



The role of generative AI in education: Perceptions of Saudi students

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ABSTRACT

Purpose: This study aims to provide an analysis of students' perceptions of the role of generative artificial intelligence (GenAI) tools in education, through five axes: (1) level of knowledge and awareness, (2) level of acceptance and readiness, (3) the role of GenAI in education, (4) level of awareness of potential concerns and challenges, and (5) The impact of GenAI tools on achieving the sustainable development goals in education.

Materials and methods: The study followed a descriptive quantitative methodology based on surveying through a questionnaire. The sample consisted of 1390 students from 15 Saudi universities.

Results: The students have positive perceptions towards the role of GenAI tools in education, as students have a high level of awareness and acceptance of adopting these tools. In addition, students are highly aware of the role of GenAI tools in improving their understanding of complex concepts, developing skills, improving their self-efficacy, learning outcomes, providing feedback, and making learning meaningful. The results also confirm their general awareness of the concerns and challenges. A relationship exists between students' perceptions of GenAI and their scientific specializations, as students in computer sciences showed greater awareness regarding concerns and challenges, whereas students in agricultural sciences showed greater awareness of the impact of GenAI tools on achieving sustainable development goals.

Conclusions: The study offers valuable insights on GenAI adoption in higher education, also there is an urgent need to consider developing appropriate use policies, spreading awareness, and creating systems capable of detecting unethical cases.

Keywords: artificial intelligence, ChatGPT, LLM, technology role, education filed, perceptions of Saudi students

INTRODUCTION

Artificial intelligence (AI) has become one of the prominent features of the 21st century, with AI technologies contributing to significant qualitative advancements in various areas, including the education sector. In recent years, AI has witnessed substantial research efforts by leading technology companies, research centers, scholars, and academics, aiming to develop its fields, techniques, and applications in diverse contexts. These efforts have contributed to the emergence of many new concepts, including generative artificial intelligence (GenAI), a recent advancement that marks a turning point in the history of AI (Obenza et al., 2023). GenAI generates new content through statistical analysis of vocabulary distribution and parts

(tokens) and common patterns, encompassing the production of texts, images, videos, music, programming codes, and scenarios (Holmes et al., 2023). It's worth noting that GenAI models have been trained on massive datasets known as Big Data, collected from diverse sources, such as web pages, social media, reports, conversations, media, and databases. GenAI models can be retrained on specific data within a particular domain (Holmes et al., 2023). This technological development carries profound implications, including the ability to continuously improve performance, adapt to individual needs, align with the sustainable development goals approved by the United Nations to solve societal problems and achieve a better future, enhance resource management, and promote environmentally friendly practices (Silva et al., 2024).

Several GenAI tools have been described as powerful innovations capable of revolutionizing the education field (Silva et al., 2024). The utilization of GenAI tools in the educational context contributes to enhancing the overall learning experience for students, delivering more personalized formats (Kalota, 2024). Additionally, it improves students' results (Sullivan et al., 2023) and increases the quality of the educational process, making it easier, more enjoyable, and engaging (Jauhiainen & Guerra, 2023). In this connected context, higher education institutions are facing major challenges related to adopting GenAI tools in curricula, as well as the need to establish policies, regulations, and ethical standards regarding usage (Johnston et al., 2024). Therefore, it is essential to engage students by uncovering their perceptions and understanding their viewpoints, particularly because they are key stakeholders playing a pivotal role in the success of integration, development, and policy implementation processes (Zastudil et al., 2023). GenAI is still in the discovery phase, with limited research focusing on it (Kasneci et al., 2023). Studies focusing on students' perceptions of GenAI are also scarce (Chan & Hu, 2023; Johnston et al., 2024). Consequently, there is uncertainty within academic environments regarding university students' perceptions of the role of GenAI in education. Likewise, several studies have highlighted the need to explore students' perceptions of GenAI in education (Bahroun et al., 2023; Chan & Hu, 2023).

In the context of higher education in the Kingdom of Saudi Arabia, the integration of GenAI is still relatively new, and students' perceptions of GenAI's role in education have not received sufficient attention. Undoubtedly, uncovering this aspect is important in contributing to the successful integration and utilization of GenAI in education, including the establishment of appropriate and implementable regulatory policies. Therefore, this paper presents an analysis of university students' perceptions of the role of GenAI in education, with a focus on their level of knowledge and awareness of GenAI tools and their level of acceptance and readiness to adopt these tools. To provide a more comprehensive analysis, we have also analyzed students' perceptions regarding their awareness of the challenges and concerns arising from using GenAI tools in education. To complete this picture, it was necessary to analyze students' perceptions of the impact of GenAI tools on the sustainable development goals in education.

This study contributes to helping fill the research gap by revealing university students' perceptions of the role of GenAI in Saudi education. To our knowledge, this study is one of the first in Saudi Arabia to examine undergraduate students' perceptions of the role of GenAI in education. Moreover, Studying the relationship between scientific disciplines and students' perceptions of the role of GenAI in education. Targeting a larger sample size compared to most existing studies. Considering the diversity of GenAI tools compared to most current studies, which focused only on Chat GPT. Therefore, this study aims to answer the following hypotheses and questions:

Questions

1. What are university students' perceptions of the role of generative artificial intelligence in education?
2. Is there a relationship between university students' perceptions of the role of generative artificial intelligence in education and their scientific disciplines?

Hypotheses

There is no relationship between university students' perceptions of the role of GenAI in education and their scientific disciplines.

LITERATURE REVIEW

The Roles of Generative Artificial Intelligence in Education

Due to rapid qualitative developments in AI technologies, academics and educational institutions are interested in integrating these new concepts and technologies into educational practices. This integration is seen as a crucial step towards creating efficient educational environments, improving learning experiences, and developing skills and capabilities to build sustainable knowledge societies. In this context, GenAI tools have reshaped education by providing innovative solutions and opening new horizons for more efficient, effective, and inclusive educational practices (Bahroun et al., 2023). Numerous literatures have highlighted the role of GenAI in education. One of the prominent roles played by GenAI is enhancing learning experiences, achieved through the adoption of natural language processing techniques, LLMs, and GPT, enabling immediate responses tailored to students' needs (Silva et al., 2024). Text-to-text GenAI tools, such as ChatGPT and Bard, can provide textual support to students by answering questions, addressing inquiries, simplifying complex concepts, and offering individualized feedback based on students' academic and cognitive levels (Atlas, 2023). GenAI tools also enable students to engage in interactive conversations simulating real-life situations, contributing to the practice of language skills in diverse and authentic contexts (Nghì & Tran, 2023). Furthermore, these tools are useful in academic writing, including checking for errors and spelling, improving sentences and paragraphs coherence, translating, summarizing, and conducting data analysis, thereby enhancing the quality of scholarly works and scientific papers (Castillo-González et al., 2022). In the field of programming education, ChatGPT has the ability to understand and analyze programming instructions, assisting in error identification and prediction (Surameery & Shakor, 2023). In the healthcare education field, GenAI tools have been able to generate personalized scenarios for real-life cases and provide immediate feedback on students' therapeutic responses to those scenarios (Sallam et al., 2023).

In a related context, text-to-image generation tools, such as DALL-E and Stable Diffusion, have proven to be valuable tools in teaching artistic concepts in design and art disciplines (Dehouche & Dehouche, 2023). These tools have added new dimensions related to expression, experimentation, prototyping, and cost. GenAI also stimulates human creativity by enhancing various dimensions, such as divergent thinking, interaction, and collaboration; it improves the quality and evaluation of ideas, surpassing the philosophy of knowledge and expertise monopolization (Kalota, 2024). Additionally, GenAI tools can be employed in the early stages of innovation processes, such as exploration, idea generation, and digital prototype design, leading to faster improvements and lower development costs (Bilgram & Laarmann, 2023). These tools also enhance students' self-efficacy and self-directed learning (Chan & Hu, 2023). GenAI tools have been able to play an effective role in educating people with disabilities. For example, Kuzdeuov et al. (2023) confirmed the capabilities of ChatGPT in supporting learning for the visually impaired by converting text into speech, which facilitates access to digital content. It also has improved communication with and integration of students with disabilities (Lyerly, 2023).

Despite the roles and advantages that GenAI offers in education, several previous studies have identified challenges and concerns. The most prominent challenges are the ethical considerations of data privacy, algorithmic bias, plagiarism, academic integrity, and intellectual property rights for works and projects submitted by students. In academic environments, there is a clear need for more specialized software to detect the use of these tools (Williams, 2024). A study conducted by Emsley (2023) examined the accuracy and reliability of medical articles and reports generated by ChatGPT, revealing that out of 155 references generated, 47% were fake, 46% were authentic but inaccurate, and only 7% were true and accurate references. This finding aligns with Kumar's (2023) analysis, which revealed that academic reports generated by ChatGPT, though mostly authentic and on-topic, contained inaccurate references. The analysis also highlighted that these reports lack the personal perspectives and beliefs stemming from emotional intelligence dimensions. In a related context, Harrer (2023) explained that GenAI systems fundamentally rely on data, so if trained on inaccurate, biased, or harmful data, it directly affects the accuracy and reliability of the output. Additionally, GenAI tools are exposed to several cybersecurity risks. A survey conducted among IT leaders worldwide indicated that 79% of them have concerns about the security aspects of these tools (Kalota, 2024). Furthermore, irresponsible and excessive use of GenAI tools can lead to a decline in students' academic self-efficacy, decreased levels of participation and human interaction, and a lack of authentic learning

experiences (Williams, 2024). In addition, using GenAI tools can lead to a decline in critical thinking skills and problem-solving abilities (Ruiz-Rojas et al., 2023).

Students' Perceptions of Generative Artificial Intelligence in Education

In higher education, understanding students' perceptions is of utmost importance as it significantly impacts the quality of the educational experience provided (Cladera, 2021). In his 3P model (presage-process-product) of teaching and learning, Biggs (2011) emphasized the importance of uncovering students' perceptions and their influence on learning outcomes. Students' perceptions of their abilities and their educational environment have a significant and direct impact on their learning style (Biggs, 1999) and, thus, on their learning outcomes. Students who have positive perceptions of their abilities and their educational environment, including its content, teaching techniques, assessment methods, and educational resources, are likely to possess confidence levels that enable them to adopt a deeper approach to learning (Biggs & Tang, 2011). Such an approach focuses on higher-order thinking levels, such as making connections and relationships between concepts. On the other hand, students' negative perceptions of their abilities and their educational environment lead them to adopt a surface-level approach to learning, thereby focusing on recall and memorization, achieving minimal results (Biggs & Tang, 2011). Therefore, uncovering, understanding, and addressing university students' perceptions and deriving real indicators from them will contribute to enriching educational practices and consequently increasing students' confidence levels, leading to the development of their thinking skills, and improving their learning outcomes.

In addition, individuals' perceptions are important factors in ensuring success in adopting technological innovations (Al-Abdullatif, 2023). Therefore, students' perceptions and views on technical innovations like GenAI are essential in determining their readiness to use these innovations in educational practices in a way that ensures maximum benefit (Kelly et al., 2023; Lokmic-Tomkins et al., 2022). It is worth noting that higher education institutions face real challenges in devising methods and approaches to employ GenAI technologies in curricula and in adopting appropriate policies (Johnston et al., 2024). Therefore, it is essential to engage students by uncovering their perceptions and understanding their viewpoints, as they are key stakeholders who play an active role in the success of integration and development processes (Zastudil et al., 2023). Unveiling university students' perceptions of the role of GenAI in education will provide valuable insights for teachers and administrators seeking to implement successful integration and development processes and adopt appropriate and applicable policies.

Despite this, most literature has not examined students' perceptions and viewpoints. For instance, the study by Yilmaz and Yilmaz (2023) particularly focused on studying the effect of using ChatGPT on developing computational thinking skills, self-efficacy in programming, and motivation toward learning. The results of the study concluded that computational thinking skills, self-efficacy in programming, and motivation toward learning among the students in the experimental group were higher than those of the control group. Also, the study by Shailendra et al. (2024) proposed a framework for integrating GenAI tools into university courses. The study emphasized the importance of restructuring curricula to align with the capabilities offered by GenAI tools and empowering both students and teachers. Furthermore, it proposed a matrix to measure the effectiveness of the integration processes. While Chiu's (2023) study evaluated the potential of GenAI in changing education from the point of view of teachers and educational leaders. One of the most prominent results is the need to provide learners with appropriate skills for using GenAI tools, such as digital and media literacy, and critical thinking skills. While the study by Bahroun et al. (2023) aimed to conduct a systematic review of recent scientific research published between 2018 and 2023 that dealt with the employment of GenAI in education, it highlighted the applications of GenAI in assessment, supporting personalized learning, smart tutoring systems, ethical considerations, interdisciplinary cooperation, and responsible use of technology. Moreover, the study by Baidoo-Anu and Ansah (2023) aimed to determine the potential benefits and risks of integrating ChatGPT into educational practices through an analysis of relevant recent literature and publications. It was found that one of the most prominent benefits is enhancing self-directed and collaborative learning, as well as customizing formative assessment processes. Conversely, generating incorrect data is one of the most significant risks.

Although there is a paucity of existing literature on student perceptions of GenAI tools in education, most of it has not considered students' perceptions and perspectives on a large scale, which includes large sample

size and explores differences among scientific disciplines as well as the diversity of GenAI tools. For instance, Firat's (2023) study unveiled the perceptions of doctoral students regarding the implications of using Chat GPT; however, the small sample size of 14 and specific context of students specializing in education-related fields remains a limitation. Similarly, Shoufan's (2023) study aimed to assess the perceptions of 56 computer engineering students towards the capabilities and challenges of Chat GPT, a small sample size with specific academic backgrounds. Limna et al.'s (2023) study also featured a small sample size seeking to identify the perceptions of 15 students regarding the use of Chat GPT in educational contexts. Haensch et al.'s (2023) study identified students' perceptions of the Chat GPT tool by analyzing 100 posts on the TikTok platform but failed to consider the diversity of scientific disciplines. Some studies have larger sample sizes, but still face the limitation of only considering one discipline or one GenAI tool. Yilmaz et al.'s (2023) study aimed to uncover the perceptions of 239 science and mathematics education students towards the role of the Chat GPT tool in the educational context. Meanwhile, Singh et al.'s (2023) study aimed to assess the perceptions of 430 master's students in computer science regarding using the Chat GPT tool in education and teaching. Therefore, this study aims to fill the research gap by revealing university students' perceptions of the role of GenAI in education, targeting a larger sample (1,390) and taking into account the diversity of scientific disciplines and GenAI tools.

MATERIALS AND METHODS

Methodology

The current study followed a descriptive quantitative methodology based on surveying through a questionnaire ([Appendix A](#)). This research approach aims to achieve a deeper and more comprehensive understanding of social phenomena and experiences by providing a quantitative description of the attitudes, preferences, and perceptions of the study population by studying the opinions of a sample of that population (Creswell, 2009). Survey studies are considered reliable and are widely used in research with social and psychological dimensions (Singleton & Straits, 2009). Furthermore, survey studies allow access to a large segment of participants, as well as the possibility of generalizing results, and the speed and cost-effectiveness of data collection (Creswell, 2009). Thus, this methodology was the most suitable for this study seeking to uncover university students' perceptions of the role of GenAI in education.

Data Collection and Participants

This study aimed to uncover university students' perceptions of the role of GenAI in education. Data were collected from a random sample of university students at fifteen universities in the Kingdom of Saudi Arabia from late March to the mid of May during the second semester of the 2024 academic year. Ultimately, 1390 complete responses were received. [Table 1](#) presents the sample profile. females make up the majority 58%, while males represent 42%. Regarding age demographics, the largest group falls within the 20-25 years (45.5%), followed by those under 20 years old (22.2%). Other age groups include 26-30 years (13.5%), 31-35 years (8.3%), 36-40 years (6.1%), and those over 40 years old (4.4%). In terms of scientific specialization, the results present a varied landscape. Educational specializations emerge as the most prevalent (18.8%), followed by computer and information technology (IT) specializations (13.5%) and health specialties (11.0%). Additionally, administrative specializations (9.9%), social sciences and arts (8.8%), engineering (8.7%), and natural sciences (chemistry, physics, mathematics, biology) (8.3%) are also notable. Tourism and archeology specializations (7.1%), agricultural and food sciences (7.3%), and law specializations account for (6.7%).

Measurement

In this study, a questionnaire was designed as a data collection tool to uncover university students' perceptions of the role of GenAI in education. Questionnaire preparation involved several steps, including drafting based on the study's objectives; a comprehensive review of tools, findings, and recommendations from numerous relevant studies and official reports; and expert opinions and suggestions (Idroes et al., 2023; Neshovski, 2019; Obenza et al., 2024; Sustainable Development, 2024; Williams, 2024). The final questionnaire consisted of 38 statements distributed across six main axes: demographic data (5 questions), level of awareness and knowledge of GenAI tools (5 statements), level of acceptance and readiness (5 statements),

Table 1. Sample profile (N = 1,390)

| Characteristics | | n | % |
|---------------------------|---|-----|------|
| Gender | Male | 584 | 42.0 |
| | Female | 806 | 58.0 |
| Age | Less than 20 years | 309 | 22.2 |
| | 20-25 years | 633 | 45.5 |
| | 26-30 years | 187 | 13.5 |
| | 31-35 years | 115 | 8.3 |
| | 36-40 years | 85 | 6.1 |
| | More than 40 years | 61 | 4.4 |
| Scientific specialization | Education | 261 | 18.8 |
| | Administration | 137 | 9.9 |
| | Health | 153 | 11.0 |
| | Engineering | 121 | 8.7 |
| | Natural sciences (chemistry, physics, mathematics, and biology) | 116 | 8.3 |
| | Computer and information technology | 187 | 13.5 |
| | Social sciences and arts | 123 | 8.8 |
| | Tourism and archaeology | 98 | 7.1 |
| | Agricultural and food sciences | 101 | 7.3 |
| | Law | 93 | 6.7 |

the role of GenAI in education (13 statements), potential fears and challenges (5 statements), and the impact of GenAI on sustainable development (5 statements). Participants were asked to indicate their level of agreement with each statement using a 5-point Likert scale (strongly agree = 5, agree = 4, neutral = 3, disagree = 2, and strongly disagree = 1).

Reliability

The analysis of reliability using Cronbach's alpha indicates satisfactory internal consistency for the questionnaire utilized in the study, as recommended by Hair et al. (2019). An acceptable level of reliability is achieved when Cronbach's alpha exceeds 0.70. Specifically, the knowledge and awareness of GenAI tools scale, comprising 5 items, demonstrated a Cronbach's alpha of 0.833, indicating good reliability. The level of acceptance and readiness scale, which consists of 5 items, showed a good Cronbach's alpha score of 0.798. Similarly, the role of GenAI in education scale, comprising 13 items, exhibited a Cronbach's alpha of 0.918, suggesting excellent internal consistency. Similarly, the fears and potential challenges scale, comprising 5 items, had a Cronbach's alpha of 0.718, suggesting good internal consistency. Lastly, the impact of GenAI on sustainable development scale, comprising 5 items, exhibited a Cronbach's alpha of 0.813, suggesting excellent internal consistency. **Table B1** in **Appendix B** shows reliability information for the questionnaire.

Validity

Validity refers to how well the items in a measure accurately represent the concept they are supposed to measure. In this study, we assessed the validity of questionnaire items using inter-construct correlation validity. This method helps us understand how each item relates to the overall score of its respective variable. The results showed that, for items related to knowledge and awareness of GenAI tools, all correlation coefficients fell between 0.677 and 0.833, each statistically significant at the 0.01 level. Similarly, items measuring acceptance and readiness showed correlation coefficients ranging from 0.652 to 0.811, also statistically significant at the 0.01 level. The correlation coefficients for items concerning the role of GenAI in education ranged from 0.557 to 0.803, again significant at the 0.01 level. Likewise, correlation coefficients for elements of fears and potential challenges ranged from 0.644 to 0.771, all statistically significant at the 0.01 level. Finally, items related to the impact of GenAI on sustainable development had correlation coefficients ranging from 0.742 to 0.808, each statistically significant at the 0.01 level. Therefore, all scales were validated and removing items did not increase alpha beyond the given value. **Table B2** in **Appendix B** shows information about the questionnaire's validity.

Table 2. Descriptive statistics for participants' responses regarding knowledge and awareness of GenAI tools

| S/N | Statements | Mean | Standard deviation | Level | Rank |
|---------------|---|-------|--------------------|-------|------|
| 1 | Realize that GenAI tools can generate inaccurate output. | 4.003 | 0.989 | High | 2 |
| 2 | Realize that GenAI tools can generate output out of context. | 3.846 | 1.012 | High | 3 |
| 3 | Realize that GenAI tools can generate outdated output. | 3.456 | 1.107 | High | 5 |
| 4 | Realize that GenAI tools have limitations in handling complex tasks. | 4.120 | 0.971 | High | 1 |
| 5 | Realize that GenAI tools have limited emotional intelligence, which may lead to inappropriate output. | 3.632 | 1.096 | High | 4 |
| Overall score | | 3.811 | 1.035 | High | |

Table 3. Descriptive statistics for participants' responses regarding level of acceptance and readiness

| S/N | Statements | Mean | Standard deviation | Level | Rank |
|---------------|---|-------|--------------------|-------|------|
| 1 | Interacting with GenAI tools is easy and clear. | 4.476 | 0.740 | High | 2 |
| 2 | GenAI tools are useful in performing my learning tasks. | 4.367 | 0.780 | High | 4 |
| 3 | GenAI tools are innovative tools. | 4.658 | 0.680 | High | 1 |
| 4 | I enjoy in using GenAI tools in education. | 4.117 | 0.866 | High | 5 |
| 5 | I am likely to use GenAI tools for educational purposes more in the future. | 4.448 | 0.760 | High | 3 |
| Overall score | | 4.413 | 0.765 | High | |

RESULTS

Level of Knowledge and Awareness of GenAI Tools

Table 2 illustrates a comprehensive analysis of participants' perceptions regarding knowledge and awareness of GenAI tools. Measurement of this aspect sought to gain a deeper understanding of the extent of participants' knowledge and awareness of GenAI tools in terms of their philosophy, mechanism of operation, quality of output, and limitations. Undoubtedly, this measurement will contribute to employing GenAI tools in appropriate educational contexts. The data demonstrate a high level of consensus among participants, as indicated by an overall mean score of 3.811 ± 1.035 , falling within the range of 3.456 to 4.120. This finding confirms that participants have a great deal of knowledge and awareness about the capabilities and limitations of GenAI tools. Among the five statements evaluated, all received high mean scores, with the lowest-rated aspect being, "Realize that generative artificial intelligence tools can generate outdated output," achieving a mean score of 3.456 ± 1.107 . This finding implies that participants are generally aware of some limitations in GenAI tools. Conversely, the highest-rated aspect, "Realize that generative artificial intelligence tools have limitations in handling complex tasks" garnered a mean score of 4.120 ± 0.971 , indicating strong recognition of this limitation among participants. Overall, these findings underscore the importance of understanding the capabilities and constraints of GenAI tools in educational contexts to maximize their utility effectively.

Level of Acceptance and Readiness

Table 3 presents a comprehensive analysis of participants' perceptions regarding their acceptance and readiness to use GenAI tools. The results show a high level of consensus among participants, with an overall mean score of 4.413 ± 0.765 , falling within the range of 4.117 to 4.658, indicating their strong satisfaction with the tools. Among the five evaluated statements, all received high mean scores, with the highest-rated statement being, "Generative artificial intelligence tools are innovative tools," achieving a mean score of 4.658 ± 0.680 . This score signifies widespread acknowledgment of the innovative nature of these tools within the educational context. Conversely, the statement, "I enjoy in using generative artificial intelligence tools in education" obtained a slightly lower mean score of 4.117 ± 0.866 , still indicating a high level of enjoyment. Overall, the findings point to a high level of acceptance and readiness to incorporate GenAI tools into educational practices, emphasizing the tools' perceived utility and innovation. These results suggest a promising trajectory for the continued utilization and advancement of these tools in educational contexts.

The Role of GenAI in Education

Table 4 illustrates a comprehensive assessment of participants' perspectives on the role of GenAI in education. The data exhibit a high level of consensus among respondents, with an overall mean score of 4.221

Table 4. Descriptive statistics for participants' responses regarding the role of GenAI in education

| S/N | Statements | Mean | Standard deviation | Level | Rank |
|---------------|---|-------|--------------------|-------|------|
| 1 | GenAI tools contribute to my access to diverse educational resources. | 4.194 | 0.860 | High | 11 |
| 2 | GenAI tools contribute to improving my understanding of complex academic vocabulary and concepts. | 4.484 | 0.717 | High | 1 |
| 3 | Employing GenAI tools in teaching strategies contributes to saving time and effort. | 4.374 | 0.693 | High | 2 |
| 4 | GenAI tools contribute to enhancing my learning outcomes. | 4.225 | 0.846 | High | 9 |
| 5 | GenAI tools contribute to developing my critical thinking and problem-solving skills. | 3.510 | 1.159 | High | 13 |
| 6 | GenAI tools contribute to enhancing my self-directed learning and better access to knowledge. | 4.321 | 0.808 | High | 3 |
| 7 | GenAI tools contribute to providing feedback tailored to my academic and cognitive level. | 4.299 | 0.857 | High | 5 |
| 8 | GenAI tools contribute to providing immediate feedback. | 4.312 | 0.923 | High | 4 |
| 9 | GenAI tools contribute to increasing the speed and efficiency of my brainstorming process. | 4.181 | 0.968 | High | 12 |
| 10 | GenAI tools are useful tools for academic editing of scientific papers. | 4.217 | 0.957 | High | 10 |
| 11 | GenAI tools are useful in practicing language skills. | 4.234 | 0.884 | High | 7 |
| 12 | GenAI tools are useful tools for proposing real-life exercises and scenarios related to study topics. | 4.290 | 0.889 | High | 6 |
| 13 | GenAI tools contribute to improving my self-efficacy level. | 4.229 | 0.931 | High | 8 |
| Overall score | | 4.221 | 0.884 | High | |

Table 5. Descriptive statistics for participants' responses regarding fears and potential challenges

| S/N | Statements | Mean | Standard deviation | Level | Rank |
|---------------|---|-------|--------------------|----------|------|
| 1 | GenAI tools can limit opportunities for human interaction and communication in the educational process. | 3.918 | 0.988 | High | 2 |
| 2 | GenAI tools can limit my critical thinking and problem-solving skills. | 3.752 | 1.082 | High | 4 |
| 3 | GenAI tools can cause a breach in the privacy, security, and confidentiality of individuals' data. | 4.011 | 0.818 | High | 1 |
| 4 | I will likely use GenAI tools excessively to perform educational tasks. | 3.795 | 1.168 | High | 3 |
| 5 | I may use GenAI tools without following ethical principles and guidelines. | 3.131 | 1.532 | Moderate | 5 |
| Overall score | | 3.721 | 1.118 | High | |

± 0.884 , falling within the range of 3.510 to 4.484, indicating substantial satisfaction with these tools. It is worth noting that all thirteen statements received high mean scores, which reflects positive perceptions of the impact of these tools on improving learning experiences, developing skills, and building capabilities. It also reflects an understanding of how to benefit from these tools in various educational contexts. In particular, "Generative artificial intelligence tools contribute to improving my understanding of complex academic vocabulary and concepts" received the highest mean score of 4.484 ± 0.717 , emphasizing their efficacy in enhancing comprehension. Conversely, the item, "Generative artificial intelligence tools contribute to developing my critical thinking and problem-solving skills" obtained a lower mean score of 3.510 ± 1.159 , suggesting a potential area for improvement. Given the roles that GenAI tools provide in different educational contexts and the significant awareness students have of these roles, teachers, educational institutions, and developers may need to address the shortcomings of these tools and employ them in a way that ensures full benefit.

Fears and Potential Challenges

Table 5 illustrates an in-depth examination of participants' perspectives on potential challenges regarding GenAI tools in education. The results indicate a high level of consensus among participants, with an overall mean score of 3.721 ± 1.118 , falling within the range of 3.131 to 4.011, which indicates that there is significant awareness of the potential challenges of GenAI tools in education. Among the fears expressed, the highest mean score was for the concern that GenAI tools could potentially lead to violations of individuals' privacy and data security (4.011 ± 0.818), followed by concerns about limiting opportunities for human interaction and communication (3.918 ± 0.988). Interestingly, the lowest-rated concern was the possibility of using GenAI

Table 6. Descriptive statistics for participants' responses regarding the impact of GenAI on sustainable development

| S/N | Statements | Mean | Standard deviation | Level | Rank |
|---------------|---|-------|--------------------|-------|------|
| 1 | GenAI tools can contribute to enhancing equitable and transparent access to educational resources. | 4.081 | 0.787 | High | 2 |
| 2 | GenAI tools can contribute to promoting lifelong learning opportunities. | 4.384 | 0.925 | High | 1 |
| 3 | GenAI tools can contribute to opening new horizons for thinking about ways and methods to overcome the economic and environmental challenges facing societies, such as climate change, poverty, and hunger. | 4.030 | 0.949 | High | 4 |
| 4 | GenAI tools can contribute to eliminating gender disparities in education. | 3.990 | 1.807 | High | 5 |
| 5 | GenAI tools can contribute to empowering young people and adults with technical and vocational skills, qualifying them to work in appropriate jobs or engage in self-employment. | 4.080 | 0.927 | High | 3 |
| Overall score | | 4.113 | 1.079 | High | |

tools without adhering to ethical principles, which received a moderate level of agreement (3.131 ± 1.532); this finding indicates a lack of sufficient awareness of the importance of adhering to ethical principles when using GenAI tools in educational contexts. Undoubtedly, this phenomenon represents a real challenge for academic institutions, requiring appropriate policies and awareness raising among learners about the importance of ethical principles in using these tools in educational contexts.

The Impact of GenAI Tools on Achieving the Sustainable Development Goals in Education

Table 6 illustrates a comprehensive assessment of participants' perspectives on the impact of GenAI tools on sustainable development. The results unveiled a high level of agreement among participants, with an overall mean score of 4.113 ± 1.079 , which suggests a significant positive view of GenAI tools' potential in fostering sustainable development. Among the five statements evaluated, all received high mean scores, indicating substantial agreement regarding their potential contributions. The highest-rated statement, "Generative artificial intelligence tools can contribute to promoting lifelong learning opportunities," garnered a mean score of 4.384. In fact, this awareness may indicate the high probability of students using GenAI tools to enhance lifelong learning opportunities. This usage will undoubtedly contribute to spreading learning, knowledge, and culture among individuals, which will reflect positively on human societies. Conversely, the statement, "Generative artificial intelligence tools can contribute to eliminating gender disparities in education," received the lowest mean score of 3.990, indicating slightly less consensus on this aspect. Nonetheless, the overall high scores signify a general acknowledgment of the transformative impact that GenAI can have on some sustainable development goals.

Test of Hypothesis

This study hypothesized that there is no relationship between university students' perceptions of the role of GenAI in education and their scientific disciplines. To test this hypothesis, a one-way ANOVA test was conducted. The results (presented in **Table B3** in **Appendix B**) show that knowledge and awareness of GenAI tools across various scientific disciplines yielded non-significant differences among groups ($F = 1.935$, $p > 0.05$). Similarly, for the level of acceptance and readiness towards GenAI tools, the ANOVA test did not show statistically significant variations across disciplines ($F = 1.410$, $p > 0.05$). Moreover, the role of GenAI in education did not demonstrate significant differences among scientific disciplines ($F = 1.195$, $p > 0.05$). However, fears and potential challenges associated with GenAI showcased statistically significant discrepancies across disciplines ($F = 3.067$, $p < 0.001$). Among the educational specializations, computer and IT specializations reported the highest mean fear and challenge score (mean [M] = 4.276), followed by health specialties ($M = 4.229$) and engineering specializations ($M = 4.122$). These findings suggest that there are indeed variations in perceived fears and challenges among different educational specializations, with computer and IT fields exhibiting comparatively higher levels. Also, the results reveal significant differences in the perceived impact of GenAI on sustainable development across various educational specializations ($F = 3.167$, $p < 0.001$). The results show that agricultural and food sciences students ($M = 4.662$) perceive the highest impact, followed by tourism and archaeology students ($M = 4.407$).

DISCUSSION AND IMPLICATIONS

GenAI tools have reshaped education by providing innovative solutions and opening new horizons for more efficient, effective, and inclusive educational practices. Therefore, it is essential to engage students by uncovering their perceptions and understanding their viewpoints, as they are key stakeholders who play a pivotal role in the success of integration, development, and policy implementation processes (Zastudil et al., 2023). This study is distinguished from existing work in that it focuses on a study of undergraduate students' perceptions of the role of GenAI in education, targeting a larger number of students and studying the relationship between different scientific specializations and its impact on students' perceptions. In addition, to our knowledge, this study is one of the first in Saudi Arabia to examine undergraduate students' perceptions of the role of GenAI in education. The study provides new insights and data that can be relied upon when implementing programs, policies, and development plans related to GenAI in education. This section discusses the study results and their implications.

Answering the First Question: What Are University Students' Perceptions of the Role of Generative Artificial Intelligence in Education?

In terms of level of knowledge and awareness of GenAI tools, the data indicate a high level of consensus and positive reception. The findings also reflect a generally favorable view of these tools and their potential value in educational environments. However, participants also demonstrate awareness of the limitations of GenAI tools, notably recognizing the potential for outdated output. Conversely, there is strong recognition of the tools' limitations in handling complex tasks. These findings underscore the importance of understanding both the capabilities and constraints of GenAI tools in educational contexts. This positive direction can be explained by the fact that current university students are classified as "digital natives"; They have sufficient ability to understand technology and awareness of its capabilities, and thus, they can deal with new technology better, such as ChatGPT, Bard, Tomi.ai, and others. This interpretation reinforces the idea that digital awareness is one of the most important attributes of a digital citizen (Bernard, 2011). Furthermore, digital transformation, a program in the Kingdom of Saudi Arabia's Vision 2030 (Digital Transformation, 2023), has significantly contributed to spreading technical awareness among members of society, forming positive perceptions regarding the importance of technology in improving the quality of people's lives.

For the level of acceptance and readiness to integrate GenAI, analysis of participants' perceptions reveals strong consensus and satisfaction among participants. All data evaluated received high average scores, with particular emphasis on recognizing these tools as innovative in the educational field. In addition to their ease of use, perceived usefulness, and participants' desire to use these tools in the future. While enjoyment in using these tools showed a slightly lower mean score, it still indicated a notable level of satisfaction. These positive perceptions can be explained according to the technology acceptance model theory (TAM), which asserts that ease of use and perceived usefulness are factors related to the extent to which individuals are willing to accept and adopt new technologies (Al-Abdullatif, 2023). In this context, the value-based adoption model (VAM) identifies the main factors that indicate the extent to which individuals are willing to adopt technology. These factors include perceived value, which encompasses benefits and enjoyment, as well as potential risks (Al-Abdullatif, 2023). Accordingly, the results indicate that students perceive that the benefits of GenAI tools outweigh the risks associated with them, and therefore students have an acceptance and willingness to integrate these tools into their educational practices. There are positive perceptions regarding the benefits derived from using these tools in educational environments, along with the enjoyment during interaction. This is despite their awareness of the limitations and challenges associated with these tools. This level of acceptance and readiness is undoubtedly a strong and encouraging sign for the success of integration and development processes that can be carried out by teachers and educational institutions. Therefore, efforts must be intensified towards developing theoretical and practical frameworks to integrate these tools into educational contexts.

As for the role of GenAI in education, the comprehensive assessment reveals a high level of consensus among respondents, indicating substantial satisfaction with these tools. What explains these positive perceptions towards enhancing education, developing skills, building capabilities, and improving learning outcomes is that GenAI tools support active learning principles (Salinas-Navarro et al., 2024). Because GenAI

tools allow students to ask questions, have discussions, and develop ideas; they also provide immediate feedback. These tools enable students to interact with various educational resources, encouraging them to build their knowledge independently and enhancing their independence and initiative. In addition, GenAI tools can provide innovative and sustainable educational experiences to make education meaningful, such as proposing questions or exercises about real-life problems related to academic topics and offering the possibility of practicing language skills in realistic contexts. This is consistent with the theory of meaningful learning, which emphasizes the importance of supporting the learner to connect new knowledge to his or her existing cognitive structure (Cottingham et al., 2023). Moreover, these tools can be used to implement problem-based learning strategies, which aim to equip learners with the knowledge and skills by suggesting related problems (Schmidt & Moust, 2024). These tools stimulate human creativity, innovation, and brainstorming processes while adding new dimensions to teaching in many fields, such as the arts, medicine, programming, and working with people with disabilities. On the other hand, this finding emphasizes the necessity of redesigning active learning experiences that are compatible with the capabilities of GenAI tools.

As for fears and potential challenges, the findings reveal notable apprehension among participants regarding the use of GenAI tools in education. Privacy and data security emerge as paramount concerns, with participants expressing significant unease about potential breaches. In addition, concerns about limiting human interaction and communication underscore the value placed on interpersonal engagement in educational environments. Although participants show comparatively less concern about adherence to ethical standards, it remains a pertinent issue deserving attention. These findings emphasize the necessity for proactive measures to address these apprehensions effectively. Safeguarding privacy, fostering meaningful human interaction, and ensuring ethical AI usage should be integral to any GenAI tools integration strategy in education. To improve students' ethical awareness, educational institutions can focus more on designing courses that address important ethical issues such as plagiarism, intellectual property rights, privacy, and others. Implementing training programs on how to use GenAI tools responsibly and ethically in different educational contexts. Establish specialized committees to adopt clear regulations and policies that define mechanisms for the responsible and ethical use of GenAI tools. Encouraging academics to conduct more research on the ethical challenges resulting from the use of GenAI tools and suggest solutions to reduce them. Creating systems capable of detecting unethical cases. Dialogue sessions can also be held with students to spread awareness of the importance of adhering to ethical standards when using GenAI tools. Through such actions, educators and policymakers can navigate potential challenges while harnessing the transformative potential of GenAI tools to enrich learning experiences.

When it comes to the impact of GenAI on sustainable development, it is evident that GenAI holds substantial promise for advancing sustainable development goals. Participants displayed consistent and strong agreement on the positive potential of GenAI across the various aspects assessed. Particularly notable is the widespread belief in GenAI capacity to promote lifelong learning opportunities, indicating a recognition of its role in fostering continuous education. Overall, these findings underscore the transformative impact that GenAI can have on sustainable development initiatives, indicating a favorable outlook for its integration into broader strategies aimed at addressing societal challenges. This level of positive perception can be explained by the Kingdom of Saudi Arabia's recent promotion of sustainable development in many areas of life, including the education sector (Sustainable Development, 2024). The concept of sustainable development has been included in academic curricula, creating colleges specializing in sustainability (King Faisal University, 2019), and initiatives have been implemented related to food (General Food Security Authority (GFSA)–Kingdom of Saudi Arabia, 2024) and more. These policies have created awareness among educational community members regarding the importance of achieving the sustainable development goals and their role in addressing problems facing societies in the Arabian Gulf region, such as female education, climate change, global warming, desertification, and wildlife endangerment.

The results of this study are consistent with the expectations of Kelly's (2023) study, which asserted that future studies related to students' perceptions of GenAI would show positive results due to the greater spread of these tools in educational environments and the passage of time, allowing students to become accustomed to these GenAI tools. Due to this exposure, students now have more pronounced perceptions and opinions. The findings of this study agree with the results of studies, including the studies of (Chan & Hu, 2023; Chan &

Lee, 2023; Obenza et al., 2023). On the other hand, the findings of this study contradict the results of studies by (Johnston et al., 2024; Kelly et al., 2023).

Answering the Second Question: Is there a Relationship Between University Students' Perceptions of the Role of Generative Artificial Intelligence in Education and their Scientific Disciplines?

The study explored the relationship between students' perceptions of the role of GenAI in education and their different scientific specializations. Surprisingly, there were no significant differences in knowledge, acceptance, or perceived role of GenAI across disciplines. However, the concerns and challenges associated with GenAI varied widely, with the computer and IT fields expressing greater awareness regarding these concerns and challenges. Furthermore, perceptions of the impact of GenAI on sustainable development varied across disciplines, with agricultural and food sciences ranking highest, followed by tourism and archaeology. Based on these results, the null hypothesis is rejected. This finding highlights the need to spread awareness among students in various disciplines about the challenges inherent to integrating GenAI tools into education. It also underscores the necessity of focusing efforts to discover ways to benefit from GenAI tools within various disciplines to achieve sustainable development goals

CONCLUSIONS AND FUTURE WORK

This study aimed to reveal undergraduate students' perceptions of the role of GenAI in education and explored the relationship between students' perceptions and their different scientific specializations. The main results of this study confirm that students accept and positively perceive the role of GenAI tools in education. It is worth noting that students are highly aware of the role of GenAI tools in improving their understanding of complex academic concepts, developing skills, building capabilities, improving their self-efficacy and learning outcomes, providing feedback at levels consistent with their needs, and making their learning meaningful by placing it in contexts relevant to real-life problems. The results also confirm their general awareness of the concerns and challenges related to these tools. The results demonstrated a concerning trend: students lack sufficient awareness of the importance of following ethical principles when using these tools. The results confirmed the existence of a relationship between students' perceptions of GenAI in education and their different scientific specializations.

This study also aims to contribute to bridging the research gap by revealing university students' perceptions of the role of GenAI in Saudi education. To our knowledge, it is one of the first studies in Saudi Arabia to examine undergraduate students' perceptions of GenAI in this context. Additionally, the study explores the relationship between academic disciplines and students' perceptions of GenAI in education. Moreover, it targets a larger sample size compared to most existing studies. The research also considers the diversity of GenAI tools, unlike most current studies that focus solely on ChatGPT. Future studies could focus on several directions. First, studying the effectiveness of employing GenAI tools and the field of prompt engineering in designing educational environments and training programs. Second, study the impact of GenAI tools in different educational contexts, such as: developing programming problem-solving skills among computer science students, enhancing non-native English speaking and reading skills, and improving diagnostic skills among medical students. and critical thinking skills and collaborative learning among students. Third, conducting more longitudinal studies to reveal the impact of GenAI tools on learning outcomes and educational methods. Fourth, examining ethical issues related to the use of GenAI tools in education, with an emphasis on designing and implementing theoretical and practical frameworks to ensure the ethical and responsible use of these tools. Future studies could explore tailored interventions leveraging GenAI to tackle challenges. Overall, this study lays a solid foundation for understanding students' perspectives on GenAI integration in education. However, further research is needed to address the limitations and explore promising avenues for maximizing the benefits of GenAI while mitigating its associated challenges.

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Data availability: Data generated or analyzed during this study are available from the authors on request.

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APPENDIX A: QUESTIONNAIRE

Table A1. Questionnaire

| | Constructs |
|--|--|
| Level of knowledge and awareness of generative artificial intelligence tools | <ol style="list-style-type: none"> 1. Realize that generative artificial intelligence tools can generate inaccurate output. 2. Realize that generative artificial intelligence tools can generate output out of context. 3. Realize that generative artificial intelligence tools can generate outdated output. 4. Realize that generative artificial intelligence tools have limitations in handling complex tasks. 5. Realize that generative artificial intelligence tools have limited emotional intelligence, which may lead to inappropriate output. |
| Level of acceptance and readiness | <ol style="list-style-type: none"> 1. Interacting with generative artificial intelligence tools is easy and clear. 2. Generative artificial intelligence tools are useful in performing my learning tasks. 3. Generative artificial intelligence tools are innovative tools. 4. I enjoy in using generative artificial intelligence tools in education. 5. I am likely to use generative artificial intelligence tools for educational purposes more in the future. |
| The role of generative artificial intelligence in education | <ol style="list-style-type: none"> 1. Generative artificial intelligence tools contribute to my access to diverse educational resources. 2. Generative artificial intelligence tools contribute to improving my understanding of complex academic vocabulary and concepts. 3. Employing generative artificial intelligence tools in teaching strategies contributes to saving time and effort. 4. Generative artificial intelligence tools contribute to enhancing my learning outcomes. 5. Generative artificial intelligence tools contribute to developing my critical thinking and problem-solving skills. 6. Generative artificial intelligence tools contribute to enhancing my self-directed learning and better access to knowledge. 7. Generative artificial intelligence tools contribute to providing feedback tailored to my academic and cognitive level. 8. Generative artificial intelligence tools contribute to providing immediate feedback. 9. Generative artificial intelligence tools contribute to increasing the speed and efficiency of my brainstorming process. 10. Generative artificial intelligence tools are useful tools for academic editing of scientific papers. 11. Generative artificial intelligence tools are useful in practicing language skills. 12. Generative artificial intelligence tools are useful tools for proposing real-life exercises and scenarios related to study topics. 13. Generative artificial intelligence tools contribute to improving my self-efficacy level. |
| Fears and potential challenges | <ol style="list-style-type: none"> 1. Generative artificial intelligence tools can limit opportunities for human interaction and communication in the educational process. 2. Generative artificial intelligence tools can limit my critical thinking and problem-solving skills. 3. Generative artificial intelligence tools can cause a breach in the privacy, security, and confidentiality of individuals' data. 4. I will likely use generative artificial intelligence tools excessively to perform educational tasks. 5. I may use generative artificial intelligence tools without following ethical principles and guidelines. |
| The impact of generative artificial intelligence on sustainable development | <ol style="list-style-type: none"> 1. Generative artificial intelligence tools can contribute to enhancing equitable and transparent access to educational resources. 2. Generative artificial intelligence tools can contribute to promoting lifelong learning opportunities. 3. Generative artificial intelligence tools can contribute to opening new horizons for thinking about ways and methods to overcome the economic and environmental challenges facing societies, such as climate change, poverty, and hunger. 4. Generative artificial intelligence tools can contribute to eliminating gender disparities in education. 5. Generative artificial intelligence tools can contribute to empowering young people and adults with technical and vocational skills, qualifying them to work in appropriate jobs or engage in self-employment. |

APPENDIX B: SUPPLEMENTARY MATERIALS

Reliability

Table B1. Reliability of the questionnaire

| V | Number of items | Cronbach's alpha |
|--|-----------------|------------------|
| Level of knowledge and awareness of generative artificial intelligence tools | 5 | 0.833 |
| Level of acceptance and readiness | 5 | 0.798 |
| The role of generative artificial intelligence in education | 13 | 0.918 |
| Fears and potential challenges | 5 | 0.718 |
| The impact of generative artificial intelligence on sustainable development | 5 | 0.813 |

Validity

Table B2. Validity of the questionnaire

| Level of knowledge and awareness of generative artificial intelligence tools | | Level of acceptance and readiness | | The role of generative artificial intelligence in education | | Fears and potential challenges | | The impact of generative artificial intelligence on sustainable development | |
|--|--------------------------|-----------------------------------|--------------------------|---|--------------------------|--------------------------------|--------------------------|---|--------------------------|
| Items | Correlation coefficients | Items | Correlation coefficients | Items | Correlation coefficients | Items | Correlation coefficients | Items | Correlation coefficients |
| 1 | .805** | 1 | .753** | 1 | .565** | 1 | .644** | 1 | .774** |
| 2 | .833** | 2 | .782** | 2 | .683** | 2 | .713** | 2 | .756** |
| 3 | .759** | 3 | .652** | 3 | .557** | 3 | .654** | 3 | .808** |
| 4 | .727** | 4 | .811** | 4 | .712** | 4 | .660** | 4 | .742** |
| 5 | .677** | 5 | .681** | 5 | .597** | 5 | .771** | 5 | .797** |
| | | | | 6 | .779** | | | | |
| | | | | 7 | .795** | | | | |
| | | | | 8 | .711** | | | | |
| | | | | 9 | .783** | | | | |
| | | | | 10 | .703** | | | | |
| | | | | 11 | .697** | | | | |
| | | | | 12 | .738** | | | | |
| | | | | 13 | .803** | | | | |

**Correlation is significant at the 0.01 level

Test of Hypothesis

Table B3. Test of hypothesis

| Scientific disciplines | | N | Mean | SD | F | p |
|--|---|-------|-------|-------|-------|-------|
| Level of knowledge and awareness of generative artificial intelligence tools | Educational specializations | 261 | 3.776 | .946 | 1.935 | 0.120 |
| | Administrative specializations | 137 | 3.832 | .684 | | |
| | Health specialties | 153 | 3.916 | .644 | | |
| | Engineering specializations | 121 | 4.084 | .461 | | |
| | Natural sciences specializations (chemistry, physics, mathematics, biology) | 116 | 3.950 | .978 | | |
| | Computer and information technology specializations | 187 | 4.044 | .784 | | |
| | Social sciences and arts | 123 | 3.863 | .714 | | |
| | Tourism and archeology specializations | 98 | 3.907 | .419 | | |
| | Agricultural and food sciences | 101 | 4.038 | .640 | | |
| Law specializations | 93 | 3.888 | .529 | | | |
| Level of acceptance and readiness | Educational specializations | 261 | 4.104 | 0.589 | 1.410 | 0.138 |
| | Administrative specializations | 137 | 4.320 | 0.741 | | |
| | Health specialties | 153 | 4.319 | 0.541 | | |
| | Engineering specializations | 121 | 4.302 | 0.420 | | |
| | Natural sciences specializations (chemistry, physics, mathematics, biology) | 116 | 4.285 | 0.666 | | |
| | Computer and information technology specializations | 187 | 4.122 | 0.549 | | |
| Social sciences and arts | 123 | 4.240 | 0.435 | | | |

Table B3. (continued)

| | Scientific disciplines | N | Mean | SD | F | p |
|---|---|-----|-------|-------|-------|-------|
| | Tourism and archeology specializations | 98 | 4.350 | 0.301 | | |
| | Agricultural and food sciences | 101 | 4.197 | 0.358 | | |
| | Law specializations | 93 | 4.236 | 0.355 | | |
| The role of generative artificial intelligence in education | Educational specializations | 261 | 4.160 | 0.607 | 1.195 | 0.141 |
| | Administrative specializations | 137 | 4.186 | 0.727 | | |
| | Health specialties | 153 | 4.125 | 0.576 | | |
| | Engineering specializations | 121 | 4.068 | 0.775 | | |
| | Natural sciences specializations (chemistry, physics, mathematics, biology) | 116 | 4.237 | 0.639 | | |
| | Computer and information technology specializations | 187 | 4.040 | 0.569 | | |
| | Social sciences and arts | 123 | 4.165 | 0.578 | | |
| | Tourism and archeology specializations | 98 | 4.303 | 0.357 | | |
| | Agricultural and food sciences | 101 | 4.254 | 0.374 | | |
| | Law specializations | 93 | 4.252 | 0.531 | | |
| Fears and potential challenges | Educational specializations | 261 | 3.280 | 0.991 | 3.067 | 0.000 |
| | Administrative specializations | 137 | 3.952 | 0.829 | | |
| | Health specialties | 153 | 4.229 | 0.798 | | |
| | Engineering specializations | 121 | 4.122 | 0.525 | | |
| | Natural sciences specializations (chemistry, physics, mathematics, biology) | 116 | 3.590 | 0.823 | | |
| | Computer and information technology specializations | 187 | 4.276 | 0.700 | | |
| | Social sciences and arts | 123 | 3.793 | 0.579 | | |
| | Tourism and archeology specializations | 98 | 3.907 | 0.543 | | |
| | Agricultural and food sciences | 101 | 3.890 | 0.485 | | |
| | Law specializations | 93 | 3.760 | 0.440 | | |
| The impact of generative artificial intelligence on sustainable development | Educational specializations | 261 | 4.123 | 0.699 | 3.167 | 0.000 |
| | Administrative specializations | 137 | 4.016 | 0.791 | | |
| | Health specialties | 153 | 3.763 | 0.667 | | |
| | Engineering specializations | 121 | 4.110 | 0.708 | | |
| | Natural sciences specializations (chemistry, physics, mathematics, biology) | 116 | 4.180 | 0.682 | | |
| | Computer and information technology specializations | 187 | 3.996 | 0.677 | | |
| | Social sciences and arts | 123 | 3.973 | 0.534 | | |
| | Tourism and archeology specializations | 98 | 4.407 | 0.709 | | |
| | Agricultural and food sciences | 101 | 4.662 | 0.708 | | |
| | Law specializations | 93 | 4.036 | 0.475 | | |

