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The challenge-based education approach and generative AI tools in the development of digital skills

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ABSTRACT
This study underscores the need to foster digital skills in higher education. It examines how integrating generative AI tools and challenge-based education into a statistics curriculum can promote data and information literacy, as well as the ethical use of information. The study aims to examine the perceptions of 112 undergraduate students enrolled in a higher education data analysis course concerning the development of six digital literacy skills following a pedagogical intervention. Conducted over one academic term, this mixed-methods study collected data through questionnaires and student reports. Results indicate that students made the greatest progress in communication, personal security, critical thinking, and technological skills, with communication standing out. These skills were strongly correlated, showing the interrelated nature of digital competence, while information skills remained the main challenge. Qualitative data highlight the role of generative AI tools in enhancing collaboration, output quality, and ethical awareness. Overall, the findings suggest that AI-supported interventions can foster digital literacy and transversal soft skills, thereby preparing students for the demands of the twenty-first century.

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Introduction

Navigating a modern knowledge society requires students to develop a deep understanding of global dynamics through various means, including education. In this context, contemporary education increasingly seeks to promote students' holistic development, transcending the often superficial or procedural mastery of academic content.

According to Kabri et al. (2024), developing digital skills in higher education offers several advantages. By fostering digital literacy, universities enable students to enhance their employability and remain competitive in a rapidly changing environment. Digital skills, such as data literacy, critical thinking, and effective use of technological tools, are now essential for future workers to engage with complex problems and optimise performance across various industries. Integrating these skills into higher education helps students become not only job-ready but also more resilient in adapting to future technological advancements (Zhao et al., 2021). Technological skills enable students to effectively navigate and utilize technology, which is crucial in the digital age (Cooper & Frey, 2021).

Therefore, it is essential to integrate strategies that foster these digital skills across various areas of the curriculum, including the teaching of statistical methods, given the growing importance of data, information literacy, and the ethical use of data in contemporary society (Nwagwu, 2024). Digital literacy enables students to access, analyse, interpret, and communicate statistical data effectively through a range of digital tools and platforms (Kabri et al., 2024). In addition, integrating digital technologies into the teaching of statistical methods can foster creativity, innovation, and a deeper understanding of the subject matter (Chama, 2023). This is especially relevant in higher education contexts, where students are expected not only to work with statistical information but also to communicate their analyses clearly in academic and professional settings. From this perspective, Vaganova et al. (2021) highlight the importance of digital educational resources in teaching professional English communication, which is pertinent to this study insofar as students in data analysis must explain statistical procedures, justify interpretations, and present findings using appropriate disciplinary language.

Overall, Challenge-Based Education (CBE) is a learner-centered approach that equips students with 21st-century skills by engaging them in authentic, real-world challenges and fostering critical thinking, problem-solving, and lifelong learning (Mayanaza et al., 2023; Van den Beemt et al., 2023). In an era increasingly defined by data and information, higher education faces the urgent challenge of equipping students not only with the ability to manage and critically analyse data, but also with the transversal soft skills needed to interpret, communicate, and act upon that information responsibly. This study aims to understand participating students' perceptions of the development of six digital literacy skills at the end of an educational intervention designed to promote these competencies. Specifically, it focuses on the perceptions of 112 undergraduate students who engaged in a challenge-based learning experience supported by generative AI tools. The central research question is: How do students perceive the development of six skills after participating in a challenge-based educational intervention supported by generative AI tools, designed to foster these skills?

This research employs a mixed-method approach to gather comprehensive data on the subject, and its findings can contribute to understanding students' perceptions of the role of digital literacy in developing these skills, thus providing insights into implementing more effective educational approaches. In this article, we present the challenge-based education approach used in the study, a theoretical contextualization of digital skills in higher education, and generative AI tools in higher education. We present the study's method and discuss the results. Finally, we present the study's main findings, suggestions for future research, and identified limitations.

Related Work

A rigorous understanding of the theoretical and empirical foundations of this study requires situating it within three complementary strands of research: challenge-based education, the development of digital skills in higher education, and the emerging role of generative AI tools in learning contexts. These areas provide the conceptual and methodological basis for our work, as the intervention described here combines challenge-based learning strategies with AI-driven tools to foster students' digital competence. Reviewing the state of the art in these domains is therefore essential to clarify how existing approaches inform our study design and how this research contributes to advancing knowledge at the intersection of these fields.

Challenge-Based Education

The structure of the following sub-sections is guided by a conceptual framework emerging from the reviewed literature on Challenge-Based Learning (CBL). CBL has been consistently characterised as a pedagogical model that combines authentic challenges, interdisciplinary collaboration, and iterative reflection (Willis et al., 2017). Recent empirical studies further show that these elements are especially relevant in higher education for fostering innovation, entrepreneurship, student agency, and self-leadership, particularly when learners engage with authentic challenges and external stakeholders (Martínez & Crusat, 2020; Willis et al., 2017). Accordingly, the following sections first address the theoretical underpinnings of CBL, then review evidence of its educational impact, and finally examine its application in contexts that promote digital competences and entrepreneurship. This organisation ensures that the theoretical discussion remains conceptually coherent rather than fragmented.

Challenge-Based Education is an experiential and active learning approach in which students acquire knowledge by collaboratively addressing open-ended, real-world problems. Such challenges require realistic thinking, action, and reflection, engaging students both cognitively and emotionally (Grabinger et al., 1997). A central feature of CBL is its connection to authentic contexts and, frequently, to external stakeholders or “challenge owners”, which strengthens the relevance of the learning process and encourages the integration of interdisciplinary knowledge (Martínez & Crusat, 2020). Throughout this process, students investigate the challenge, generate ideas, develop representations of their learning, and ultimately produce a solution, proposal, or artefact aligned with the challenge context. CBL can be implemented in face-to-face, digital, or blended formats, often incorporating coaching, mentoring, and modeling, and has been widely adopted in higher education to support competencies required in complex professional and societal settings (Van den Beemt et al., 2023).

In higher education, CBL offers several pedagogical advantages. It facilitates collaborative problem-solving by embedding real-world challenges in the curriculum and providing practical opportunities to experience the dynamics of professional work (Ruiz-Cantisani et al., 2021). It also creates a more engaging teaching and learning environment, fostering teamwork, creativity, problem-solving, and the ability to work under pressure (Barbedo et al., 2023; Carella & Colombo, 2024; Mai et al., 2020). In addition, CBL supports the application of theoretical concepts, including algorithm design and development skills in technology-related contexts (Barbedo et al., 2023; Capone et al., 2019; Mai et al., 2020). The model further expands possibilities for curriculum delivery through new forms of communication and access to instructional content beyond traditional face-to-face settings (Boubsil & Carabajal, 2009). Although this broadens the potential for improving the quality of learning experiences, it also introduces new curricular and organisational challenges (Boubsil & Carabajal, 2009). At the same time, CBL has been shown to nurture initiative and entrepreneurship, particularly in programmes where structured challenge-based pathways lead students to develop innovative solutions with real social or entrepreneurial impact (Martínez & Crusat, 2020).

Digital Skills in Higher Education

The development of digital skills is crucial for university students, the future professionals of the 21st-century. Digital competence is a transversal competence that must be strengthened in undergraduate and postgraduate training (Marrero-Sánchez & Vergara-Romero, 2023). Promoting the development of digital skills in higher education is essential to preparing students for the challenges of the modern workplace. As technology becomes integrated into every sector, it is crucial for universities to bridge the digital skills gap by incorporating digital literacy into their curricula. This approach ensures that students are equipped with the technological adaptability required to navigate the ever-evolving job market (Zhao et al., 2021). In this modern era, educators are expected to be able to use technological developments in their teaching practices, as technology connected to the internet directly yields positive impacts (An-Nisa et al., 2021). Current university students, particularly those in traditional undergraduate age groups, have their learning experiences and expectations strongly shaped by the technologies and media they use in everyday life (An-Nisa et al., 2021; Cooper & Frey, 2021). Therefore, they need to use existing technologies critically and effectively, as these can positively influence both their academic trajectories and future careers (An-Nisa et al., 2021). Developing digital skills is thus crucial for university students' preparation for the twenty-first-century workforce, given that technological literacy is a key component of the contemporary skill set (Kabri et al., 2024). Therefore, they must be able to make proper use of existing technology, as it can positively affect their lives and careers (An-Nisa et al., 2021). Developing digital skills is crucial for university students to be prepared for the 21st-century workforce, as technological literacy is a key component of the 21st-century skillset (Kabri et al., 2024).

The development of personal security skills enables students to navigate the increasingly digital and technology-driven workplace, allowing them to adapt and thrive in the modern work environment (Cooper & Frey, 2021). Equipping students with proficiency in personal security skills will better prepare them to manage the challenges and risks of the digital world, empowering them to become responsible and autonomous professionals (Passey et al., 2018).

The development of critical thinking skills is crucial for students in higher education (Zhang, 2020). Critical thinking enables students to analyse information, evaluate arguments, and solve problems more effectively, which are essential skills for success in both academic and professional settings. (Kabri et al., 2024). By cultivating critical thinking abilities, students can better understand and apply what they have learned and adapt more readily to the demands of the 21st-century job market (Kabri et al., 2024; Thornhill-Miller et al., 2023). This is particularly important as employers increasingly seek graduates who can think critically, communicate effectively, and work collaboratively (Kabri et al., 2024). Several studies have highlighted the importance of developing critical thinking skills in higher education (Sabalza, 2023). These skills can be cultivated using teaching methods such as problem-based learning, project-based learning, and cooperative learning, which encourage students to engage in critical analysis and problem-solving (Kabri et al., 2024).

Effective communication abilities are essential for success in both academic and professional settings (Wang, 2023). In the context of globalization, proficiency in business English has become an increasingly significant factor for successful business communications (Liesa-Orús et al., 2020). Improving students' communication competence should be a key teaching objective (Wang, 2023). Specifically, the use of authentic materials can significantly enhance students' motivation and learning outcomes (Liesa-Orús et al., 2020). The importance of developing communication skills in higher education students is further underscored by the need for modern talents to possess strong cross-cultural communication abilities (Wang, 2023). In higher education, English teaching should also respond to contemporary educational demands by adopting innovative approaches that strengthen students' communication in disciplinary and professional contexts (Wang, 2023). In the context of this study, this is relevant not as a separate aim, but because the development of digital skills and challenge-based learning in statistics also requires students to interpret information, discuss evidence, and communicate results clearly, including in academic and professional English when appropriate.

The development of device security skills is crucial for university students. Firstly, it helps prepare them for the digital workplace, where cybersecurity is a growing concern (English & Maguire, 2023). By gaining an understanding of key cybersecurity concepts, students will be better equipped to contribute to security practices in their future careers (English & Maguire, 2023). It addresses the growing need for advanced, theoretical cybersecurity knowledge to meet accreditation requirements and ensure students are well prepared for security-focused roles (English & Maguire, 2023). Finally, developing device security skills can empower students to protect themselves and their personal devices from cyber threats, fostering a culture of digital responsibility (Maqsood & Chiasson, 2021). Overall, equipping university students with device security skills is crucial for their future success and the security of the digital landscape (Martini & Choo, 2014).

Generative AI tools in Higher Education

The integration of Artificial Intelligence in higher education presents both significant opportunities and important challenges. Among its main advantages are the potential to enhance personalised learning, improve administrative efficiency, and support innovation in teaching and learning processes. AI-based tools can provide intelligent student support systems, adaptive learning environments, automated assessment, and data-informed insights that help educators better understand student needs and identify those at risk (Kamalov et al., 2023; Karimi & Khawaja, 2023; Doğan et al., 2025; Anwar et al., 2024). At the same time, the adoption of AI raises substantial concerns related to privacy, data protection, algorithmic bias, reduced human interaction, institutional readiness, and the risk of widening digital inequalities (Jianzheng & Xuwei, 2023; Aprianto et al., 2024; Akhtar, 2024). Although some concerns persist regarding the future role of educators, current literature generally emphasises that AI should not replace teachers, but rather complement their work and strengthen their pedagogical capacity (Wang et al., 2023). Accordingly, maximising the benefits of AI in higher education requires responsible institutional strategies grounded in transparency, equitable access, ethical frameworks, and collaboration among stakeholders to support the development of innovative resources and the adaptation of teaching practices (Aprianto et al., 2024; Akhtar, 2024).

The rapid digitalisation of society has made the development of digital skills a central priority in higher education, as universities are called to prepare students not only to master disciplinary knowledge but also to act as critical, ethical and collaborative users of technology. Recent research highlights that approaches such as challenge-based education, which engage students in authentic, interdisciplinary and problem-driven learning experiences, provide fertile ground for the development of these competences (Willis et al., 2017; Martínez & Crusat, 2020). At the same time, the integration of generative AI tools in learning contexts is beginning to transform how students search for, analyse and communicate information, offering new opportunities for personalised support, collaboration and creative output while raising important questions around responsible and critical use (Wang et al., 2023; Rios-Campos et al., 2023).

Recent studies have explored the opportunities and risks of AI in higher education, emphasizing its potential to personalize learning, improve student support, and enhance institutional efficiency (Aprianto et al., 2024; Akhtar, 2024; Doğan et al., 2025). However, they also underline persistent concerns related to reduced human interaction, equity, ethics, and institutional readiness. These contributions, while valuable, have largely focused on descriptive analyses of AI adoption or general discussions of its benefits and risks. There is still limited empirical research examining how AI tools, particularly generative AI, can be intentionally combined with pedagogical approaches that promote active, authentic, and collaborative learning experiences. Our study addresses this gap by integrating generative AI tools into a challenge-based educational intervention explicitly designed to foster a structured set of digital skills. This combination, generative AI with challenge-based education, has received very little attention in current literature and represents a novel contribution to understanding how AI can support the development of digital competences in higher education.

These converging trends underscore the importance of deliberately targeting the acquisition of a structured set of digital skills when designing educational interventions. The decision to focus specifically on these six skills, technological, personal security, critical, device security, informational, and communication, was grounded in both theoretical and practical considerations. First, the selection was informed by widely recognised frameworks of digital literacy, such as those proposed by the European Commission (Vuorikari et al., 2022), which conceptualise digital competence as a multidimensional construct encompassing technical, safety-related, cognitive, and communicative domains. Within these broader models, these six skills represent core dimensions that are most directly relevant to the educational level and digital practices of the student population participating in this study. Secondly, the intervention was intentionally designed with a manageable and pedagogically coherent focus. Prioritising these six skills allowed for depth of exploration rather than superficial coverage of a larger number of skills, facilitating both targeted instruction and meaningful opportunities for students to reflect on their learning. This delimitation is consistent with research indicating that digital literacy interventions are more effective when they concentrate on a set of interrelated and developmentally appropriate skills (Blanc et al., 2025). Finally, these six skills also emerged from a needs analysis conducted prior to the intervention, in which educators identified them as particularly critical for fostering students' safe, informed, and critical engagement with digital technologies in their current academic and personal contexts. While other aspects of digital literacy are certainly important, this focus ensured that the study addressed the skills most relevant to the participants' immediate educational environment.

Method

The objective of this study is to understand the perceptions of participating students regarding the development of six skills (technological, personal security, critical, device security, informational, and communication) related to digital literacy following an intervention promoting digital literacy. We utilised the Challenge-Based Education (CBE) approach, an active learning methodology designed to engage students in real-world problem-solving by integrating knowledge from various disciplines. By following these stages, CBE ensures that students not only acquire subject-specific knowledge but also develop critical soft skills such as problem-solving, collaboration, and communication (Leijon et al., 2021; Van den Beemt et al., 2022; Vilalta-Perdomo et al., 2020).

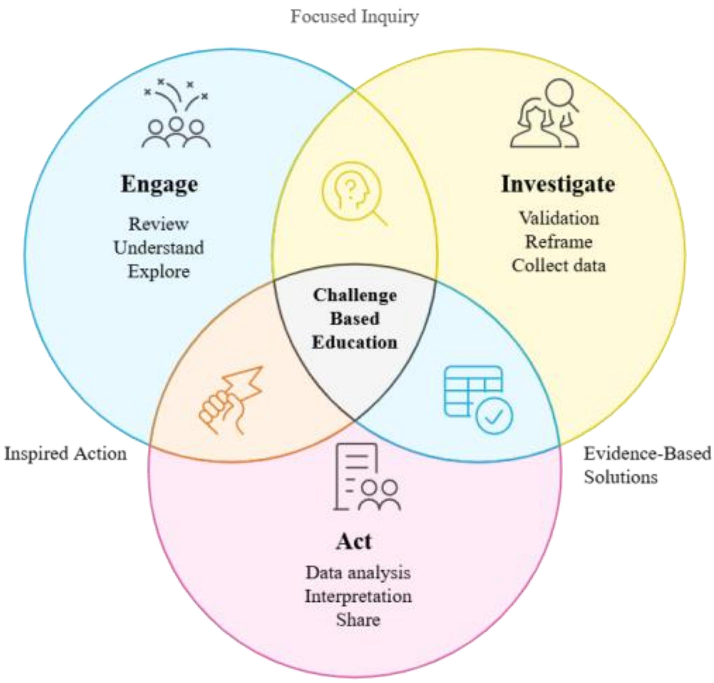
The intervention took place over four months. In the first lesson, the project was proposed to the students, with the final presentation scheduled for the last class. Throughout the various stages of Challenge-Based Education, students were encouraged to utilise a range of digital tools, primarily AI-based, to collaborate, research, analyse quantitative data, create videos, and deliver presentations in large groups. The intervention took place over four months. In the first lesson, the project was introduced to the students, and the final presentation was scheduled for the last class. Throughout the intervention, students were encouraged to use a range of digital tools, primarily AI-based, to collaborate, research, analyse quantitative data, create videos, and deliver presentations.

The framework illustrated in Figure 1 was adopted to provide the conceptual structure for the challenge-based educational intervention implemented in this study. It is grounded in the original CBL model proposed by Johnson et al. (2009) and subsequently adapted and extended in higher education as CBE (Willis et al., 2017; Martínez & Crusat, 2020). The model consists of three interrelated phases, Engage, Investigate, and Act, which form an iterative and inquiry-driven cycle. In the Engage phase, learners explore a broad theme, review relevant knowledge, and collaboratively define authentic challenges. The Investigate phase involves reframing the challenge through research, collecting evidence, and validating possible directions for action. Finally, in the Act phase, students develop and present evidence-based solutions, supported by interpretation and reflection on the process.

This framework was selected because of its strong alignment with the aims of the present study, which seeks to foster the development of digital skills through pedagogical approaches that are active, experiential, and collaborative (Grabinger et al., 1997), and supported by technology. CBE has been shown to enhance critical thinking, innovation, ethical awareness, and the ability to connect knowledge to real-world applications (Van den Beemt et al., 2023; Martínez & Crusat, 2020). It also promotes multidisciplinarity and creativity, creating opportunities for students to work across knowledge domains and to integrate diverse perspectives (Martínez & Crusat, 2020). These competencies are directly linked to the acquisition of digital literacy, particularly in contexts where learners must evaluate and apply information responsibly. Within this study, the CBE model provided a coherent pedagogical foundation for integrating generative AI tools into the curriculum, including the teaching of statistical methods. By structuring learning around authentic challenges and evidence-based actions, this approach ensures that the use of AI technologies remains purposeful, critically informed, and ethically grounded. Such an approach has relevance for the scientific and educational community, as it addresses how challenge-based pedagogies can be strategically combined with emerging technologies to cultivate digital competences essential for higher education in a data-driven society. Figure 1 illustrates the CBE process adopted in the intervention, organised around three interrelated phases: Engage, Investigate, and Act.

Figure 1

Challenge-based education process adopted in the intervention



Note. Own Authorship

As shown in Figure 1, the intervention was structured according to the three phases of the CBE process: Engage, Investigate, and Act. Each phase was associated with specific tasks and outputs, enabling students to progress from formulating a challenge to data collection, statistical analysis, and the presentation of findings.

In the Engage phase, students were introduced to the challenge and asked to select a relevant topic from their field of study. This phase comprised two steps: Step 1, reviewing and understanding the theoretical context related to the chosen topic; and Step 2, exploring the challenge by identifying the relevance, aims, and objectives of the proposed research.

In the Investigate phase, students designed, validated, and administered a questionnaire in order to collect data on the selected topic. This phase comprised two steps: Step 3, validating the questionnaire through review and adjustment based on initial feedback; and Step 4, collecting data by administering the questionnaire to a representative sample.

In the Act phase, students analysed the collected data and prepared the presentation of their results. This phase comprised three steps: Step 5, analysing the data using statistical software; Step 6, interpreting the results according to established performance criteria; and Step 7, preparing the final presentation, including explanatory graphs and tables.

Through this sequence, the CBE model provided an organising structure for the intervention, supporting students' progression from problem formulation to evidence-based interpretation and communication. The integration of generative AI was embedded in this phased process as pedagogical support, rather than as an isolated technological tool, helping students engage critically and responsibly with digital resources throughout the learning activities.

The intervention was structured according to the three phases of Challenge-Based Learning-Engage, Investigate, and Act. Across these phases, students defined a research focus, designed and validated a questionnaire, collected data from a relevant sample, analysed the results using statistical software, and communicated their findings through presentations supported by graphs and tables.

Throughout this process, the students utilised AI tools to support various aspects of their work, including research, text correction, questionnaire creation, and presentation design. They employed free AI tools such as TextCortex for text correction, Google Forms for creating and administering questionnaires, and Gamma for designing presentations, which ensured accessibility given their limited budget for paid services. Additionally, the students made use of chatbots like Copilot, ChatGPT, and Gemini to quickly clarify doubts, obtain personalised feedback, and receive assistance in researching the concepts covered in their group work. These chatbots were accessed both via computers and mobile devices, providing flexibility in how and where students could engage with the tools. During their use of these AI tools, students actively shared knowledge and clarified doubts among themselves, which fostered a collaborative learning environment and enhanced their overall educational experience. These practices align with recent work distinguishing technology use from technology integration in education, underscoring that meaningful learning gains arise when digital tools are embedded within pedagogy and content rather than employed merely as add-ons. Moreover, the emphasis on peer collaboration and iterative improvement mirrors recommendations for practical, discipline-sensitive professional development that enables sustained, pedagogically coherent integration of technology (Dinçer, 2024).

Given the study objective, an explanatory sequential mixed-methods design was adopted (Wasti et al., 2022). The quantitative phase examined students' perceptions of the development of six digital literacy skills, while the qualitative phase enriched these findings by exploring students' perceptions of the ease of use, effectiveness, and challenges associated with the AI tools. This combination enabled a more comprehensive understanding of the phenomenon under study.

Data Collection

The study was conducted with a sample of 112 higher education students from different degree programmes, all of whom were enrolled in a shared curricular unit in statistics. Of these, 84 were female (75%), and 28 were male (25%). Regarding age, 72 participants (64.3%) were aged 18-20, 2 (1.7%) were aged 21-23, 3 (2.7%) were aged 30–32, 5 (4.5%) were aged 33-35, and 30 (26.8%) were over 35 years old. Participants were selected through convenience sampling, a non-probability procedure based on availability and willingness to participate. While this approach was appropriate to the educational context in which the intervention was implemented, it limits the generalisability of the findings; this issue is therefore acknowledged in the limitations section. After being informed of the study's objectives, the participants voluntarily agreed to participate and consented to the use of the study results.

One of the data collection methods used in the study was a questionnaire. A questionnaire survey was deemed the most suitable data collection tool, as a large number of responses was required within a short timeframe (Fife-Schaw, 2006). Data collection for this study was conducted via an online questionnaire, administered during the final session of formal contact. The questionnaire was based on the Scale for Teenagers by Rodríguez-de-Dios et al. (2016) and was adapted to reflect students' current use of AI tools. It was also subjected to scientific validation by two experts in Educational Technologies, who individually proposed amendments that were incorporated into the final version of the questionnaire.

The first expert suggested several key modifications to the original questionnaire. Firstly, they recommended standardising the verb tenses across the questions for consistency. They also proposed merging the items "*download/save a photo I found online*" and "*download information I found online*" into a single item under the technological skill dimension. Additionally, the expert suggested including a question on confidence in using the internet, so we added the question "I am confident in my ability to assess the credibility and quality of the information I find online" to the Critical thinking skill dimension. To address safety concerns, he advised adding a question about evaluating the reliability of webpages.

Regarding communication skills, the expert recommended incorporating questions about the collaborative use of smart devices and digital tools, resulting in new items. The second expert provided additional feedback, particularly focusing on the safe use of AI tools and intellectual property. He suggested adding a question under the Personal Security skill dimension to address the risks associated with AI tools, leading to the inclusion of the item "*I understand the dangers of the misuse of AI tools*". He also recommended incorporating a question on understanding intellectual property rights. Furthermore, the expert proposed adding a question about using chatbots to search for information. Finally, he advised including the item "*I can make an online presentation using digital tools*" in the Communication skill dimension. All these suggested changes were incorporated.

These enhancements are also consonant with recent evidence that learners' creative and higher-order thinking flourish when digital and research-oriented tasks are explicitly structured and assessed with clear, construct-aligned items. Research-based and cooperative approaches in school settings have been shown to benefit from instruments that distinguish between technical, critical, communicative, and safety competencies, thereby enabling more precise diagnosis and targeted support for skill development (Leasa et al., 2025).

Table 1

Questions according to skills

Skills	Questions
Technological skill	I can bookmark a webpage to view later. [TS1]
	I can search for images online considering copyright using AI tools. [TS2]
	I can easily connect to a Wi-Fi network with my phone. [TS3]
	I frequently use keyboard shortcuts. [TS4]
	I don't like downloading apps to my phone because I find it difficult to learn how to use them. [TS5]
	If I need to install new software on my computer, I ask for help because I don't know how to do it. [TS6]
Personal security skill	I can easily disable the feature that shows my location. [PSS1]
	I know when I can share photos and videos of others online. [PSS2]
	I use "report abuse" buttons on social media. [PSS3]
	I can change sharing settings on social networks to control what others can see about me. [PSS4]
	I know the consequences of illegally downloading music and movies. [PSS5]
	I understand the dangers of misusing AI tools. [PSS6]
Critical thinking skill	I compare different sources to determine whether the information is accurate. [CTS1]
	I make sure the information I find online is reliable. [CTS2]
	I identify the author of online information to assess its credibility. [CTS3]
	When I want an app, I compare several to see which is the best and safest, including those using AI. [CTS4]
	I know how to verify whether someone's online profile is real. [CTS5]
	I am confident in my ability to assess the credibility and quality of the information I find online. [CTS6]
Devices security skill	I use software to detect and remove viruses. [DSS1]
	If the computer detects a virus on my digital device, I know how to act. [DSS2]
	I use mechanisms to block unwanted emails/spam. [DSS3]
	If something doesn't work while I'm using a digital device (computer, smartphone, etc.), I generally know how to solve the problem. [DSS4]
	I can assess if a webpage is safe and reliable. [DSS5]
	I can identify the intellectual property rights of Internet content. [DSS6]
Informational skill	I find it difficult to decide on the best keywords for online searches. [IS1]
	I find the way many webpages present information confusing. [IS2]
	Sometimes I struggle to determine how useful the information I find online is for my purposes. [IS3]
	I get tired when looking for information online. [IS4]
	Sometimes I end up on webpages without knowing how I got there. [IS5]
	It's easier to get information from a chatbot than internet searches. [IS6]
Communication skill	I use different forms of communication with my colleagues. [CS1]
	I can send a file to a contact via a smartphone. [CS2]
	I communicate using emojis. [CS3]
	I can collaborate with people using various smart devices, platforms, and digital tools. [CS4]

	I can make an online presentation using digital tools. [CS5]
	I do group work using tools that allow simultaneous collaboration. [CS6]

The final survey consisted of two sections and aimed to collect the intensity levels of opinion using a 5-point Likert scale (SD–strongly disagree, D–disagree, N–neutral, A–agree, SA–strongly agree). The first section collected sociodemographic data from the participants, specifically age and gender. The second section gathered data on the participants' knowledge related to various skills: technological skill, personal security skills, critical skills, devices security skills, informational skills, and communication skill. Although there are various definitions for these skills in the literature, Table 1 presents a definition according to reference authors, which was used to analyse the study results.

The quantitative data were subjected to statistical analysis using IBM® SPSS® Statistics for Windows, version 24.0. This software facilitated descriptive data analysis based on the nature of the variables under study. For the descriptive analysis, we presented and interpreted the frequency and mean values on the Likert scale as perceived by the students. Pearson's rank correlation coefficient was used to examine associations between variables, as the data from Likert-scale responses did not meet the assumptions of parametric correlation procedures.

In the construct validation of the instrument, Cronbach's alpha (α) was employed to quantify the reliability of the questionnaire on a scale from 0 to 1. For the specific questions related to the six digital skills, we obtained an α value of 0.866, indicating good reliability of the data. Cronbach's alpha is a widely used measure of internal consistency in psychometrics and statistics, providing insight into the extent to which a set of items measures a single unidimensional latent construct (Tavakol & Dennick, 2011). The reports on the students' work were subjected to qualitative analysis to understand the students' perceptions in their accounts of the promotion of the use of generative AI tools in completing their assignments. The qualitative data consisted of the information extracted from each student's report, denoted as RSi (i = 1, ..., 112), and were analysed using qualitative content analysis to identify recurrent themes in students' perceptions and experiences.

Results and Discussion

The development of technological skills is essential for university students to adapt to the evolving educational landscape and future job demands. Digital competence, including information literacy, communication, collaboration, and security, is positively perceived by students. As technology becomes more integrated into education, it is crucial to provide targeted training to ensure equal opportunities for skill development (Zhao et al., 2021). Table 2 displays frequencies, means, and standard deviations for responses regarding technological skills. Most respondents can easily connect to a Wi-Fi network with an average rating of 4.455 (SD = 0.5677), indicating high proficiency. Similarly, the ability to bookmark a webpage is also high, with an average of 4.286 (SD = 0.6497). Searching for images online with copyright considerations has a slightly lower mean of 4.027 (SD = 0.8643), showing good but not exceptional skill. The use of keyboard shortcuts shows moderate proficiency, with a mean of 3.563 (SD = 0.9565). There is notable difficulty with downloading apps, reflected in a low mean of 1.848 (SD = 0.9792), and a similar trend is seen in needing help to install new software, with a mean of 2.509 (SD = 1.1624). These results highlight strengths in basic and essential technological skills while also pointing out significant challenges in more advanced or less frequently used tasks.

Table 2

Frequencies regarding the assessment of technological skill (n=112)

	1	2	3	4	5	Mean	Std. Deviation (SD)
TS1	0	2	6	62	42	4,286	0,6497
	0%	1,9%	5,4%	54,9%	37,8%		
TS2	2	5	13	60	32	4,027	0,8643

	1,8%	4,4%	11,5%	53,1%	28,3%		
TS3	0	0	4	53	55	4,455	0,5677
	0%	0%	3,5%	46,9%	48,7%		
TS4	2	15	29	50	16	3,563	0,9565
	1,8%	13,3%	25,7%	44,2%	14,2%		
TS5	50	42	7	13	0	1,848	0,9792
	44,2%	37,2%	6,2%	11,5%	0%		
TS6	26	35	22	26	3	2,509	1,1624
	23,0%	31,0%	19,5%	23,0%	2,7%		

Table 3 presents Pearson's rank correlation coefficients among the technological skill variables. The strongest positive association was observed between frequently using keyboard shortcuts (TS4) and finding it difficult to download apps to a phone (TS5) ($r= 0.769$, $p < 0.01$), which may be interpreted as strong according to Cohen's (1988) conventions. Other moderate positive associations were found between considering copyright when searching for images online (TS2) and frequently using keyboard shortcuts (TS4) ($r= 0.480$, $p < 0.01$), and between frequently using keyboard shortcuts (TS4) and easily connecting to a Wi-Fi network with a phone (TS3) ($r = 0.414$, $p < 0.01$). Overall, the results suggest that technological skills are interrelated, with several items showing moderate-to-strong positive associations across the variables.

These associations highlight that certain technological skills and difficulties tend to co-occur, reflecting their interconnected nature. It is important to emphasise that the correlation analyses presented in Table 3 describe patterns of association rather than causal associations. No causal conclusions can be drawn from these results. In classifying the strength of the correlations, we follow Cohen's (1988) conventions: coefficients around 0.10 are interpreted as small, around 0.30 as moderate, and 0.50 or above as strong. These descriptors refer exclusively to the strength of the association and do not imply any directionality or causality. This approach ensures that the findings are understood as exploratory, highlighting associations among skills without attributing cause and effect. These patterns are consistent with broader evidence that foundational operational abilities underpin, and often co-vary with, higher-order dimensions of digital competence. Studies of technology literacy and integration in education show that gaps in basic skills tend to propagate to adjacent competencies and constrain more sophisticated uses of technology, reinforcing the need to target core skills in any digital-skills curriculum (Kurniaman et al., 2025).

Students found AI tools like TextCortex and Gamma to significantly enhance the quality and efficiency of their work. One student stated, "*TextCortex helped me identify grammatical errors that I wouldn't have noticed, and it made the text more accurate without changing what I wanted to convey*" (S28), demonstrating the tool's capability to improve accuracy without altering the meaning. Another student noted, "*using TextCortex made correcting sentences and texts easier, but sometimes the suggestions did not apply to the specific context of my academic work*" (S3), highlighting the importance of ensuring contextual appropriateness when using AI tools. Similarly, Gamma was praised for its ease of use, with one student commenting, "*Gamma is great for creating beautiful presentations and has a free version, which is a plus for us*" (S46). Generative AI is transforming the skills needed for white-collar jobs, and education must adapt to prepare students for these roles (Frank, 2023).

Table 3
Pearson Correlation Among Technological Skill Variables

		TS1	TS2	TS3	TS4	TS5	TS6
TS1	Pearson Correlation	1	0.492**	0.367**	0.213*	0.370**	0.266**
	Sig. (2-tailed)		0.000	0.000	0.024	0.000	0.005
TS2	Pearson Correlation	0.492**	1	0.351**	0.480**	0.446**	0.329**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000
TS3	Pearson Correlation	0.367**	0.351**	1	0.414**	0.482**	0.252**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.007
TS4	Pearson Correlation	0.213*	0.480**	0.414**	1	0.769**	0.254**

	Sig. (2-tailed)	0.024	0.000	0.000		0.000	0.007
TS5	Pearson Correlation	0.370**	0.446**	0.482**	0.769**	1	0.461**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000
TS6	Pearson Correlation	0.266**	0.329**	0.252**	0.254**	0.461**	1

Note. **Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Personal security skills help protect students against cyber threats and ensure the safe and responsible use of technology (Vodă et al., 2022). The ability to disable location features has a high average rating of 4.161 (SD = 0.8335), indicating strong proficiency. Knowledge of sharing photos and videos online also scores well with an average of 4.214 (SD = 0.7876). Using "report abuse" buttons on social media is slightly lower at 3.893 (SD = 1.0342), reflecting moderate proficiency. Changing sharing settings on social networks has a high rating of 4.259 (SD = 0.8025), suggesting good control over privacy settings. Understanding the consequences of illegal downloads and the dangers of AI misuse both show high proficiency with means of 4.286 (SD = 0.7525) and 4.143 (SD = 0.8038), respectively. Overall, the data indicates that respondents generally possess strong personal security skills, with some variation in the proficiency of specific tasks. In Table 4, we summarize the frequencies, means, and standard deviations for respondents' personal security skills.

Table 4

Frequencies (%) regarding the assessment of personal security skills

	1	2	3	4	5	Mean	Std. Deviation (SD)
PSS1	0	4	19	44	45	4,161	0,8335
	0%	3,5%	16,8%	38,9%	39,8%		
PSS2	2	2	7	60	41	4,214	0,7876
	1,8%	1,8%	6,2%	53,1%	36,3%		
PSS3	2	11	21	41	37	3,893	1,0342
	1,8%	9,7%	18,6%	36,3%	32,7%		
PSS4	2	1	10	52	47	4,259	0,8025
	1,8%	0,9%	8,8%	46,0%	41,6%		
PSS5	2	1	5	59	45	4,286	0,7525
	1,8%	0,9%	4,4%	52,2%	39,8%		
PSS6	2	2	11	60	37	4,143	0,8038
	1,8%	1,8%	9,7%	53,1%	32,7%		

Table 5 presents Pearson's rank correlation coefficients for the personal security skill variables. A strong positive association was observed between the ability to disable location features and knowledge of sharing photos and videos online (s = 0.592, $p < 0.01$), indicating that students who reported greater proficiency in one skill also tended to report greater proficiency in the other. Similarly, changing sharing settings on social networks was strongly associated with understanding the consequences of illegal downloads ($r = 0.742$, $p < 0.01$). By contrast, the weakest association was found between using "report abuse" buttons and disabling location features ($r= 0.010$, $p > 0.05$), suggesting little or no relationship between these skills. Overall, the results indicate that personal security skills are interrelated, with privacy management and awareness of online risks tending to cluster within students' digital safety practices.

Table 5

Pearson correlation coefficients for security skills

		PSS1	PSS2	PSS3	PSS4	PSS5	PSS6
PSS1	Pearson Correlation	1	.779**	.314**	.608**	.556**	.523**
	Sig. (2-tailed)		.000	.001	.000	.000	.000
PSS2	Pearson Correlation	.779**	1	.327**	.653**	.554**	.549**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
PSS3	Pearson Correlation	.314**	.327**	1	.153	.073	.135
	Sig. (2-tailed)	.001	.000		.107	.444	.156
PSS4	Pearson Correlation	.608**	.653**	.153	1	.684**	.616**

	Sig. (2-tailed)	.000	.000	.107		.000	.000
PSS5	Pearson Correlation	.556**	.554**	.073	.684**	1	.710**
	Sig. (2-tailed)	.000	.000	.444	.000		.000
PSS6	Pearson Correlation	.523**	.549**	.135	.616**	.710**	1

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

While AI tools enhanced academic tasks, students encountered challenges. For instance, one student said, "*TextCortex sometimes interfered with writing when it wasn't what we wanted*" (S5), indicating the need for careful use to avoid unwanted changes. This reflects the importance of being cautious with AI-generated content to ensure the final work aligns with the user's intent. AI in education holds great potential for aiding students in their academic journey. AI's role in improving learning and outcomes is promising, and higher education institutions should prioritise the development of AI applications to create more inclusive, accessible, and effective learning environments. With thoughtful implementation, AI can revolutionise education for international students, supporting their success regardless of their background (Wang et al., 2023).

Critical thinking skills allow students to evaluate information, solve problems, and make informed decisions (Kabri et al., 2024). The highest proficiency is observed in ensuring the reliability of information found online, with an average rating of 4.205 (SD = 0.6863). Comparing different sources to verify information also scores high, with a mean of 4.098 (SD = 0.6145). The ability to identify the author of online information for credibility assessment is moderate with an average of 3.884 (SD = 0.6677). When selecting apps, the practice of comparing several options has a mean of 3.938 (SD = 0.6614). Verifying the authenticity of online profiles shows moderate proficiency, with a mean of 3.607 (SD = 0.9897). Overall confidence in assessing the credibility and quality of online information is rated moderately high, with an average of 3.839 (SD = 0.7540). These results indicate strong critical skills in verifying online information, with some variation across specific tasks. Table 6 summarises frequencies, means, and standard deviations for respondents' critical skills related to evaluating online information. As stated earlier, these results reflect statistical associations rather than cause-and-effect relationships.

Table 6

Frequencies regarding the assessment of critical skill

	1	2	3	4	5	Mean	Std. Deviation (SD)
CTS1	0	1	13	72	26	4,098	0,6145
	0%	0,9%	11,6%	64,3%	23,2%		
CTS2	2	0	5	71	34	4,205	0,6863
	1,8%	0%	4,5%	63,4%	30,4%		
CTS3	0	4	20	73	15	3,884	0,6677
	0%	3,6%	17,9%	65,2%	13,4%		
CTS4	0	1	25	66	20	3,938	0,6614
	0%	0,9%	22,3%	58,9%	17,9%		
CTS5	0	17	34	37	24	3,607	0,9897
	0%	15,2%	30,4%	33,0%	21,4%		
CTS6	0	4	30	58	20	3,839	0,7540
	0%	3,6%	26,8%	51,8%	17,9%		

Table 7 presents Pearson's rank correlation coefficients for the critical thinking skill variables. There are strong positive correlations between several key skills, indicating interconnected skills. For example, comparing different sources to verify information strongly correlates with ensuring information reliability ($r = 0.529$, $p < 0.01$), which, based on Cohen's (1988) conventions, can be regarded as a strong correlation, and confidence in evaluating information credibility ($r = 0.598$, $p < 0.01$). Similarly, the ability to confirm the authenticity of online profiles is strongly correlated with ensuring information reliability ($r = 0.558$, $p < 0.01$) and confidence in evaluating information credibility ($r = 0.760$, $p < 0.01$). The weakest correlations are observed between identifying the author of online information and comparing applications ($r = 0.308$, $p < 0.01$), which, according to Cohen's conventions, is considered moderate, suggesting a weaker association between these skills, indicating these skills are less related. Overall, the data highlights that strong critical thinking skills in one area are likely associated with strong skills in other related areas, reinforcing the holistic nature of critical thinking competency. These findings further suggest that the ability to critically evaluate information online operates as a networked competence: students who excel in verifying and cross-checking information are also those who can most confidently judge credibility, authenticity, and reliability, demonstrating that critical thinking in digital contexts is not a set of isolated skills but an integrated cognitive process.

Table 7

Pearson Correlation Coefficients for critical thinking skill

		CTS1	CTS2	CTS3	CTS4	CTS5	CTS6
CTS1	Pearson Correlation	1	0.529**	0.533**	0.436**	0.360**	0.598**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000
CTS2	Pearson Correlation	0.529**	1	0.308**	0.326**	0.558**	0.709**
	Sig. (2-tailed)	0.000		0.001	0.000	0.000	0.000
CTS3	Pearson Correlation	0.533**	0.308**	1	0.453**	0.298**	0.392**
	Sig. (2-tailed)	0.000	0.001		0.000	0.001	0.000
CTS4	Pearson Correlation	0.436**	0.326**	0.453**	1	0.334**	0.395**
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000
CTS5	Pearson Correlation	0.360**	0.558**	0.298**	0.334**	1	0.760**
	Sig. (2-tailed)	0.000	0.000	0.001	0.000		0.000
CTS6	Pearson Correlation	0.598**	0.709**	0.392**	0.395**	0.760**	1

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

This networked pattern is consistent with recent work on technology integration in education, which argues that authentic, well-designed digital tasks cultivate interconnected higher-order competencies rather than isolated skills (Dinçer, 2024). In parallel, research-based and inquiry-oriented pedagogies have been shown to enhance pupils' creative and evaluative capacities, capabilities that sit alongside critical judgement when processing online information (Leasa et al., 2025).

One student acknowledged that, while AI tools improved efficiency, "it is necessary to pay attention", as suggestions may not always fit the academic context (S3). This highlights the need for critical thinking when using AI tools to ensure that the content produced or suggested by AI is appropriate and relevant. GenAI is easy to use and can assist students in producing useful content; however, generating more sophisticated outputs requires skilled human input and critical evaluation before implementation (Holmes & Miao, 2024).

Table 8 summarises frequencies, means, and standard deviations for respondents' device security skills.

Table 8

Frequencies regarding the assessment of devices security skill

	1	2	3	4	5	Mean	Std. Deviation (SD)
DSS1	0	11	14	52	35	3,991	0,9153
	0%	9,8%	12,5%	46,4%	31,3%		
DSS2	0	11	30	47	24	3,750	0,9054
	0%	9,8%	26,8%	42,0%	21,4%		
DSS3	0	3	18	59	32	4,071	0,7439
	0%	2,7%	16,1%	52,7%	28,6%		
DSS4	0	12	38	41	21	3,634	0,9104
	0%	10,7%	33,9%	36,6%	18,8%		
DSS5	0	8	27	49	28	3,866	0,8750
	0%	7,1%	24,1%	43,8%	25,0%		

DSS6	0	5	39	48	20	3,741	0,8025
	0%	4,5%	34,8%	42,9%	17,9%		

Device security skills help safeguard students' devices and data, minimising the risk of cyber-attacks (Vodă et al., 2022). The highest proficiency is in using mechanisms to block unwanted emails/spam, with a mean score of 4.071 (SD = 0.7439), indicating strong competence in this area. The ability to detect and remove viruses using software also shows high proficiency, with a mean of 3.991 (SD = 0.9153). Respondents are moderately proficient in acting when a virus is detected on their device, with a mean of 3.750 (SD = 0.9054), and in identifying intellectual property rights online, with a mean of 3.741 (SD = 0.8025). The ability to solve problems with digital devices and assess the safety and reliability of web pages show moderate proficiency, with mean scores of 3.634 (SD = 0.9104) and 3.866 (SD = 0.8750), respectively. These results indicate that while respondents are generally proficient in various aspects of device security, there is still room for improvement in specific areas. As noted above, the reported correlations indicate patterns of association only and should not be read as evidence of causality.

Table 9 presents Pearson Correlation coefficients for various device security skills, revealing significant interrelationships. There is a strong positive correlation between knowing how to act if a virus is detected and using software to detect and remove viruses ($r = 0.606$, $p < 0.01$), which, following Cohen’s (1988) conventions, is classified as strong. Similarly, the ability to block unwanted emails/spam strongly correlates with knowing how to act if a virus is detected ($r = 0.468$, $p < 0.01$), which is considered moderate according to Cohen’s conventions, and identifying intellectual property rights online ($r = 0.590$, $p < 0.01$), which is classified as strong. Assessing the safety and reliability of web pages shows significant positive correlations with both using mechanisms to block spam ($r = 0.513$, $p < 0.01$), classified as strong and solving problems with digital devices ($r = 0.332$, $p < 0.01$), which is considered moderate. The weakest correlation is between solving problems with digital devices and using software to detect and remove viruses ($r = 0.320$, $p < 0.01$), also moderate according to Cohen’s conventions and indicating a weaker association. Overall, these results indicate that device security skills tend to be interrelated, particularly between virus-related actions and other security measures. This pattern suggests that students who demonstrate proactive behaviours in handling digital threats, such as virus detection and spam blocking, are also more capable of adopting preventive practices like evaluating website reliability and protecting intellectual property. This highlights how digital security competence develops as an integrated skillset rather than isolated technical abilities.

Table 9

Pearson Correlation Coefficients for devices security skill

		DSS1	DSS2	DSS3	DSS4	DSS5	DSS6
DSS1	Pearson Correlation	1	0.606**	0.424**	0.320**	0.471**	0.303**
	Sig. (2-tailed)		0.000	0.000	0.001	0.000	0.001
DSS2	Pearson Correlation	0.606**	1	0.468**	0.609**	0.480**	0.356**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000
DSS3	Pearson Correlation	0.424**	0.468**	1	0.332**	0.513**	0.590**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000
DSS4	Pearson Correlation	0.320**	0.609**	.332**	1	0.481**	0.424**
	Sig. (2-tailed)	0.001	0.000	0.000		0.000	0.000
DSS5	Pearson Correlation	0.471**	0.480**	0.513**	0.481**	1	0.579**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000
DSS6	Pearson Correlation	0.303**	0.356**	0.590**	0.424**	0.579**	1

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

No specific issues related to device security were mentioned in the student feedback. However, the overall positive and cautious use of AI tools implies that students may be mindful of the security implications when handling AI-generated content. This awareness of security also appears to influence how students approach information online, where difficulties with navigation and evaluation become key challenges.

Table 10

Frequencies (%) regarding the assessment of information skill

	1	2	3	4	5	Mean	Std. Deviation (SD)
IS1	17 15,2%	36 32,1%	29 25,9%	21 18,8%	9 8,0%	2,723	1,1718
IS2	6 5,4%	30 26,8%	31 27,7%	39 34,8%	6 5,4%	3,080	1,0235
IS3	9 8,0%	30 26,8%	33 29,5%	34 30,4%	6 5,4%	2,982	1,0568
IS4	10 8,9%	24 21,4%	35 31,3%	36 32,1%	7 6,3%	3,054	1,0725
IS5	18 16,1%	45 40,2%	16 14,3%	27 24,1%	6 5,4%	2,625	1,17112
IS6	11 9,8%	28 25,0%	49 43,8%	22 19,6%	2 1,8%	2,786	0,9341

Table 10 provides frequencies, means, and standard deviations for respondents' information skills. The highest difficulty is found in deciding on the best keywords for online searches, with a mean of 2.723 (SD = 1.1718), indicating moderate difficulty. The way many web pages present information is confusing for respondents, with a higher mean of 3.080 (SD = 1.0235), suggesting that this issue is quite common. Struggling to determine the usefulness of online information also scores high, with a mean of 2.982 (SD = 1.0568). Respondents often get tired when looking for information online, with a mean of 3.054 (SD = 1.0725), reflecting a notable level of fatigue. Ending up on web pages without knowing how they got there shows moderate difficulty, with a mean of 2.625 (SD = 1.1712). Lastly, finding it easier to get information from a chatbot than through internet searches has a mean of 2.786 (SD = 0.9341). Overall, these results indicate that respondents face significant challenges in navigating and effectively utilising online information. In line with the earlier clarification, these findings represent associations and do not imply any causal direction.

Table 11 presents the Pearson correlation coefficients among the information skill variables. A moderate positive association was found between finding it difficult to decide on the best keywords for online searches and finding the way many webpages present information confusing ($r = 0.492$, $p < 0.01$), according to Cohen’s (1988) conventions. Similarly, a moderate association was observed between struggling to determine the usefulness of information and feeling tired when searching for information ($r = 0.414$, $p < 0.01$).

Table 11

Correlations among information skill variables

		IS1	IS2	IS3	IS4	IS5	IS6
IS1	Pearson Correlation	1	.492**	.367**	.213*	.370**	.266**
	Sig. (2-tailed)		.000	.000	.024	.000	.005
IS2	Pearson Correlation	.492**	1	.351**	.480**	.446**	.329**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
IS3	Pearson Correlation	.367**	.351**	1	.414**	.482**	.252**
	Sig. (2-tailed)	.000	.000		.000	.000	.007
IS4	Pearson Correlation	.213*	.480**	.414**	1	.769**	.254**
	Sig. (2-tailed)	.024	.000	.000		.000	.007
IS5	Pearson Correlation	.370**	.446**	.482**	.769**	1	.461**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
IS6	Pearson Correlation	.266**	.329**	.252**	.254**	.461**	1

Note. ** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

A strong correlation ($r = 0.769$, $p < 0.01$) is observed between feeling tired when searching for information and accidentally ending up on irrelevant web pages, indicating a close association between fatigue and navigation errors. The weakest correlation is observed between finding it easier to get information through chatbots and ending up on irrelevant web pages ($r = 0.254$, $p < 0.05$), classified as small, suggesting this skill is somewhat independent. These patterns underline that students who experience more cognitive effort and confusion while searching online also tend to show weaker control over their search pathways, a finding consistent with research on cognitive load in digital environments.

These results highlight that difficulties in one area of information skills are often associated with challenges in other related areas. Informational skills enable students to effectively locate, evaluate, and use information from various sources (Vodă et al., 2022).

Regarding AI Quiz Maker, students appreciated its ease of use but expressed concerns about its limited capabilities for in-depth data analysis. One student said, "AI Quiz Maker could be better to avoid us having to use SPSS for the statistical analysis required in the work" (S98). This indicates the need for more advanced features in AI tools to meet academic demands.

Communication skills help students effectively convey their ideas and collaborate with others using digital tools (Kabri et al., 2024). The highest proficiency is observed in using different forms of communication, such as calls, WhatsApp messages, and emails, with a mean score of 4.563 (SD = 0.5332), indicating strong competence. Sending a file via a smartphone also shows high proficiency, with a mean of 4.446 (SD = 0.5826).

Communicating using emojis has a lower mean of 4.054 (SD = 1.0556), suggesting moderate proficiency with some variability. Collaboration using various smart devices and digital tools scores a mean of 4.214 (SD = 0.7644), indicating good competence. Making online presentations using digital tools has a mean of 4.027 (SD = 0.7993), showing moderate to high proficiency. Finally, group work using tools that allow simultaneous collaboration has a mean of 4.089 (SD = 0.9159), indicating moderate proficiency.

These results suggest that while students are adept at basic and collaborative digital communication, there is still room for improving the sophistication of their communication strategies when using emerging AI-supported platforms. Overall, the data reflects strong communication skills across different modalities, with slight variations in specific tasks. As previously noted, these correlations describe associations only and cannot be interpreted as causal.

Table 12 summarises frequencies, means, and standard deviations for various communication skills.

Table 12

Frequencies (%) regarding the assessment of communication skill

	1	2	3	4	5	Mean	Std. Deviation (SD)
CS1	0	0	2	45	65	4,5632	0,5332
	0%	0%	1,8%	40,2%	58,0%		
CS2	0	0	5	52	55	4,446	0,5826
	0%	0%	4,5%	46,4%	49,1%		
CS3	7	3	8	53	41	4,054	1,0556
	6,3%	2,7%	7,1%	47,3%	36,6%		
CS4	0	2	17	48	45	4,214	0,7644
	0%	1,8%	15,2%	42,9%	40,2%		
CS5	0	6	16	59	31	4,027	0,7993
	0%	5,4%	14,3%	52,7%	27,7%		
CS6	1	6	18	44	43	4,089	0,9159
	0,9%	5,4%	16,1%	39,3%	38,4%		

Table 13 presents the correlation coefficients for the communication skill items, highlighting significant interrelationships. The highest correlation is between using different forms of communication -for example, calls, WhatsApp, email- and sending a file via a smartphone ($r = 0.779$, p

< 0.01), suggesting that proficiency in one area enhances the other. Collaborating with people using various digital tools is also strongly correlated with both sending files via a smartphone (r = 0.653, p < 0.01) and making online presentations (r = 0.684, p < 0.01). Using emojis has a lower correlation with other skills, such as making online presentations (r = 0.073, p > 0.05), indicating this skill is less relevant to formal digital communication tasks.

Making online presentations and collaborating with smart devices also show a strong correlation (r = 0.684, p < 0.01), demonstrating interconnected skills. These findings emphasise the importance of fostering multifunctional communication strategies, as proficiency in core tasks like file sharing and collaboration appears to underpin the ability to adapt effectively to a variety of digital communication contexts. Overall, the data indicates that strong communication skills in one digital area are often associated with strong skills in other areas, particularly in collaborative and multifunctional digital tasks. As previously noted, these correlations describe associations only and cannot be interpreted as causal.

Table 13

Pearson correlation coefficients for communication skill

CS1	Pearson Correlation	1	0.779**	0.314**	0.608**	0.556**	0.523**
	Sig. (2-tailed)		0.000	0.001	0.000	0.000	0.000
CS2	Pearson Correlation	0.779**	1	0.327**	0.653**	0.554**	0.549**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000
CS3	Pearson Correlation	0.314**	0.327**	1	0.153	0.073	0.135
	Sig. (2-tailed)	0.001	0.000		0.107	0.444	0.156
CS4	Pearson Correlation	0.608**	0.653**	0.153	1	0.684**	0.616**
	Sig. (2-tailed)	0.000	0.000	0.107		0.000	0.000
CS5	Pearson Correlation	0.556**	0.554**	0.073	0.684**	1	0.710**
	Sig. (2-tailed)	0.000	0.000	0.444	0.000		0.000
CS6	Pearson Correlation	0.523**	0.549**	0.135	0.616**	0.710**	1
	Sig. (2-tailed)	0.000	0.000	0.156	0.000	0.000	

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

The combination of AI tools also benefited students in collaborative work. One student said, *"tools were very helpful ... allowed us to make the presentation much quicker and more enjoyable"* (S70). Another commented, *"TextCortex helped avoid errors in the text, and Gamma made creating the presentation much easier"* (S82), demonstrating how AI tools facilitated smoother and faster group presentations.

Developing digital skills in higher education is essential for both academic and professional success to enable students to navigate and utilise technology effectively, which is crucial in the digital age (Dinçer, 2024). Personal security skills protect students against cyber threats (Vodă et al., 2022), while critical thinking skills help in evaluating information and solving problems (Kabri et al., 2024). Additionally, digital literacy enhances students' ability to access, analyse, and communicate data, fostering creativity and a deeper understanding of statistical methods (Chama, 2023), preparing them to tackle 21st-century challenges (Kabri et al., 2024). The analysis of the correlation tables reveals several noteworthy aspects. The values obtained indicate that, where correlations exist, they are all significant. These findings highlight the interconnected nature of various technological skills and difficulties, emphasizing the holistic approach needed to develop digital literacy comprehensively.

The successful integration of AI in higher education requires careful consideration of both the benefits and challenges to ensure ethical and responsible application (Rios-Campos et al., 2023). The result of the content analysis of what students mentioned in their statistical work reports on the use of

AI tools, based on the following dimensions, is listed in the table below. These dimensions helped categorise their experiences and reflections on the effectiveness, ease of use, and challenges encountered with AI tools.

Table 14

Qualitative themes identified in student reports regarding AI tool usage

Categories	Evidence in the report
The perceived ease of use	"*Creating forms with AI Quiz Maker was super easy, but I found the theme customisation limited*" (S7). "*Gamma allowed us to create a very beautiful presentation quickly and easily, but we noticed that the screen sometimes became slow*" (S61). "*Gamma has design features, which made the presentation part easier*" (S59).
The effectiveness of AI tools	"*TextCortex helped me identify grammatical errors that I wouldn't have noticed, and it made the text more accurate without changing what I wanted to convey*" (S28). "*Throughout this work, I realised that using TextCortex made correcting sentences and texts easier, but sometimes suggestions did'n apply to the specific context of work, so I realised it is necessary to pay attention*" (S3). "*Gamma is great for creating beautiful presentations and has a free version, which is an advantage for us*" (S46). "*The tools were very helpful, both AI Quiz Maker for facilitating creation, and TextCortex and Gamma allowed us to make the presentation much quicker and more enjoyable*" (S70). "*TextCortex helped avoid errors in the text and Gamma made creating the presentation much easier*" (S82).
The challenges encountered while using AI tools	"*TextCortex sometimes interfered with the writing when it wasn't what we intended, which was sometimes annoying*" (S5). "*The tools made the writing task easy; I didn't know Gamma and enjoyed learning about it, but I found the interface could be confusing for someone just starting to use the tool*" (S20). "*Gamma has a free version with many restrictions, which was limiting because it prevented us from selecting some options we wanted*" (S28). "AI Quiz Maker *is easy to use, but the lack of options for customisation made me waste a lot of time on that part*" (S44). "*The data analysis in AI Quiz Maker could be better to avoid us having to use SPSS for the statistical analysis required in the work*" (S98). "*The theme customisation in AI Quiz Maker is limited, which can be a problem, and it made us spend a lot of time trying to get the best image to frame the work*" (S105).

Note: *Minor typographical errors within student quotes were left intact to preserve original qualitative data accuracy, though "[sic]" could be considered for clarity.

Throughout the study, students leveraged chatbots to address queries, obtain personalised feedback, and access support in sourcing information related to the concepts explored in group projects. Chatbots can be programmed to provide swift and efficient responses to student inquiries, enhancing their understanding of content and helping them overcome challenges (Davar et al., 2025). Additionally, chatbots offer tailored feedback based on student responses and performance, facilitating the identification of areas that require further development and aiding in the acquisition of specific skills (Kim et al., 2023). Furthermore, specialised chatbots assist in searching for relevant information within databases, digital libraries, and other resources, streamlining the research process for students (Garcia, 2025). This integration of AI tools not only supports students in their academic tasks but also fosters the development of critical thinking and problem-solving skills by encouraging them to engage more deeply with the material and collaborate effectively with peers.

Conclusion

This article presents a pedagogical experience involving 112 higher education students within a Challenge-Based Education learning environment supported by Generative AI, aimed at developing digital skills. In an era characterised by an overabundance of information, the ability to process, critically analyse, and interpret data has become an urgent priority. This study highlights how fostering data literacy is intrinsically linked to the development of essential soft skills, such as critical thinking, communication, collaboration and ethical awareness, equipping students for the complex challenges of contemporary society. Its distinctive contribution lies in demonstrating a model that deliberately integrates generative AI tools into a structured CBE framework, showing how this combination can foster the acquisition of digital competences essential for students' academic and professional futures. This model illustrates a replicable way to embed CBE and AI in curricula, including the teaching of statistical methods, to advance data literacy, information literacy, and the ethical use of information, all of which are increasingly crucial in today's society. Challenge-Based Education (CBE) is an experiential learning approach characterized by being active, learner-centred, collaborative, transformative, real-life, reflective, contextual, multidisciplinary, and creative (Van den Beemt et al., 2023). It aims to foster critical thinking, problem-solving, and lifelong learning skills, which are crucial for success in today's competitive society (Grabinger et al., 1997). In this study, CBE provided the pedagogical foundation for the purposeful use of generative AI tools, enabling students to approach statistical concepts and data literacy through authentic, collaborative, and inquiry-driven activities.

The findings reveal that students perceived clear improvements in the six digital literacy skills addressed, with all skills achieving mean ratings above 3.77 on a five-point Likert scale. Communication, personal security, critical thinking, and technological skills were the areas with most notable progress. The pattern of associations between skills, highlighted by the correlation analyses, reinforces the interdependent nature of digital competence. These results also confirm specific relationships among skills: for example, a strong correlation between basic tasks such as connecting to Wi-Fi and bookmarking webpages, and between more advanced tasks such as software installation and app downloading. This suggests that interventions need to support both basic and advanced digital abilities as part of an integrated approach. Students valued the inclusion of generative AI tools, such as TextCortex, Gamma, and AI Quiz Maker, for improving efficiency, presentation quality, and text accuracy, but also pointed to their limitations, including restricted free versions, interface usability and the need for careful oversight to ensure contextual appropriateness. These insights illustrate that while AI tools can support learning and enhance output, their pedagogical potential depends on critical engagement.

From a broader perspective, this study shows that embedding generative AI in a structured CBE process creates a novel form of learning environment that simultaneously promotes active and reflective engagement, fosters ethical awareness in the use of technology, and strengthens students' capacity for collaboration and innovation. The originality of this work lies in presenting and testing a model that explicitly links CBE, AI tools, and statistical methods, thereby providing a blueprint for institutions seeking to develop comprehensive digital competences aligned with the demands of a rapidly evolving, data-driven society (Zhao et al., 2021).

These findings suggest that universities should consider systematically combining CBE with emerging AI technologies to design interventions that develop digital skills in a coherent and holistic way. For researchers, the study underscores the need to investigate how these approaches influence not only self-perceptions of competence but also actual performance outcomes. Future research could build on this study by adopting longitudinal designs to examine the retention and transfer of skills, expanding the set of competences explored, and analysing how factors such as prior experience, socio-economic background, or discipline affect the impact of CBE–AI interventions.

Study Limitations

This study has several methodological limitations that should be considered when interpreting its findings. Firstly, the relatively small and context-specific sample limits the extent to which the results can be generalised to broader student populations or other higher education contexts. Secondly, the study relied on self-reported data, which introduces potential sources of bias such as social desirability, selective recall, and inaccurate self-assessment, and these factors may have influenced the reported perceptions of skill development. Thirdly, the cross-sectional research design does not allow for the examination of how students' digital competences evolve over time, and no causal relationships can be inferred from the analyses. Finally, the study focused on six specific digital literacy skills which, although deliberately selected and theoretically grounded, represent only part of the broader construct of digital competence. Future research could use larger and more diverse samples, incorporate objective performance data and longitudinal designs, and expand the scope of skills examined to provide a more comprehensive and generalisable understanding of how generative AI-supported CBE interventions influence digital competence.

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