BMC Medical Education

RESEARCH

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Using Generative AI in nursing education: Students' perceptions

Zuheir N. Khlaif[1*], Nisreen Salameh[2], Mousa Ajouz[3], Allam Mousa[4], Jamil Itmazi[5], Abdallah Alwawi[6] and Aidah Alkaissi[7]

Abstract

Generative Artificial Intelligence (Gen AI) has brought about a significant transformation in various societal domains, including higher education. It offers a plethora of advantages aimed at enhancing learning outcomes in higher education. This research aimed to examine the factors affecting student performance in nursing when Gen AI is employed in undergraduate nursing programs at Palestinian higher education institutions. A survey was developed based on prior studies, and data were gathered from 517 undergraduate nursing students across various Palestinian higher education institutions. The data were analyzed using Smart PLS. The results indicated that trust in AI positively influences the perceived usefulness of Gen AI and enhances student performance in nursing education. However, the study also noted that AI competencies have a negative impact on student performance. This study's contribution lies in highlighting the critical role of trust in Gen AI in enhancing perceived usefulness and learning outcomes in nursing education. One limitation of this study is its reliance on self-reported instruments, suggesting that future research should consider adopting a mixed-methods and experimental research approach.

Keywords Generative AI, Nursing education, Trust in AI, AI competencies

Introduction

Nursing education plays a vital role in the healthcare sector by providing nurses with the necessary knowledge and skills to deliver high-quality services to society and patients. Nurses in the healthcare system have various responsibilities, including patient assessment and admission, mentoring, administering treatments, and providing emotional support [23]. Therefore, the integration of technologies and innovation in nursing education is essential to ensure that nurses are equipped with high-quality skills and knowledge.

The development of emerging technologies, particularly Artificial Intelligence (AI), including Generative AI (Gen AI), has sparked significant interest among decision-makers in higher education institutions. Gen AI, such as ChatGPT, has the potential to benefit nursing education [37]. AI is transforming healthcare, including nursing education, with its increasing use gaining attention and popularity in recent years [13]. Gen AI has the potential to enhance nursing education by providing innovative teaching and learning methods, personalized learning experiences, innovative assessments, and improving clinical decision-making skills [12, 32].

*Correspondence:
Zuheir N. Khlaif
zkhlaif@najah.edu
[1] Faculty of Humanities and Educational Sciences, An Najah National University, Nablus, Occupied Palestinian Territory, Palestine
[2] College of Nursing, Arab American University, Jenin, Palestine
[3] Palestine Ahliya University, Bethlehem, Occupied Palestinian Territory, Palestine
[4] Artificial Intelligence and Virtual Reality Research Center, Department of Electrical and Computer Engineering, An Najah National University, Nablus, Occupied Palestinian Territory, Palestine
[5] Department of Information Technology, College of Engineering and Information Technology, Palestine Ahliya University, Bethlehem, Occupied Palestinian Territory, Palestine
[6] College of Nursing, Al-Quds University, Abu Dis, Palestine
[7] Dean of the Faculty of Nursing, An Najah National University, Nablus, Palestine

AI applications in healthcare include machine learning (ML), which can mimic human decision-making. Predictive analytics, a branch of data analytics using ML, analyzes data patterns and predicts future outcomes. AI-powered clinical decision support systems, virtual avatar apps, and social robots are used in clinical practice to assist nurses in decision-making and simulate interactive conversations between health professionals and patients [15]. AI has become increasingly important in healthcare due to its ability to handle large datasets and solve complex problems [60]. Despite being around since 1956, when John McCarthy, a computer scientist at Stanford University, first used the term, AI adoption among end users remains relatively low at 15%–20% [59].

Furthermore, countries like China, South Korea, the European Union, and the National Science Foundation are investing in AI education and research to develop leadership in the field and prepare students for the future workforce [15]. AI technology can create simulations to help nursing students develop critical thinking skills and prepare for real-world patient care situations. However, there are risks associated with AI use, such as breaches of academic integrity and intellectual property theft. Ethical use of AI can enhance learning experiences, scientific research, and prepare nursing students for the evolving healthcare landscape [15, 33, 58].

Despite the potential benefits of Gen AI in undergraduate nursing education, there is a lack of studies on how Gen AI influences the outcomes of nursing education programs in Palestinian higher education institutions. Recent studies have also highlighted the need for research on the impact of Gen AI on digital transformation and knowledge, as well as the effectiveness of using Gen AI [21, 48]. This study aims to explore the relationship between the challenges and considerations of using Gen AI in nursing education and its potential impact on nursing practice. The findings could help decision-makers in higher education institutions develop regulations for integrating these emerging tools in nursing education and guide researchers in investigating the opportunities offered by Gen AI in the healthcare sector. The study is guided by the following two questions: How does the use of Gen AI in nursing education influence the outcomes of nursing education? How do the challenges of integrating Gen AI in nursing education affect the outcomes of AI integration in nursing education?

Literature review

The use of Generative Artificial Intelligence (Gen AI) in nursing education has gained popularity in recent years as educators seek new methods to train future nurses amidst technological advancements [61]. In Palestine, where nursing education is rapidly evolving, understanding nursing university students' perspectives on Gen AI's use is crucial. The integration of Gen AI in nursing education holds the potential to enhance education quality and boost nursing students' competencies [40]. This literature review aims to explore Palestinian nursing university students' views on AI use in nursing education, covering its advantages, challenges, and impact.

Technology and AI in nursing education

Technology has been widely adopted in nursing education to improve teaching and learning methods. According to Dampier and Alele [54], technology has the potential to enhance nursing students' critical thinking, clinical reasoning, and decision-making skills. It also offers simulation-based learning opportunities, enabling students to practice clinical skills in a safe environment Alzayyat & Al-Ghadban [8]. AI has been applied in various healthcare fields to enhance efficiency and accuracy. In nursing, AI has improved patient outcomes and supported the nursing workforce. However, its use in nursing education has been less explored [22, 29]. Akhtar-Danesh et al. [3, 53] suggested that AI can simulate real-life scenarios, personalize learning, and offer instant feedback to students in nursing education.

AI's potential in nursing education

AI has the potential to revolutionize nursing education by providing personalized learning experiences and enhancing clinical decision-making skills. Alzayyat and Al-Ghadban [8] found that AI in nursing education improves students'understanding of complex concepts and enhances critical thinking and problem-solving skills. Real-time feedback from AI allows students to adjust their learning strategies, improving their performance.

Personalized learning and instant feedback

Artificial intelligence (AI) has the potential to revolutionize education by enabling personalized learning experiences tailored to individual student needs [31]. By analyzing student performance in real time, AI can provide adaptive feedback, allowing learners to focus on areas that require improvement and gain a deeper understanding of complex concepts. This is particularly valuable in disciplines such as nursing education, where mastering theoretical knowledge and practical skills is essential for success.

Research by Liu et al. [38] demonstrated that AI-driven personalized learning significantly enhanced nursing students' academic performance and overall satisfaction. One of the key benefits of AI in nursing education is its ability to deliver instant, precise feedback, which is critical for students to recognize and correct their mistakes

[22, 29]. Timely feedback ensures continuous improvement in both theoretical comprehension and practical application. Furthermore, AI-powered learning tools can simulate real-world clinical scenarios, providing students with opportunities to practice decision-making and critical thinking in a risk-free environment [40].

Al-Jarrah et al. [55] further highlighted that AI-driven feedback mechanisms contribute to the development of essential clinical skills by offering immediate insights into student performance. This helps nursing students refine their competencies, reinforce their understanding of complex medical concepts, and build confidence in their abilities. By integrating AI into nursing education, institutions can foster a more effective and engaging learning environment that prepares students for the challenges of real-world healthcare settings.

Integration of Gen AI in higher education

Gen AI integration in higher education is increasing globally due to its potential to enhance teaching and learning. Studies have shown that Gen AI, specifically ChatGPT, can pass medical licensing examinations and improve student engagement, personalized learning, and success rates [31, 35, 41, 43]. AI can also automate administrative tasks like grading, designing assessments, and scheduling, allowing instructors to focus on critical tasks [11, 30]). Despite these affordances there are risks related to ethical issues and academic integrity [33, 40].

AI and palestinian nursing education

Generative Artificial Intelligence (AI) refers to advanced machine learning models capable of producing new content based on learned patterns from vast datasets. Unlike traditional AI, which primarily classifies, predicts, or analyzes data, Gen AI can create human-like text, images, code, and even audio or video content [33]. These capabilities make Gen AI particularly relevant in education, where it can support students and educators by generating summaries, explanations, quizzes, and interactive learning materials [11]. Examples of Gen AI include large language models (LLMs) such as ChatGPT, Bard, Bing, DeepSeek. AI, which generate text-based responses; DALL E and Midjourney, which create images from textual descriptions; and GitHub Copilot, which assists with code generation.

In the context of nursing education, Gen AI holds significant potential in various areas, including personalized tutoring, clinical decision-making support, redesigning assessments, and academic writing [11]. For example, AI-driven chatbots can simulate patient interactions, helping nursing students practice clinical reasoning skills. Similarly, AI-generated text can aid students in writing and refining their assignments, enhancing their understanding of complex medical concepts. Given the growing integration of AI in healthcare and education, it is crucial to explore its implications in nursing education to ensure ethical, effective, and pedagogically sound implementation.

This study specifically focuses on text-based generative AI tools, particularly large language models (LLMs), that assist nursing students in their learning processes. The primary AI tools explored in this research include ChatGPT, Bard, and Bing AI. These tools were selected due to their accessibility, advanced natural language processing capabilities, and widespread use in educational settings. They enable students to engage with interactive learning materials, receive real-time explanations of complex topics, and improve their academic writing skills.

While artificial intelligence as a field encompasses various subdomains, such as machine learning, predictive analytics, and decision-support systems, this study is not concerned with AI in a broad sense. Instead, it specifically investigates the applications and challenges of generative AI within nursing education. By narrowing the scope to generative AI, we aim to provide a focused analysis of its benefits, limitations, and potential ethical concerns in an academic setting. This distinction is essential to ensure clarity and relevance in discussing AI's role in nursing education. Despite challenges in implementing technology, Palestine has the potential to integrate AI into nursing education. Al-Samarraie et al. [7] noted that inadequate infrastructure and limited resources hinder technology adoption. However, Palestinian students and educators are willing to embrace technology, creating an opportunity to leverage AI in nursing education. Nursing students in Palestine have a positive attitude towards AI integration in their education, believing it can enhance learning experiences, improve understanding of complex concepts, and prepare them for future roles [57]. As nursing education advances in Palestine, AI integration could significantly impact education quality and healthcare professional development.

Barriers and challenges to Gen AI Use in nursing education

Despite AI's potential benefits, several barriers and challenges exist. These include inadequate infrastructure and resources, fear of job displacement among educators, limited access to AI technology, inadequate technical skills among faculty, concerns about AI-generated content accuracy and reliability, and ethical and legal concerns regarding privacy and data ownership [33, 42, 49, 56]. Addressing these challenges is crucial for successful Gen AI integration in nursing education.

Despite the increasing interest in using (AI) in higher education, the existing literature on the application of

Generative AI (Gen AI) in nursing education remains limited. Many of the available studies primarily focus on theoretical benefits and potential applications, with relatively few empirical studies assessing its direct impact on learning outcomes [3, 15, 53]. Moreover, most research relies on surveys and self-reported data, which may introduce biases and limit the ability to draw causal conclusions regarding AI's effectiveness in improving student performance [26, 42, 49]. One of the key limitations of the current body of research is the small sample sizes and the restriction of studies to specific academic disciplines, which affects the generalizability of findings [38]. Additionally, much of the literature focuses on students' perceptions rather than measuring actual academic achievements or clinical competencies, limiting the understanding of how AI contributes to practical nursing education [8]. Another significant gap in the literature is the lack of discussion on the environmental and infrastructural challenges that may influence the integration of AI in nursing education. In developing contexts such as Palestine, universities often face technological and financial constraints that impact the effective implementation of AI-based tools in education [7]. Furthermore, there is a limited number of longitudinal and experimental studies that assess the sustained impact of Gen AI on nursing education outcomes. To address these gaps, future research should employ mixed-methods and experimental designs to explore the effectiveness of Gen AI in enhancing student learning and engagement [21].

Hypothesis development

Based on Davis [19], perceived usefulness reflects the individual evaluation of the benefits gained when using new technology. In the context of this study the new technology is Gen AI in nursing education in higher education institutions. As reported by Davis [19] and other study that people tend to use new technology if they believe it is improving their performance [6]. Another study reported that perceived usefulness has positive impact on students satisfaction and get benefits such as improving their performance and their usage of new technology [39]. Therefore, we assume the following hypotheses:

- ***H1****: Perceived usefulness of Gen AI has a positive effect on students' performance*

Trust is the individual attitudes that enables individuals to take a decision that exposes them to vulnerability [16, 52]. This concept emphasizes the willingness of individuals to place confidence in situations despite the inherent risk of being let down or harmed. In the context of this study, trust in Gen AI is that students believe that Gen AI is useful for their study and can improve their performance. Trust in Gen AI allows students to believe that using it will achieve the desired goal. The findings of Choung et al. [18] revealed that trust positively affect perceived usefulness as well as Albayati [4] findings. Moreover many studies found that trust in AI has a positive impact on performance of users [14, 20]. Therefore, we assume the following hypotheses:

- ***H2****: Trust in Gen AI has a positive effect on perceived usefulness of using Gen AI in nursing education*
- ***H3****: Trust in Gen AI has a positive effect on students' performance in nursing education*

AI competencies refers to the students' knowledge, experience, and skills to complete tasks and assignments for his study by implementing different strategies and approaches that are proficient [28]. The findings of previous studies revealed that students who have more experience, knowledge, and skills in AI has a higher perception of usefulness compared with other who has less knowledge and experience with AI [36, 44]. Moreover, AI competencies has a significant effect on job performance as reported by Chen et al. [17]. In addition, Agarry et al. [5] found that AI competencies increased students' performance to do their assignments. Therefore, we assume the following hypothesis:

- ***H4****: Gen AI competency has a positive effect on perceived usefulness*
- ***H5****: Gen AI competency has positive effect on students' performance in nursing education*

Based on the developed hypothesis, we proposed a model in Fig. 1 to describe the relationship among these constructs. A conceptual model depicting the relationships between generative AI competency (Gen AI Competency; Gen AIC), generative AI trust (Gen AI Trust), perceived usefulness (PU), and students' outcomes (SO) in nursing education.

Note. Gen AI Competency (Gen AIC) refers to students' knowledge, skills, and experience in utilizing generative AI tools for learning and academic tasks. Generative AI Trust (Gen AI Trust) represents students' confidence in the reliability and usefulness of AI for educational purposes. Perceived Usefulness (PU) measures students' belief that generative AI enhances their learning experience. Students' Outcomes (SO) denote the impact of AI integration on students' academic performance and skill development. Hypotheses (H1–H5) illustrate the proposed relationships among these constructs.

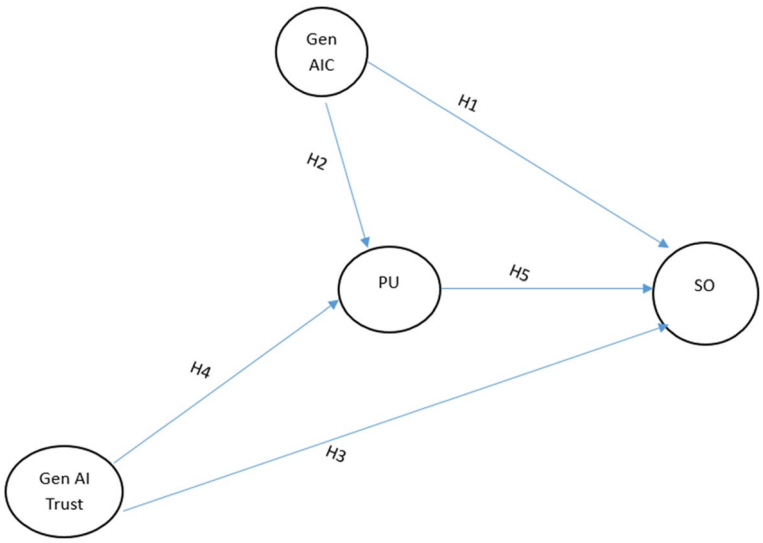

Fig. 1 Proposed model based on the hypothesis of the study

Methodology

This study adopted a cross-sectional survey design, a widely utilized approach in educational research to gather data on participants' perceptions, attitudes, and experiences at a single point in time. This design was particularly suitable for examining how undergraduate nursing students in Palestinian higher education institutions perceive the integration of generative AI in their learning. Specifically, the study explored the influence of factors such as AI trust, AI competency, and perceived usefulness on students' academic performance and learning experiences.

To analyze the collected data, the study employed Partial Least Squares Structural Equation Modeling (PLS-SEM), a statistical method well-suited for exploratory research and predictive modeling of relationships among latent variables. PLS-SEM was selected due to its capability to manage complex models with multiple constructs and its robustness in analyzing relationships with small to moderate sample sizes. The choice of this method ensures that the relationships between key study variables are examined comprehensively, allowing for meaningful insights into the role of generative AI in nursing education.

Additionally, an online survey was developed based on established research instruments to collect data from nursing students across multiple Palestinian universities. This quantitative approach facilitated the systematic investigation of students' perspectives on generative AI in education, ensuring a structured and data-driven exploration of their experiences and perceptions.

Context of the study

The participants were recruited from various universities in Palestine, specifically undergraduate students enrolled in nursing education programs. Nursing education in Palestine typically necessitates four years to attain a Bachelor's degree. Nursing graduates must pass licensure examinations to get registered nurse status and participate in healthcare practice. This educational framework aims to provide students with comprehensive knowledge and clinical skills essential for effective patient care. The nursing education in Palestine is progressively incorporating advanced technologies, including Artificial Intelligence (AI), into its curriculum. Artificial intelligence is employed to enhance educational experiences, simulate clinical environments, and provide personalized feedback to students, so improving their critical thinking and decision-making abilities. AI-driven simulation laboratories are integrated into nursing education to offer realistic and dynamic training environments for students to safely and effectively practice clinical skills. The gradual integration of AI into nursing education prepares the next generation of nurses in Palestine for the future of healthcare.

The primary inclusion criterion was being an undergraduate nursing student enrolled in a nursing program at a Palestinian higher education institution. While prior experience with AI was not a mandatory requirement for participation, students were asked about their familiarity and previous interactions with generative AI tools as part of the survey. This approach allowed us to capture a diverse range of perspectives, including those of students with varying levels of AI exposure.

By including students regardless of their prior AI experience, we aimed to gain a more comprehensive understanding of how generative AI is perceived across different user groups—both those who have actively engaged with AI tools and those who may be encountering them for the first time. This decision was made to ensure that our findings reflect the broader reality of AI adoption in nursing education, including both potential benefits and challenges faced by students at different levels of familiarity with the technology.

Development of the research instrument

The survey items for this study were developed based on established literature to ensure validity and alignment with previously tested measurement constructs. The items assessing the perceived usefulness of Generative AI (Gen AI) were adapted from Davis [19] and Venkatesh and Davis [50], who originally developed the Technology Acceptance Model (TAM) to measure individuals' beliefs about the usefulness of technology in improving task performance

. These items were slightly modified to fit the context of AI in nursing education by replacing general references to "technology" with "Gen AI" to maintain relevance to this study's focus.

Similarly, the AI competency items were adapted from the study by Wang et al. [51], which defines AI competency as the ability to effectively utilize AI tools to support learning, decision-making, and problem-solving. Previous research has shown that AI competency significantly impacts students' ability to integrate AI into their educational activities, influencing their perceived usefulness and actual usage of AI tools [5, 28]. Given these findings, our study incorporated modified versions of these measurement items to assess nursing students' competency levels in using generative AI tools. Additionally, the survey included constructs related to trust in AI, which were adapted from studies by Bitkina et al. [14] and Choung et al. [18]. Trust in AI has been recognized as a critical factor influencing AI adoption in education and healthcare settings. Items measuring trust in AI assessed students' confidence in the accuracy, reliability, and ethical implications of using Gen AI in their academic work. To ensure the validity of the survey instrument, a multi-step process was undertaken to confirm that the items accurately measured the intended constructs and were suitable for the context of nursing education and AI integration. Content validity was first established by adapting survey items from well-recognized and validated measurement scales, including Davis [19] and Venkatesh and Davis [50] for perceived usefulness, and Wang et al. [51] for AI competencies. To further refine the instrument, a panel of experts specializing in AI in education, nursing education, and survey methodology reviewed the items for clarity, relevance, and comprehensiveness. Their feedback was incorporated by making minor modifications to the wording to ensure the questions aligned with the experiences of nursing students using AI tools in their learning.

In addition**,** Convergent and discriminant validity were examined to confirm the robustness of the measurement model. The Average Variance Extracted (AVE) values were calculated to assess convergent validity, ensuring that each construct explained more variance in its items than measurement error. Discriminant validity was tested using the Fornell-Larcker criterion, verifying that the constructs were sufficiently distinct from each other.

To evaluate the internal consistency and reliability of the survey instrument, Cronbach's Alpha (α) and Composite Reliability (CR) values were calculated, both of which met or exceeded the recommended threshold of 0.7, confirming strong internal consistency across the constructs. By implementing this rigorous validation process, the survey instrument was ensured to be methodologically sound, reliable, and well-suited for investigating the impact of generative AI in nursing education. These validation steps strengthened the credibility of the study's findings and ensured that the data collected accurately reflected nursing students' perceptions of AI integration in their academic learning. This structured approach ensured that the survey instrument was grounded in validated theoretical frameworks, maintaining internal consistency and construct validity while being specifically tailored to the context of nursing education in Palestine.

Data collection

Data were collected using the online survey. The survey was created and distributed using google forms to 1200 students via email. A total of 517 participants responded to the survey, representing a response rate of approximately 43%. The participants included both male (36.4%) and female (63.6%) students from various universities in Palestine. The survey utilized a five-point measurement scale, and Table 1 presents the measurement scale along with the descriptive statistics for each construct and its items.

Table 1 Assessment of the Measurement Model

Code	Constructs	Cronbach's Alpha	Composite Reliability		AVE
			Rho_a	Rho_c	
SO	Students' Outcomes	0.753	0.757	0.858	0.669
PU	Perceived Usefulness	0.913	0.915	0.939	0.793
AC	AI Competency	0.806	0.809	0.885	0.721
TA	Trust in AI	0.864	0.868	0.902	0.648

Author's Own Creation based on Smart-PLS Results

Ethical consideration

Ethical concerns were a crucial component of this investigation, and the research complied with the WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Participants. The Institutional Review Board (IRB) of An-Najah National University examined and approved the study under reference number: Med.April.2023/17. Informed consent was acquired from all participants, guaranteeing their comprehensive understanding of the study's objectives, methodologies, and possible harm. Confidentiality and privacy were upheld during the study, with all data securely saved and anonymized to avert any identifying of participants. The researchers were dedicated to mitigating any potential harm to individuals and ensuring their involvement was voluntary. These ethical precautions were meticulously executed to maintain the utmost standards of research integrity, safeguarding the dignity, safety, and rights of all participants.

Results and discussion

Respondent description

The survey, disseminated through Google Forms, was completed by 517 nursing students. The analysis included all respondents, undergraduate students from eight different universities in Palestine. The demographic breakdown of the study's participants is predominantly female, constituting 63.63% (N= 329), with the remaining 36.36% (N= 188) being male. Regarding academic standing, 16.44% of the respondents are in their first year, 31.33% are in their second year, 34.24% are in their third year, and 17.99% are in their fourth year of study.

In terms of non-academic internet usage, the average daily duration varied among the participants as follows: 9.52% (N= 30) reported 0–2 h, 47.62% (N= 150) reported 3–5 h, 31.75% (N= 100) reported 6–8 h, 7.94% (N= 25) reported 9–11 h, and 3.17% (N= 10) reported 12 or more hours. The purposes for internet use were diverse, with students engaging in activities such as gaming (N= 149), other unspecified activities (N= 76), searching for information (n =311), using social media networks (N= 433), and watching movies/videos or listening to audio (N= 257).

Regarding the exposure to AI education in higher education, a majority of the respondents, 364, indicated they have not had AI education experience, while 153 affirmed they have. Finally, the living arrangements of the respondents were varied, with 256 living in villages, 232 in cities, and 29 in refugee camps. This demographic and behavioral data provides a comprehensive overview of the respondents' backgrounds, internet usage habits, and educational experiences related to AI, offering valuable context for further analysis of the survey results. Figure 2 presents the frequency of using Gen AI by the nursing students based on their responses on the research instrument.

Assessment and refinement of the measurement model

In evaluating the psychometric properties of the measurement model, this investigation thoroughly examines reliability and validity, accentuating the substantial nature of outer loadings and internal consistency. The findings of this research corroborate the postulations posited by Hair et al. [25], which emphasize the criticality of outer loadings surpassing a predefined minimal

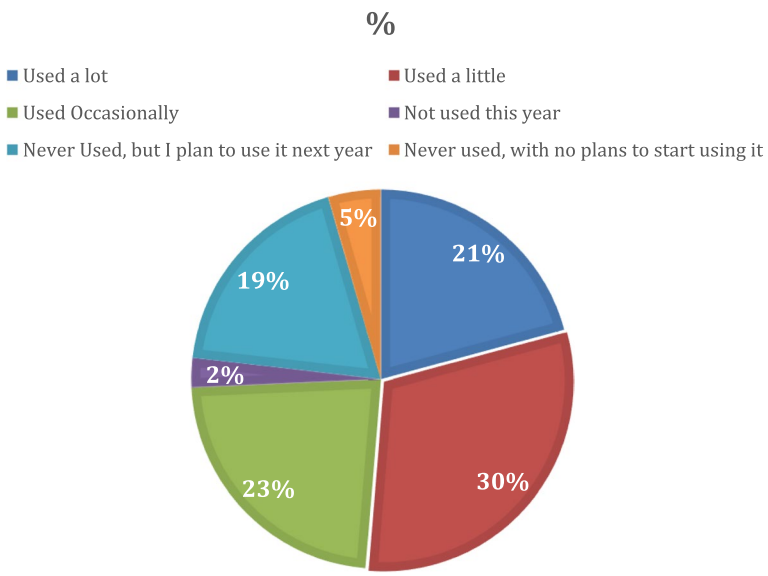

Fig. 2 The frequency of using Gen AI

threshold of 0.701. Empirical data from the current study reveal that outer loadings oscillate between 0.778 and 0.901, fulfilling the convergent validity requisites [10]. This conformance is further substantiated by the metrics of Cronbach's Alpha (CA) and Composite Reliability (CR), which exhibit values transcending the conventional thresholds of 0.6 and 0.7 [2], respectively, as illustrated in Table 1. Specifically, the observed metrics for composite reliability and Cronbach's Alpha span between 0.757 to 0.958 and 0.753 to 0.939, respectively, thereby endorsing the robustness and consistency of the measurement model. These findings underscore the model's adherence to established psychometric standards and reinforce its applicability and reliability for subsequent empirical inquiries [9, 47].

Furthermore, the Average Variance Extracted (AVE) for each construct decidedly exceeds the established benchmark of 0.5 [25, 46], illustrating that the constructs proficiently encapsulate the variance attributed to the observed variables. This efficacious capture of variance reinforces the model's explanatory power and underscores the constructs' robustness. Discriminant validity, a crucial facet of the model's integrity, is rigorously affirmed through a methodical comparative analysis. This involves juxtaposing the square roots of the AVE values with the inter-construct correlations, thereby ensuring that each construct contributes distinctively and significantly to the model. The AVE values, ranging from 0.648 to 0.793, further attest to the constructs' substantial explanatory capacity [45].

The current study applies Fornell and Larcker [24] methodological framework to assess discriminant validity, demonstrating through statistical analysis that each primary construct's Average Variance Extracted (AVE) significantly exceeds the correlational values with other constructs, thus affirming discriminant validity [1, 25]. It also incorporates the Heterotrait-Monotrait (HTMT) ratio by Henseler et al. [27], with derived HTMT values falling below the maximum threshold of 0.85, as per Kline, [34]. The AVE and HTMT ratios detailed in Table 2 provide strong empirical evidence of the distinctiveness of the constructs, highlighting the methodological accuracy and affirming the discriminant validity of the study.

Table 2 Discriminant Validity for First-Order Model

	SO	PU	AC	TA
Students' Outcomes	0.818	0.385	0.846	0.344
Perceived Usefulness	0.322	0.891	0.368	0.647
AI Competency	0.662	0.318	0.849	0.364
Trust in AI	0.285	0.579	0.309	0.805

Diagonal and italicized are the square roots of the AVE. Below the diagonal elements are the correlations between the construct's values. Above the diagonal elements are the Heterotrait–Monotrait ratio of correlations values

Source: Author's Own Creation based on Smart-PLS Results

Structural Model

Evaluating the structural model (Fig. 3) through the Adjusted R^2, Fig. 3 delineates that the model captures 57.6 percent of the variability in students' outcomes, with the remaining 42.4 percent attributed to external factors. AI competency and trust in AI account for 35.6 percent of the variation in perceived usefulness of AI use in nursing education, leaving 64.4 percent influenced by external variables.

Delving into hypothesis testing, and based on Table 3 below, all hypotheses are statistically validated, each showing t-values surpassing the critical value of 1.96. This indicates a solid adherence to the posited relationships within the model, with Hypotheses 1 and 2 displaying significant negative impacts: Hypothesis 1 with a coefficient of −0.618 and T-value of 3.592, and Hypothesis 2 with a coefficient of −0.154 and a *p*-value of 4.060. These results underscore that as AI competency increase, there is a notable decline in both the students' outcomes and perceived usefulness of AI in nursing education.

Conversely, Hypotheses 3 and 4 reflect positive relationships. The trust in AI is shown to positively impact on the students' outcomes with a coefficient of 0.082 and T-value of 1.983 (H3), and the perceived usefulness with a coefficient of 0.530 and T-value of 12.347 (H4). These findings emphasize the importance of leveraging AI's potential to enhance effectiveness and adoption in nursing education.

Lastly, Hypothesis 5 highlights a robust positive correlation between the perceived usefulness and the students' outcomes, evidenced by a coefficient of 0.393 and a T-value of 10.547. This relationship signifies that a more extensive use of AI correlates with improved outcomes, advocating for the integration of AI to bolster the quality and efficacy of nursing education. This comprehensive analysis demonstrates the model's predictive strength and the varied impacts of AI on nursing education, advocating for nuanced strategies to harness AI's full potential effectively.

The findings from Table 4 highlight the significant impact of AI competency on students' outcomes in nursing education, mainly through the mediation of perceived usefulness of AI. The total effect demonstrates a strong negative influence of AI competency on student learning and engagement, indicated by a beta of −0.542 and a T-value of 13.759, suggesting that more AI competency correlate with poorer educational outcomes. Indirectly, as posited in Hypothesis 6, these competencies also negatively impact students' outcomes by reducing

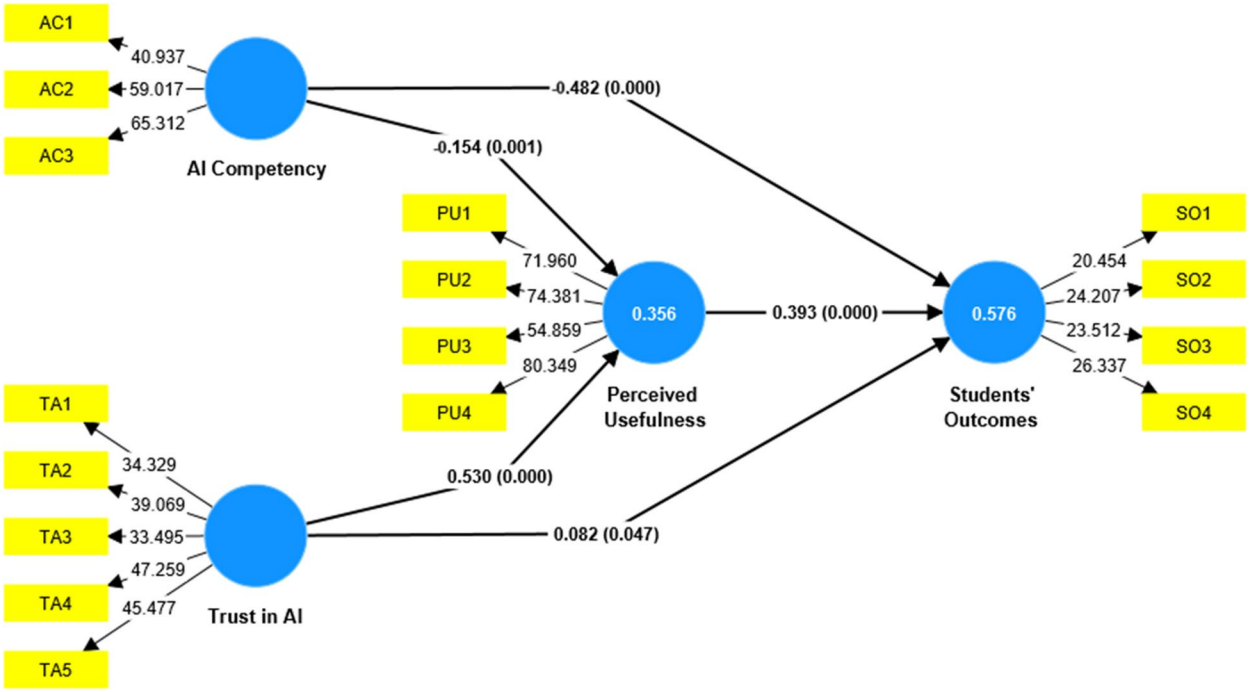

Fig. 3 Structural model results. Source: Author's Own Creation based on Smart-PLS Results

Table 3 PLS-SEM Results: Direct Path Coefficients of the Adjusted Model

H_X	Relationship	Std Beta	T-Value	*P*-Value	Decision
H_1	AC-> SO	−0.482	12.490	0.000	Supported
H_2	AC-> PU	−0.154	3.411	0.001	Supported
H_3	TA-> SO	0.082	1.983	0.047	Supported
H_4	TA-> PU	0.530	12.347	0.000	Supported
H_5	PU-> SO	0.393	10.547	0.000	Supported

Source: Author's Own Creation based on Smart-PLS Results

the effective use of AI, evidenced by a beta of −0.061, a T-value of 3.231, and a P-value of 0.000. These results emphasize the importance of addressing AI competency to enhance its utilization and improve learning and engagement in nursing education. The study suggests a nuanced relationship where addressing AI competency can significantly affect both the direct and mediated use and outcomes of AI in educational settings.

Additionally, the study finds that the trust in AI has a modest but direct positive impact on the students' outcomes, as evidenced by a beta coefficient of 0.291 and a T-value of 6.965. This suggests that while trust in AI's potential contributes positively, it is not the sole or dominant predictor of students' outcomes. Additionally, the indirect effects supported by Hypothesis 7 show that the potential of AI affects nursing education outcomes indirectly through perceived usefulness of AI, with a significant beta of 0.209 and a T-value of 8.241. This indicates that the effective perceived usefulness of AI is crucial in mediating its overall impact on students' outcomes, emphasizing the importance of recognizing AI's potential and strategically integrating it into nursing education practices.

Variations in access to and use of technology represent a critical factor that may have influenced the findings of this study. In the context of nursing education in Palestine, disparities in digital infrastructure, internet connectivity, and device availability create an uneven landscape for the adoption of generative AI tools [43]. While some

Table 4 PLS-SEM of Serial Mediation Results

Relationship	Total effects		H_X	Relationship	β	T-Value	*P*-Value	Decision
	β	T-Value						
AC-> SO	−0.542	13.759	H_6	AC-> PU-> SO	−0.061	3.231	0.001	Supported
TA-> SO	0.291	6.965	H_7	TA-> PU-> SO	0.209	8.241	0.000	Supported

Source: Author's Own Creation based on Smart-PLS Results

students had seamless access to AI-powered platforms, others faced significant barriers, such as unreliable internet service, limited access to personal computing devices, or institutional restrictions on AI usage. These disparities could have impacted students' ability to engage with and benefit from generative AI, thereby introducing variability in their experiences and perceptions. As noted by Al-Samarraie et al. [7], inadequate infrastructure and limited resources hinder the effective adoption of emerging educational technologies, particularly in developing regions.

Additionally, digital literacy levels among students and faculty played a role in shaping the use of generative AI in educational settings. Students who were more technologically proficient and accustomed to using digital tools in their academic work were more likely to integrate AI into their learning processes effectively. Conversely, those with limited digital skills may have encountered challenges in understanding AI-generated content, refining prompts, or critically evaluating AI responses. Previous studies have emphasized that AI literacy is a crucial determinant of students' ability to leverage AI tools effectively in academic settings [42]. Institutional policies and faculty support for AI adoption further contributed to these differences, as some universities provided guidance and training on AI integration, while others lacked structured AI-related support, leaving students to navigate its use independently. Akhtar-Danesh et al. [3, 53] suggest that the successful adoption of AI in nursing education requires targeted faculty training and structured guidelines to ensure that students receive adequate support in developing AI competencies.

These variations highlight the need for equitable access to AI-driven learning resources and targeted digital literacy training to ensure that all students can benefit from technological advancements in education. Future research should explore the impact of digital inequality on AI adoption in nursing education, investigating how socio-economic, institutional, and technological factors intersect to shape students' engagement with AI tools. Addressing these disparities is essential for maximizing the potential of generative AI in education and ensuring that its benefits are accessible to all learners, regardless of their technological background or institutional context. As Alzayyat and Al-Ghadban [8] emphasize, AI has the potential to revolutionize nursing education, but its effectiveness depends on addressing digital access disparities and ensuring adequate support mechanisms for students and faculty alike.

Theoretical implications

This paper presents several theoretical implications that contribute to the existing and emerging literature on nursing education utilizing generative AI innovations. Firstly, it expands current research on generative AI by investigating the impact of trust in generative AI on students' outcomes, specifically their performance, as well as other factors such as perceived usefulness and AI competencies. While much research has focused on the technology acceptance model, fewer studies have explored the factors influencing the intention to continue using new technologies like generative AI, or its effects on practitioners. The study's findings provide theoretical justification for the importance of trust and competencies in the context of emerging technologies, as indicated by hypotheses H3 and H4.

Secondly, this paper contributes to the development of theory by examining variables that explain students' performance in nursing education when using generative AI in their learning. While some variables from the technology acceptance model, such as perceived usefulness, have been extensively studied, less is known about trust in generative AI and generative AI competencies.

Thirdly, the data analysis in this study supports the theoretical justifications of the hypotheses based on undergraduate students' responses, helping to understand the role of generative AI in nursing education. This input was crucial for examining the study hypotheses and identifying new variables that could influence students' performance when using emerging technology in their learning.

Managerial implications

As AI, in general, and generative AI, in particular, become more prevalent and accessible in higher education institutions, the findings of this paper have several implications for decision-makers. Firstly, decision-makers in higher education institutions should consider introducing generative AI in managerial and academic departments.

Secondly, it is important for decision-makers in global higher education institutions to collaborate and initiate new research projects in this field, and to disseminate findings to practitioners in nursing and the health sector, informing them about the benefits of using generative AI in their practices.

Conclusion

This study explored the impact of Generative AI (Gen AI) on nursing education, particularly its influence on students' performance in Palestinian higher education institutions. The findings indicate that trust in AI significantly enhances students' perceived usefulness of Gen AI and their academic performance, while AI competencies negatively affect performance, suggesting that familiarity with AI does not necessarily translate into improved learning outcomes. These results highlight the need to

foster trust in AI among nursing students while ensuring better integration and understanding of AI tools within the curriculum.

By providing insights into nursing students' perspectives on Gen AI, this study offers valuable guidance for educators and policymakers on both the benefits and challenges of integrating AI into nursing education programs. Additionally, it contributes to the broader literature on AI in education, offering a unique perspective from the Palestinian context.

Future research should adopt mixed-methods and experimental designs to address the limitations of self-reported measures and further investigate the complex interactions between AI trust, AI competencies, and educational outcomes. Further exploration of effective AI integration strategies in nursing education is also recommended to maximize its potential benefits.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-025-07416-z.

Supplementary Material 1.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT 4 for proofreading of the manuscript. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Authors' contributions

Z.Kh and N. S prepared the research instrument and collected data; M.A analyzed the data; A. M and A.A wrote the literature review; J.I and A. A wrote the introduction. Z.Kh and J.I wrote the discussion. All authors reviewed the manuscript.

Funding

Not applicable.

Data availability

Data will be available upon request from the corresponding author.

Declarations

Ethics approval and consent to participate

The authors of this study got approve from the (Institutional Review Board (IRB) committee at An Najah National University, Nablus, Palestine. The IRB approval reference is Med.April.2023/17. Informed consent was obtained from all of the participants to participate in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 4 April 2024 Accepted: 28 May 2025
Published online: 01 July 2025

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