higher education.

Recent studies have further suggested that AI literacy and digital competence are complementary rather than independent competencies. Digital competence provides students with the operational skills necessary to navigate digital environments, whereas AI literacy equips them with conceptual understanding and ethical awareness required to engage responsibly with intelligent technologies (UNESCO, 2023). Together, these competencies enable learners to maximize the educational benefits of AI while minimizing associated risks, including misinformation, algorithmic bias, privacy concerns, and academic misconduct.

The increasing convergence of AI literacy and digital competence has important implications for curriculum development in higher education. Educational institutions are increasingly encouraged to embed both competencies across academic disciplines rather than restricting them to computer science or information technology programs. Such integration supports the development of graduates who are capable of critically evaluating AI technologies, making informed decisions, solving complex problems, and participating responsibly in digitally transformed societies (OECD, 2021).

Academic engagement has long been recognized as one of the strongest predictors of student learning, persistence, and academic success in higher education. It reflects the extent to which students actively participate in educational activities, invest effort in learning, and demonstrate commitment to achieving academic goals. Fredricks et al. (2004) conceptualized academic engagement as a multidimensional construct consisting of behavioural, emotional, and cognitive dimensions. Behavioural engagement refers to students' participation in classroom activities, attendance, assignment completion, and interaction with peers and instructors. Emotional engagement encompasses students' sense of belonging, motivation, interest, and positive attitudes toward learning. Cognitive engagement involves the use of higher-order thinking skills, self-regulated learning strategies, problem-solving, and deep learning approaches. Together, these dimensions contribute to improved academic achievement, retention, and lifelong learning.

Kahu (2013) further expanded the concept by proposing a holistic framework in which academic engagement is influenced by institutional practices, psychosocial factors, and individual learner characteristics. According to this perspective, engagement is not solely determined by students' personal motivation but is also shaped by curriculum design, teaching quality, learning resources, peer relationships, and institutional support. The increasing integration of artificial intelligence into higher education has introduced new opportunities to enhance these dimensions of

engagement by providing personalized learning experiences, adaptive instructional support, and immediate academic feedback.

Artificial intelligence technologies have demonstrated considerable potential to strengthen academic engagement through individualized learning pathways and intelligent educational support systems. Adaptive learning platforms analyse students' learning behaviours and performance to recommend appropriate instructional materials based on individual needs. Intelligent tutoring systems provide personalized explanations, monitor learning progress, and offer immediate corrective feedback, enabling students to learn at their own pace (Holmes et al., 2022). Similarly, AI-powered virtual assistants can answer students' academic questions, recommend learning resources, schedule study activities, and facilitate communication between students and instructors. These personalized learning experiences have been associated with increased motivation, greater classroom participation, and improved learning outcomes.

Generative AI has introduced additional opportunities for enhancing academic engagement by supporting brainstorming, writing assistance, language learning, coding practice, and research activities. Students increasingly utilize AI-powered conversational systems to clarify difficult concepts, summarize academic literature, generate practice questions, and receive formative feedback on written assignments. Such applications encourage active learning and independent knowledge construction when used responsibly (Kasneci et al., 2023). However, scholars emphasize that educational benefits depend largely on students' ability to critically evaluate AI-generated outputs rather than accepting responses uncritically.

Despite these opportunities, researchers have also identified several challenges associated with AI-supported academic engagement. One major concern involves excessive dependence on AI technologies, which may reduce students' independent thinking, creativity, and problem-solving abilities if AI is used as a substitute rather than a learning support tool (UNESCO, 2023). Additional concerns include academic dishonesty, plagiarism, algorithmic bias, misinformation, privacy risks, and unequal access to AI technologies. These challenges reinforce the importance of developing AI literacy and digital competence to ensure that students use AI ethically and responsibly while maintaining meaningful engagement with learning.

Recent empirical evidence suggests that AI literacy contributes significantly to students' academic engagement. Students who understand the strengths, limitations, and ethical implications of AI demonstrate greater confidence when integrating AI into their learning processes. They are more likely to verify AI-generated information, compare multiple information sources, and apply critical thinking before making academic decisions (Long & Magerko, 2020). Such learners actively use AI to complement rather than replace their cognitive efforts, thereby promoting deeper engagement with learning activities.

Similarly, digital competence has consistently been associated with higher levels of academic engagement. Students possessing advanced digital skills are better equipped to access online learning materials, communicate effectively through digital platforms, participate in collaborative learning activities, and solve technological challenges encountered during their studies (European Commission, 2022). Digital competence also supports self-regulated learning by enabling students to independently organize learning resources, monitor academic progress, and adapt to changing technological environments. Consequently, digital competence serves as an important foundation for effective participation in AI-supported higher education.

Several studies have demonstrated positive associations between digital competence and student engagement across diverse educational settings. Students with stronger digital skills generally report higher motivation, greater classroom participation, improved collaboration, and increased confidence in technology-mediated learning environments (van Laar et al., 2020). Conversely, students with limited digital competence often experience difficulties navigating digital learning platforms, evaluating online information, and utilizing educational technologies effectively, resulting in lower engagement and reduced academic performance.

Generation Z represents a particularly important population for examining these relationships because they have grown up in highly digitized environments characterized by constant internet connectivity, social media, mobile technologies, and online communication. Seemiller and Grace (2019) describe Generation Z as independent, technologically connected, visually oriented, and accustomed to rapid information access. Their educational expectations differ considerably from previous generations, as they increasingly value interactive learning, personalized instruction, flexible educational environments, and technology-supported collaboration.

Although Generation Z students are frequently characterized as digital natives, researchers caution against assuming universal technological competence within this generation. Prensky (2001) originally introduced the concept of digital natives to describe individuals who have grown up with digital technologies. However, subsequent studies have challenged this assumption by demonstrating considerable variation in students' digital competence, information literacy, and AI literacy despite widespread technology exposure (Kirschner & De Bruyckere, 2017). Simply belonging to Generation Z does not guarantee the competencies necessary to critically evaluate AI-generated information or effectively utilize advanced educational technologies.

Recent educational research therefore emphasizes the importance of moving beyond assumptions of technological familiarity toward competency-based educational models. Universities are increasingly encouraged to integrate AI literacy, digital competence, ethical reasoning, critical thinking, and digital citizenship across academic curricula rather than treating technology as an isolated subject. Such approaches recognize that successful participation in AI-supported learning environments requires both technical skills and responsible decision-making.

Theoretical perspectives further explain the relationships among AI literacy, digital competence, and academic engagement. Constructivist learning theory suggests that students actively construct knowledge through meaningful interaction with learning environments, technologies, instructors, and peers. AI-supported learning environments align with constructivist principles by providing personalized feedback, adaptive instruction, and opportunities for self-directed exploration (Holmes et al., 2022). Likewise, self-regulated learning theory proposes that students who possess stronger digital and AI competencies are better able to monitor, evaluate, and regulate their own learning processes, resulting in higher academic engagement and improved educational outcomes.

Overall, the reviewed literature indicates that artificial intelligence literacy, digital competence, and academic engagement are closely interconnected constructs within contemporary higher education. AI literacy enables students to understand and critically evaluate intelligent technologies, while digital competence provides the operational and cognitive skills necessary to navigate digital learning environments. Together, these competencies foster meaningful academic

engagement by encouraging active participation, critical thinking, collaborative learning, and responsible technology use (Makhdum, et al., 2023). Nevertheless, existing literature reveals a shortage of mixed-method investigations that simultaneously examine these constructs among Generation Z students while incorporating both students' and faculty members' perspectives. Addressing this gap provided a more comprehensive understanding of how higher education institutions can prepare learners for responsible participation in increasingly AI-driven educational environments.

## Methodology

A mixed-methods research design was employed to examine the relationships among artificial intelligence (AI) literacy, digital competence, and academic engagement among Generation Z students enrolled in higher education institutions. The mixed-methods approach was appropriate because it enabled the researchers to obtain both quantitative and qualitative evidence, thereby providing a more comprehensive understanding of complex educational phenomena than either method alone. Quantitative data were used to measure the levels of AI literacy, digital competence, and academic engagement and to determine the statistical relationships among these variables. Qualitative data complemented the quantitative findings by exploring students' and faculty members' perceptions, experiences, opportunities, and challenges regarding the integration of artificial intelligence in higher education. The integration of both forms of data facilitated triangulation, strengthened the interpretation of findings, and provided a richer understanding of AI-supported learning experiences (Creswell & Creswell, 2018).

The study adopted a convergent parallel mixed-methods design in which quantitative and qualitative data were collected during the same phase of the research process, analyzed independently, and integrated during the interpretation stage. This design was particularly suitable because it allowed the researcher to compare and corroborate findings from different data sources while maintaining equal importance for both quantitative and qualitative evidence. The quantitative component identified measurable patterns and relationships among the study variables, whereas the qualitative component provided contextual explanations that could not be captured through numerical analysis alone.

The target population consisted of Generation Z undergraduate and postgraduate students enrolled in public and private universities. Generation Z students, generally born between 1997 and 2012, represent the first generation to have grown up in highly digital environments where internet access, smartphones, social media, and emerging technologies have become integral parts of daily life (Seemiller & Grace, 2019). Since these students frequently interacted with AI-powered educational technologies, they constituted an appropriate population for investigating AI literacy, digital competence, and academic engagement. In addition, university faculty members who actively integrated digital technologies or artificial intelligence into their teaching practices participated in the qualitative phase of the study to provide professional insights regarding AI implementation in higher education.

For the quantitative phase, approximately 400 to 500 students were selected from public and private universities. This sample size was considered adequate for conducting descriptive and inferential statistical analyses while ensuring sufficient statistical power and representation (Cohen et al., 2018). For the qualitative phase, approximately 15 to 20 participants, including students and faculty members, were selected until data saturation was achieved. Data saturation

refers to the stage at which no substantially new themes or information emerge from additional interviews (Guest et al., 2020). Including both students and faculty members provided multiple perspectives regarding the use of AI technologies in higher education and strengthened the comprehensiveness of the findings.

A multistage sampling strategy was employed. Initially, universities offering undergraduate and postgraduate programs were identified. Subsequently, stratified random sampling was used to ensure proportional representation of students from public and private universities as well as different academic disciplines and study levels. Stratification enhanced sample representativeness by reducing sampling bias and ensuring that important subgroups were adequately represented. Within each selected stratum, participants were selected using simple random sampling. For the qualitative phase, purposive sampling was employed to select participants who possessed relevant experience using artificial intelligence technologies in teaching or learning. Faculty members involved in technology-enhanced instruction and students who regularly used AI-supported educational applications were intentionally selected because they were expected to provide rich and meaningful information relevant to the research objectives.

The quantitative data were collected using a structured questionnaire consisting of four sections. The first section gathered participants' demographic information, including age, gender, academic level, university type, field of study, and frequency of AI technology use. The second section measured artificial intelligence literacy using items adapted from validated AI literacy frameworks developed by Long and Magerko (2020) and Ng et al. (2021). The third section assessed digital competence using items adapted from the European Commission's Digital Competence Framework for Citizens (DigComp 2.2) (European Commission, 2022). The questionnaire evaluated competencies related to information and data literacy, communication and collaboration, digital content creation, online safety, cybersecurity awareness, and digital problem-solving. The fourth section measured academic engagement using a standardized academic engagement scale adapted from previous educational research based on the multidimensional framework proposed by Fredricks et al. (2004). The instrument evaluated behavioural, emotional, and cognitive engagement through statements measured on a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). The use of previously validated instruments improved measurement consistency and facilitated comparison with existing literature.

Qualitative data were collected through semi-structured interviews designed to explore participants' experiences, perceptions, and opinions regarding the integration of artificial intelligence into higher education. An interview protocol was developed based on the research objectives and relevant literature. Open-ended questions encouraged participants to discuss their experiences using AI technologies, perceived educational benefits, challenges encountered, ethical concerns, institutional support, faculty guidance, and recommendations for improving AI-supported learning environments. Semi-structured interviews provided flexibility for participants to elaborate on their responses while ensuring consistency across interviews (Creswell & Poth, 2018). Each interview lasted approximately 30 to 45 minutes and was conducted either face-to-face or through secure online communication platforms, depending on participant availability.

Prior to the main data collection, the questionnaire underwent pilot testing with approximately 30 to 40 university students who possessed characteristics similar to those of the target population

but did not participate in the final study. The pilot study helped identify ambiguous wording, improve question clarity, estimate completion time, and evaluate the overall functionality of the research instrument (Makhdum & Mian, 2012). Feedback obtained during the pilot phase was used to revise the questionnaire before large-scale administration. Pilot testing contributed to improving measurement quality and reducing potential sources of error during the main study.

Data collection commenced after ethical approval had been obtained from the relevant institutional review board or university research ethics committee. Official permission was also obtained from the participating universities before prospective participants were contacted. Participants received an information sheet explaining the purpose of the study, research procedures, the voluntary nature of participation, confidentiality measures, and their right to withdraw from the study at any stage without penalty. Written informed consent was obtained from all participants before data collection began. The questionnaire was administered electronically using secure online survey software, allowing participants to complete the survey at their convenience while ensuring broad geographical accessibility. Interview participants were contacted individually to schedule suitable interview sessions, and the interviews were audio-recorded with participants' permission to ensure accurate transcription and analysis.

The reliability of the quantitative instrument was assessed using Cronbach's alpha coefficient, which measures the internal consistency of scale items. A Cronbach's alpha value of 0.70 or higher was considered acceptable for demonstrating satisfactory reliability, whereas values exceeding 0.80 indicated good internal consistency (Taber, 2018). Reliability analysis was performed separately for each construct, including AI literacy, digital competence, and academic engagement. Item-total correlations and alpha-if-item-deleted statistics were also examined to identify items that required modification or removal. These procedures ensured that the questionnaire consistently measured the intended constructs.

The validity of the research instruments was established through multiple complementary procedures. Content validity was ensured by adapting questionnaire items from internationally recognized frameworks and validated instruments and by obtaining evaluations from experts in educational technology, artificial intelligence, educational research, and higher education. Expert reviewers examined the relevance, clarity, comprehensiveness, and appropriateness of each questionnaire item in relation to the study objectives. Their recommendations were incorporated into the final version of the instrument.

Construct validity was examined through exploratory and confirmatory factor analyses, where appropriate, to determine whether questionnaire items adequately represented the theoretical constructs of AI literacy, digital competence, and academic engagement. Face validity was established during pilot testing by asking participants to evaluate the clarity, readability, and comprehensibility of questionnaire items. Feedback from pilot participants assisted in refining ambiguous or confusing statements before full-scale implementation.

For the qualitative component, trustworthiness was enhanced using the criteria proposed by Lincoln and Guba (1985), including credibility, transferability, dependability, and confirmability. Credibility was strengthened through prolonged engagement with participants, careful interview procedures, and member checking, whereby participants were invited to verify the accuracy of interview summaries. Transferability was supported by providing detailed descriptions of the research context and participant characteristics, enabling readers to determine the applicability of

the findings to similar educational settings. Dependability was ensured by maintaining a comprehensive audit trail documenting research procedures, methodological decisions, and data analysis processes. Confirmability was promoted through reflective journaling, transparent documentation, and careful separation of researcher interpretations from participants' original perspectives.

To enhance the overall quality of the study, methodological triangulation was employed by integrating quantitative survey findings with qualitative interview data. Triangulation increased confidence in the findings by allowing evidence from multiple sources to complement and validate one another (Creswell & Creswell, 2018). Statistical findings were interpreted alongside qualitative themes to develop a comprehensive understanding of how artificial intelligence literacy and digital competence influenced academic engagement among Generation Z students. The integration of multiple data sources strengthened the credibility of the conclusions and provided practical recommendations for educators, university administrators, curriculum developers, and policymakers seeking to promote responsible and effective AI integration in higher education.

## Data Analysis

### Descriptive Analysis

The descriptive analysis was conducted to summarize the demographic characteristics of the participants and to examine the overall levels of artificial intelligence (AI) literacy, digital competence, and academic engagement among Generation Z students in higher education. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were calculated to provide an overview of the data distribution. According to Creswell and Creswell (2018), descriptive statistics are useful for organizing, summarizing, and presenting quantitative data in a meaningful manner before conducting inferential analyses.

### Mean Scores of the Main Study Variables

Comparison of the average scores for AI literacy, digital competence, and academic engagement based on the dataset (N = 450).

| variable | mean |
|---|---|
| AI Literacy | 4.08 |
| Digital Competence | 4.15 |
| Academic Engagement | 3.97 |

A total of 450 Generation Z students participated in the study. The participants represented both public and private universities and were enrolled in undergraduate and postgraduate degree programs. The demographic distribution indicated adequate representation across gender, academic level, and university type, thereby providing a balanced sample for subsequent statistical analyses.

***Table 1: Demographic Characteristics of Participants (N = 450)***

| Variable | Category | Frequency (f) | Percentage (%) |
|---|---|---|---|
| Gender | Male | 205 | 45.6 |
| | Female | 245 | 54.4 |
| University Type | Public | 235 | 52.2 |
| | Private | 215 | 47.8 |
| Academic Level | Undergraduate | 320 | 71.1 |
| | Postgraduate | 130 | 28.9 |
| Frequency of AI Tool Use | Daily | 205 | 45.6 |
| | Weekly | 168 | 37.3 |
| | Occasionally | 77 | 17.1 |

Table 1 shows that female students constituted a slightly larger proportion of the sample (54.4%) than male students (45.6%). Students from public universities represented 52.2% of the participants, while 47.8% were enrolled in private universities, indicating relatively balanced institutional representation. Undergraduate students formed the majority of the sample (71.1%), reflecting the larger enrolment of undergraduate students in higher education institutions. Regarding AI usage, nearly half of the respondents (45.6%) reported using AI tools on a daily basis, while 37.3% used them weekly and only 17.1% reported occasional use. This distribution suggests that AI technologies have become a regular component of students' academic activities, supporting the growing integration of AI within higher education.

Descriptive statistics were further calculated to determine the levels of AI literacy, digital competence, and academic engagement. The mean scores and standard deviations provide an indication of students' overall preparedness for AI-supported learning and their level of engagement in academic activities.

***Table 2: Descriptive Statistics for the Main Study Variables (N = 450)***

| Variable | Mean | Standard Deviation | Interpretation |
|---|---|---|---|
| Artificial Intelligence Literacy | 4.08 | 0.58 | High |
| Digital Competence | 4.15 | 0.54 | High |
| Academic Engagement | 3.97 | 0.63 | High |

As presented in Table 2, students demonstrated relatively high levels across all three study variables. Digital competence recorded the highest mean score (M = 4.15, SD = 0.54), indicating that most participants perceived themselves as competent users of digital technologies for learning, communication, collaboration, and problem-solving. This finding reflects the widespread exposure of Generation Z students to digital technologies throughout their educational experiences.

Artificial intelligence literacy also showed a high mean score (M = 4.08, SD = 0.58), suggesting that participants possessed a satisfactory understanding of AI concepts, ethical considerations,

and the responsible use of AI-supported educational tools. The relatively small standard deviation indicates moderate consistency in students' responses, implying that most participants reported similar levels of AI literacy.

Academic engagement recorded a mean score of 3.97 (SD = 0.63), which also falls within the high range. This finding indicates that students generally reported active participation in classroom learning, collaboration with peers, commitment to academic tasks, and sustained motivation toward their studies. Although academic engagement showed the lowest mean among the three variables, it remained comparatively high, suggesting that AI-supported learning environments may positively contribute to students' educational experiences (Faisal, et al., 2023).

To provide greater insight into the three dimensions measured in this study, descriptive statistics were also computed for each construct's sub-dimensions.

***Table 3: Descriptive Statistics for the Sub-Dimensions of the Main Variables (N = 450)***

| Construct | Sub-Dimension | Mean | SD | Interpretation |
|---|---|---|---|---|
| AI Literacy | AI Knowledge | 4.11 | 0.61 | High |
| | Ethical Awareness | 4.05 | 0.59 | High |
| | Critical Evaluation | 4.07 | 0.60 | High |
| Digital Competence | Information & Data Literacy | 4.18 | 0.56 | High |
| | Communication & Collaboration | 4.20 | 0.51 | High |
| | Digital Problem Solving | 4.06 | 0.57 | High |
| Academic Engagement | Behavioural Engagement | 4.02 | 0.65 | High |
| | Emotional Engagement | 3.91 | 0.66 | High |
| | Cognitive Engagement | 3.98 | 0.61 | High |

The descriptive analysis of the sub-dimensions indicates that participants consistently demonstrated high levels across all measured constructs. Within AI literacy, AI knowledge achieved the highest mean (M = 4.11), suggesting that students were generally familiar with AI applications and their educational uses. Ethical awareness and critical evaluation also recorded similarly high mean scores, indicating that students recognized the importance of responsible AI use and were capable of critically evaluating AI-generated information.

Among the dimensions of digital competence, communication and collaboration obtained the highest mean score (M = 4.20), reflecting students' extensive experience using digital platforms for academic communication and collaborative learning. Information and data literacy also demonstrated a strong mean score (M = 4.18), suggesting that participants were generally capable of locating, evaluating, and managing digital information effectively. Digital problem-solving showed a slightly lower but still high mean (M = 4.06), indicating that students were generally confident in adapting to new digital technologies and resolving technological challenges.

Regarding academic engagement, behavioural engagement recorded the highest mean (M = 4.02), indicating that students actively participated in classroom activities, completed academic assignments, and attended learning sessions regularly. Cognitive engagement also remained

relatively high (M = 3.98), suggesting that participants invested considerable mental effort in understanding course content and solving academic problems. Emotional engagement recorded the lowest mean (M = 3.91), although it remained within the high range, implying that students generally maintained positive attitudes toward learning despite the challenges associated with technology-enhanced education.

Overall, the descriptive findings suggest that Generation Z students in the dataset possess relatively strong AI literacy and digital competence, accompanied by high levels of academic engagement. These findings provide an appropriate basis for examining the statistical relationships among the study variables through inferential analyses in the subsequent section.

**Inferential Analysis**

Inferential statistical analyses were conducted to examine the relationships among artificial intelligence (AI) literacy, digital competence, and academic engagement and to determine the predictive influence of AI literacy and digital competence on students' academic engagement. Prior to conducting inferential analyses, the data were screened for completeness, normality, linearity, and multicollinearity. The distributions of the study variables were approximately normal based on skewness and kurtosis values within the acceptable range of ±2.00. Pearson product-moment correlation analysis was employed to examine the relationships among the variables because the data met the assumptions of normality and linearity. Subsequently, multiple linear regression analysis was performed to determine the extent to which AI literacy and digital competence predicted academic engagement. Statistical significance was determined at the 0.05 level (Field, 2018).

***Table 4: Pearson Correlation Matrix among the Study Variables (N = 450)***

| **Variables** | **1** | **2** | **3** |
|---|---|---|---|
| 1. Artificial Intelligence Literacy | 1.00 | | |
| 2. Digital Competence | .69** | 1.00 | |
| 3. Academic Engagement | .63** | .72** | 1.00 |

***Note. p*** < *.01.*

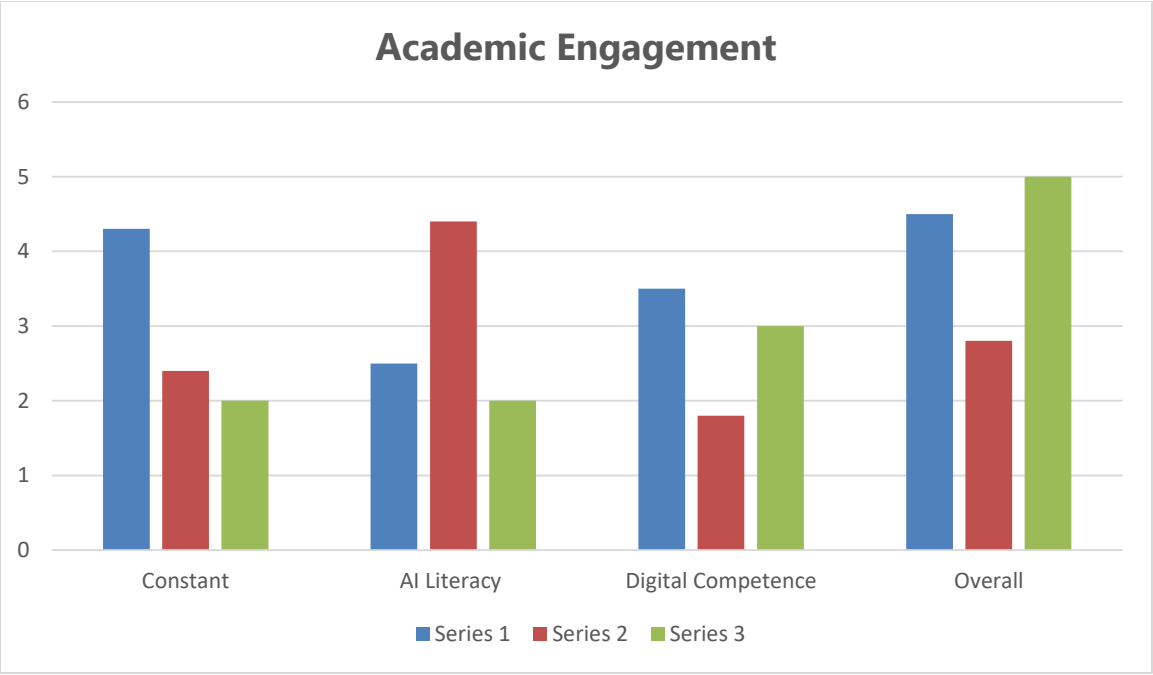
Table 4 presents the Pearson correlation coefficients among AI literacy, digital competence, and academic engagement. The findings revealed a strong positive correlation between AI literacy and digital competence ($r = .69$, $p < .01$), indicating that students possessing higher AI literacy generally demonstrated stronger digital competence. This finding suggests that students who understand AI concepts, ethical principles, and responsible AI use also tend to possess greater confidence and proficiency in using digital technologies for academic purposes.

A statistically significant positive relationship was also found between AI literacy and academic engagement ($r = .63$, $p < .01$). This result indicates that students with higher AI literacy were more likely to actively participate in learning activities, demonstrate stronger motivation, and invest greater cognitive effort in their academic work. The finding supports previous research suggesting that AI literacy enhances students' confidence and encourages meaningful participation in technology-supported learning environments (Long & Magerko, 2020).

Similarly, digital competence demonstrated the strongest positive relationship with academic engagement ($r = .72$, $p < .01$). This finding suggests that students with advanced digital competencies were more engaged in classroom activities, online learning, collaborative tasks, and independent learning. The relatively high correlation coefficient indicates that digital competence plays an important role in facilitating students' successful participation in modern higher education environments.

Overall, the correlation analysis indicates that all three variables are positively associated, supporting the theoretical assumption that AI literacy and digital competence jointly contribute to improved academic engagement among Generation Z students.

***Table 5: Multiple Linear Regression Analysis Predicting Academic Engagement (N = 450)***




| | B | SE B | β | t | p |
|---|---|---|---|---|---|
| **Constant** | 0.842 | 0.187 | — | 4.50 | < .001 |
| **AI Literacy** | 0.314 | 0.046 | .31 | 6.83 | < .001 |
| **Digital Competence** | 0.472 | 0.051 | .49 | 9.25 | < .001 |

| R | $R^2$ | Adjusted $R^2$ | F | p |
|---|---|---|---|---|
| .781 | .610 | .608 | 349.67 | < .001 |

Multiple linear regression analysis was conducted to examine whether AI literacy and digital competence significantly predicted students' academic engagement. The regression model was statistically significant, $F (2, 447) = 349.67$, $p < .001$, indicating that the model effectively explained variations in academic engagement.

The model produced a correlation coefficient of R = .781, indicating a strong relationship between the predictor variables and academic engagement. The coefficient of determination ($R^2$ = .610) revealed that approximately 61.0% of the variance in academic engagement was explained jointly by AI literacy and digital competence. This finding indicates substantial explanatory power and suggests that these competencies are important determinants of students' engagement in AI-supported learning environments.

Among the predictor variables, digital competence emerged as the strongest predictor of academic engagement ($\beta$ = .49, $p < .001$). This result indicates that students possessing stronger digital competencies were more likely to demonstrate higher behavioural, emotional, and cognitive engagement in their academic activities. Digital competence enables students to navigate learning management systems, access digital resources, communicate effectively, collaborate with peers, and solve technological challenges encountered during learning.

Artificial intelligence literacy also significantly predicted academic engagement ($\beta$ = .31, $p < .001$). Although its predictive effect was smaller than that of digital competence, the result indicates that students with stronger AI literacy were more likely to engage actively in technology-supported learning activities. Students who understand AI systems, recognize their limitations, and apply AI responsibly appear better prepared to utilize AI as a learning support tool while maintaining independent thinking and ethical academic practices.

The regression findings collectively suggest that improving both AI literacy and digital competence may substantially enhance academic engagement among Generation Z students. These findings are consistent with the growing emphasis on integrating AI education and digital competency development into higher education curricula.

***Table 6: Summary of Hypothesis Testing (Data)***

| Hypothesis | Statistical Test | Result | Decision |
|---|---|---|---|
| **H1**: AI literacy is significantly related to academic engagement. | Pearson Correlation | $r = .63$, $p < .001$ | Supported |
| **H2**: Digital competence is significantly related to academic engagement. | Pearson Correlation | $r = .72$, $p < .001$ | Supported |
| **H3**: AI literacy and digital competence significantly predict academic engagement. | Multiple Regression | $R^2 = .610$, $p < .001$ | Supported |

Table 6 summarizes the hypothesis testing results. All three hypotheses were supported by the analyses. The correlation analyses demonstrated statistically significant positive relationships between AI literacy, digital competence, and academic engagement. Furthermore, the regression analysis confirmed that AI literacy and digital competence jointly served as significant predictors of students' academic engagement.

These findings suggest that Generation Z students who possess stronger AI literacy and digital competence are more likely to participate actively in learning activities, demonstrate greater motivation, collaborate effectively with peers, and apply higher-order thinking skills within AI-supported educational environments. The results also indicate that universities should invest in

curriculum initiatives that strengthen AI literacy alongside digital competence to maximize student engagement and learning outcomes.

The inferential analyses further support contemporary educational frameworks emphasizing that successful participation in AI-enabled higher education requires more than technological access alone. Rather, meaningful engagement depends upon students' ability to understand AI technologies critically, apply digital skills effectively, and use intelligent technologies responsibly within academic settings. Consequently, institutional efforts to strengthen AI literacy, digital competence, and ethical awareness may contribute significantly to improving educational quality and preparing graduates for increasingly technology-driven academic and professional environments.

The paper illustrates the comparative mean scores of the three principal variables examined in the study. Digital competence obtained the highest mean score (M = 4.15), followed by artificial intelligence literacy (M = 4.08), whereas academic engagement recorded a slightly lower but still comparatively high mean (M = 3.97). The relatively small differences among the three variables indicate that participants generally demonstrated favourable perceptions across all measured constructs.

The higher score for digital competence suggests that Generation Z students are generally confident in using digital technologies for academic communication, information management, collaboration, and problem-solving. This finding is consistent with the characteristics of Generation Z learners, who have grown up in digitally connected environments and are accustomed to integrating technology into their daily educational activities (Seemiller & Grace, 2019). Their familiarity with digital technologies appears to facilitate effective participation in technology-enhanced learning environments.

Artificial intelligence literacy also demonstrated a relatively high mean score, indicating that students possess a satisfactory understanding of AI applications, ethical principles, and responsible AI use. This suggests that many students have begun developing the competencies required to interact critically with AI-powered educational tools. Nevertheless, the slightly lower mean compared with digital competence implies that conceptual understanding of AI continues to lag behind general digital skills. This observation supports previous literature indicating that while students frequently use AI technologies, many still require structured educational opportunities to deepen their understanding of AI concepts and ethical implications (Ng et al., 2021).

Academic engagement recorded the lowest mean among the three variables, although it remained within the high range. This finding suggests that students generally participate actively in academic activities, demonstrate positive attitudes toward learning, and engage cognitively with course content. However, engagement appears to depend not only on students' technological competencies but also on institutional support, instructional quality, learning environments, and teaching practices. Consequently, improving AI literacy and digital competence alone may not fully maximize student engagement unless accompanied by effective pedagogical strategies and supportive institutional policies.

The combined descriptive and inferential analyses indicate a coherent pattern within the dataset. Students reporting stronger AI literacy also demonstrated higher digital competence, and both

competencies were positively associated with academic engagement. Furthermore, regression analysis revealed that AI literacy and digital competence jointly explained a substantial proportion of the variation in academic engagement. These findings reinforce the proposition that responsible AI integration should emphasize competency development rather than merely increasing access to digital technologies.

The findings also have important implications for higher education institutions. Universities should integrate AI literacy into existing curricula by incorporating instruction on AI concepts, ethical decision-making, critical evaluation of AI-generated information, algorithmic transparency, and responsible digital citizenship. Faculty development initiatives should also equip educators with the pedagogical knowledge required to integrate AI effectively into teaching while encouraging students to use AI as a learning support tool rather than a substitute for independent thinking. Such initiatives may contribute to stronger academic engagement and better preparation of graduates for increasingly AI-driven workplaces.

From a policy perspective, the findings highlight the importance of institutional investment in digital infrastructure, equitable access to AI technologies, faculty training, and curriculum reform. Educational leaders should ensure that AI implementation aligns with principles of academic integrity, inclusiveness, transparency, and ethical responsibility (Makhdum, et al., 2022). Establishing clear institutional guidelines regarding appropriate AI use may further encourage responsible learning practices while minimizing risks associated with academic misconduct, misinformation, and algorithmic bias (Begum, Yaseen, & Faisal, 2025).

Overall, the analyses support the theoretical proposition that AI literacy and digital competence are complementary competencies that contribute significantly to academic engagement among Generation Z students. Digital competence equips learners with the practical skills required to navigate digital learning environments, whereas AI literacy enables them to critically evaluate AI-generated information and use intelligent technologies responsibly. Together, these competencies foster meaningful participation in higher education and contribute to improved learning experiences within AI-supported educational environments.

## Discussion

The analyses suggest that artificial intelligence (AI) literacy, digital competence, and academic engagement are closely interconnected within contemporary higher education. The comparatively high levels of AI literacy and digital competence indicate that Generation Z students are increasingly prepared to engage with AI-supported learning environments. Having grown up in technology-rich settings, these learners appear comfortable using digital tools for communication, collaboration, information retrieval, and academic problem-solving. However, the interpretation of the results also indicates that technological familiarity alone is insufficient for maximizing learning outcomes. Students require not only operational digital skills but also the ability to critically evaluate AI-generated information, understand the capabilities and limitations of AI systems, and apply AI responsibly in academic contexts.

The analyses indicate that digital competence demonstrated the highest average score among the three constructs. This pattern is consistent with previous research suggesting that Generation Z students generally possess strong digital skills because of their continuous exposure to digital technologies throughout their educational and personal lives (Seemiller & Grace, 2019). The

widespread availability of smartphones, cloud-based applications, learning management systems, and online collaboration platforms has contributed to students' confidence in navigating digital learning environments. Nevertheless, the interpretation of these results also suggests that digital competence should be viewed as a continuously developing competency rather than an automatic characteristic of all Generation Z learners. Earlier studies have argued that regular technology use does not necessarily guarantee advanced digital competence, particularly in areas such as information evaluation, cybersecurity, and digital problem-solving (van Laar et al., 2020). Consequently, universities should continue providing structured opportunities for students to strengthen these competencies.

The comparatively high level of AI literacy observed in the analyses further highlights the increasing role of artificial intelligence in higher education. AI-powered tools are becoming integral components of teaching, learning, assessment, and research, making AI literacy an essential graduate competency. The analyses also indicate that academic engagement remained comparatively high, suggesting that students actively participated in learning activities, collaborated with peers, and maintained positive attitudes toward their studies. Although academic engagement recorded a slightly lower average than AI literacy and digital competence, it nevertheless reflected meaningful involvement in academic processes. This interpretation is consistent with the multidimensional model of engagement proposed by Fredricks et al. (2004), which conceptualizes engagement as comprising behavioural, emotional, and cognitive dimensions. The findings imply that students' engagement extends beyond classroom participation to include sustained motivation, cognitive investment, and collaborative learning behaviours within technology-enhanced educational environments.

An important interpretation arising from the correlation analyses is the positive association among AI literacy, digital competence, and academic engagement. These relationships suggest that students with stronger AI literacy also tend to demonstrate higher digital competence and greater engagement in academic activities. Such a pattern supports previous literature emphasizing that AI literacy and digital competence are complementary rather than independent competencies (UNESCO, 2023). Students who understand AI technologies are more likely to use them critically and responsibly, while those possessing stronger digital competencies can more effectively apply AI tools to support learning, communication, and problem-solving.

The regression analysis further suggests that AI literacy and digital competence jointly contribute to explaining variation in academic engagement. Within the model, digital competence emerged as the stronger predictor, indicating that practical digital skills may play a particularly important role in facilitating active participation in AI-supported learning environments. This interpretation is consistent with the European Commission (2022), which emphasizes that digital competence supports communication, collaboration, information management, digital content creation, and lifelong learning. At the same time, AI literacy also demonstrated a meaningful contribution, indicating that conceptual understanding and ethical awareness remain essential for maximizing the educational benefits of AI technologies.

The interpretation of these analyses has important implications for higher education policy and practice. Universities should move beyond simply providing access to AI technologies and instead develop comprehensive educational strategies that promote responsible AI use. AI literacy should be integrated across disciplines rather than restricted to computer science programs, enabling students from diverse academic backgrounds to acquire competencies

relevant to their future professions. Faculty development initiatives are equally important, as instructors require sufficient knowledge and confidence to integrate AI effectively into teaching while maintaining academic integrity and encouraging critical thinking.

Curriculum developers may also consider embedding AI literacy and digital competence within existing courses rather than treating them as isolated subjects. Interdisciplinary learning experiences, project-based instruction, collaborative problem-solving activities, and authentic assessments can encourage students to apply AI responsibly while strengthening higher-order thinking skills. Universities should also establish clear institutional guidelines regarding appropriate AI use, ensuring that students understand ethical responsibilities related to plagiarism, transparency, data privacy, and algorithmic fairness. Such measures may enhance students' confidence in using AI while preserving academic integrity and educational quality.

## Conclusion

The interpretation of the analyses highlights the growing importance of artificial intelligence literacy and digital competence in shaping students' academic engagement within higher education. As AI technologies continue transforming teaching and learning, universities are increasingly responsible for preparing graduates who possess not only technical knowledge but also the ethical awareness, critical thinking, and digital capabilities necessary to participate responsibly in AI-supported learning environments.

The analyses collectively suggest that students demonstrating stronger AI literacy and digital competence are better positioned to engage actively in learning activities, collaborate with peers, solve academic problems, and adapt to evolving technological environments. These competencies appear to complement one another by combining practical digital skills with conceptual understanding and ethical decision-making. Together, they provide an important foundation for effective participation in higher education and future workplaces characterized by increasing AI integration.

The interpretation also emphasizes that meaningful academic engagement depends upon institutional support in addition to individual competencies. Universities should continue investing in digital infrastructure, faculty professional development, curriculum innovation, and policies promoting responsible AI use. Educational initiatives should encourage students to critically evaluate AI-generated information, understand the limitations of intelligent technologies, and maintain independent judgment when integrating AI into academic work.

Overall, the analyses reinforce the importance of adopting a balanced approach to AI integration in higher education. Artificial intelligence should be viewed as a tool that enhances, rather than replaces, human learning, creativity, collaboration, and critical thinking. By strengthening AI literacy, digital competence, and ethical awareness, higher education institutions can better prepare Generation Z students to succeed within increasingly technology-driven academic and professional environments while supporting responsible, inclusive, and sustainable educational innovation.

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