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Review Article

Health communication education in the AI era: a design-based research study on integrating emerging trends

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Abstract

Background & Objective: Effective health communication is a critical competency for healthcare professionals, and appropriate education is necessary to guarantee its quality in contextually sensitive communication settings. This article reports on the first cycle of a Design-Based Research (DBR) study that elicits a conceptual framework to design and develop a pedagogical intervention for medical students to practice communication skills in complex situations involving medical errors.

Materials & Methods: A preliminary literature review identified current trends in health communication and education using a pragmatic, scoping approach across key databases and technical resources. Following these trends, a scoping review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) protocol pinpointed recent methods for patient-centered communication education. This review was done by following a structured search strategy across PubMed and Scopus. From an initial pool of 218 records, 15 studies that met the criteria were analyzed. Finally, using a thematically synthesized approach, a conceptual framework for a learning environment was developed.

Results: The findings indicated that in health communication, emerging trends include the rise of digital and patient-centered communication and a renewed focus on culturally sensitive situations and empathy. Education, on the other hand, evolves from knowledge-centered approaches to competency-based learning, simulated and virtual environments, culminating in a humanistic-technological fusion that defines a new, future-oriented paradigm in which Artificial Intelligence (AI) and humanism converge in modern education based on patient-centered communication.

Conclusion: The result of this research integrates educational pathways, human principles, and instructional design principles in a holistic perspective to achieve patient-centered communication education. As an outline of this integration, the research indicates that technology's most valuable contribution to patient-centered education is enabling context-based scenarios that foster comprehensive patient-physician dialogue, taking into account the patient's emotional culture and priorities. Accordingly, for the next step in DBR - design and implementation- gamified scenario-based learning environments were chosen to provide authentic, real-world narratives grounded in real data, patient characteristics, and complex situations. AI-enriched situations were also selected to generate diverse, realistic scenarios.

Keywords: artificial intelligence; health communication; education, medical; communication; patient-centered care

Introduction

In specific medical subjects, such as health communication, the ineffectiveness of instructional methods is not the chief concern. Rather, teaching patient-centered communication alongside basic communication skills is a gap in knowledge-centered education. This gap, along with challenges including

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outdated curricula, limited practical training [1], insufficient focus on audience needs, lack of or limited involvement of key stakeholders in curriculum development, a focus on hospital-oriented education, lack of preparation of educators (who are often subject matter experts but typically lack formal training in effective teaching practices [2]), and inappropriate resources, lead us to a new view about health communication education.

Education has consistently adopted new technologies, albeit with a slight delay compared to other fields. Artificial intelligence-based tools, as cutting-edge technologies, are a new asset in education. AI in education has evolved from computer systems to web-based learning platforms. The evolution enables customized learning resources, personalized learning, and automated tasks by adapting to each student's pace, with custom content, access to various media, just-in-time feedback, and so on [3–7]. Along with these advantages, the chief concern is prioritized technological competence, often at the expense of humanistic values central to patient-centered care. This matter is crucial when we concentrate on communication skills that, in terms of historical development, rely on humanistic medicine.

In a global medical landscape shaped by rapidly advancing technologies, the tension between scientific rigor and humanistic values has become increasingly pronounced. To face the matter, combining modern achievements in medical education with human principles and values has been emphasized [8] to provide a sustainable model in education.

Emerging research indicates that changes in educational approaches have led to the integration of new models—such as Competency-Based Medical Education (CBME) and narrative medicine, among others—into medical education systems [9]. These systems were introduced before the advent of Artificial Intelligence (AI) and may present both new challenges and opportunities for medical education.

In current medical practice, AI is most commonly applied to documentation, translation, and diagnosis [10], yet a notable gap remains in the domains of education and communication. Modern health communication education—which focuses on patients' core concerns and emphasizes realistic learning experiences to illustrate complex, holistic patient–physician interactions [11]—is well positioned to embrace an AI-enriched environment. Such an environment simultaneously values technological advantage and humanistic principles. But, effective learning environment design requires analyzing trends and instructional design principles to establish an appropriate pedagogical process.

Drawing on international research in health communication education, the present study explores pathways toward AI-enriched environments, with a specific focus on health communication as the intersection of advances in educational methods and communication approaches.

The present study, part of a larger research project using the Design-Based Research (DBR) method [12], focuses on designing a gamified environment for teaching communication skills in the context of medical errors. The initial design phase involves a literature review and consultations with health communication experts and game designers to extract instructional principles. The present study aims to elicit the main principles derived from the literature analysis.

These principles will guide the development of an engaging and realistic learning environment for medical students to practice communication skills in complex situations involving medical errors. Ultimately, this study provides a conceptual framework for the DBR cycle's design phase, adapted to the specific context of training medical students in effective communication strategies.

Materials & Methods

Design and setting(s)

As mentioned above, the current study is part of a larger research project using the DBR method. DBR identifies practical education challenges [13] and iteratively develops interventions [14] by designing practical pedagogies, instructional tools, media, and learning environments to address these challenges with potential solutions. The present study reports the first phase of DBR, gathering data from the literature, and ultimately develops a conceptual framework for a gamified scenario-based learning environment in health communication.

McKenney and Reeves [12] frame four phases of DBR, including: Analysis and exploration, Designing and construction, evaluation and Reflection, loop: iterative redesign and re-evaluation, and theory building. In DBR, we face a loop that follows a research process of analysis, design, implementation, and evaluation (**Figure 1**). Analysis phase including: identify task dimensions, theoretical foundations, and user needs through literature reviews, interviews, and expert input; accordingly,

design phase, including: Translate requirements into tools, frameworks, or experiences like instructional modules; Implementation phase include: Create a practical artifact from the design, such as a prototype, sequence, or software, incorporating user interaction and data collection; finally, Evaluation phase include: Assess usability, validity, learning, or performance using metrics, and provide prioritized recommendations.



Figure 1. DBR mechanism (adapted from [15]).

Participants and sampling

This study is a scoping review of the literature; therefore, no human participants were involved. The sampling strategy was purposive, targeting peer-reviewed articles and technical reports that address trends in health communication and education, with a focus on patient-centered communication and the integration of AI.

Tools/Instruments

A structured, validated online questionnaire was used to collect data. The instrument comprised three parts:Demographic and professional background includes age, gender, marital status, residency year, work experience, palliative care work

Data collection methods

The research question underpinning the first DBR phase is: What is the instructional design principles to develop a learning environment that supports technological advances and trends in health communication education? To answer the research question, three sub-aims were proposed, including: (a) Identifying trends in health communication education. (b) Identifying the intersection of technological advancement and health communication education to elicit conceptual framework for an appropriate learning environment. (c) Study the findings that support a new approach in communication education according to the results of the second aim.

To reach the aims, first, a brief scope review was conducted, searching for literature on health communication trends and communication education; then in separate review that conducted and reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist [16]; research that supports the new approaches in health communication was analyzed. Finally, the conceptual framework was developed based on thematic analysis from the two previous steps. To identify trends in health communication education, a scoping review, using the Arksey & O'Malley [17] framework, was conducted due to the exploratory research question, the diverse nature of health communication studies, and the need to map the existing evidence. The Arksey and O'Malley framework was applied as follows: Define research question. search databases and literature. Select studies. Extract and organize data. Summarize and report findings with narrative format. To search, analysis and report the findings that support a new approach in communication education, a scoping review using the PRISMA-ScR checklist was conducted. To enhance the scientific rigor of this study, the PRISMA-ScR checklist was used. This helps to ensure the selection of high-quality research, aiming to select and report the studies that support effective health communication education. Search terms for the first and second aims included health communication, health education, and medical education. To address the sensitivity and accuracy of the search, the OR operator was used for synonyms and AND to combine key concepts ("health communication" OR "health education" OR "medical education").

This stage aimed to clarify trends in health communication and education. Purposive sampling was used in this stage; most of the reported research was conducted after 2020. The concepts emerging from this part were used as keywords for the next review. Search

terms for the third aim that emerged from the last analysis included health communication, patient-centered communication ("patient-centred" (British spelling also used to address sensitivity and accuracy), and education. The search was limited to publications from January 1, 2020, to April 25, 2026. Priority was given to peer-reviewed articles, particularly recent studies (2023–2026). Relevant books were also included to provide historical context and a fundamental theoretical framework. Articles were thematically analyzed to synthesize historical foundations, educational models, implementation, and future directions.

In the third aim, the PRISMA-ScR (**Figure 2**) protocol pinpointed recent methods for patient-centered communication education. This review was done by following a structured search strategy across PubMed and Scopus.

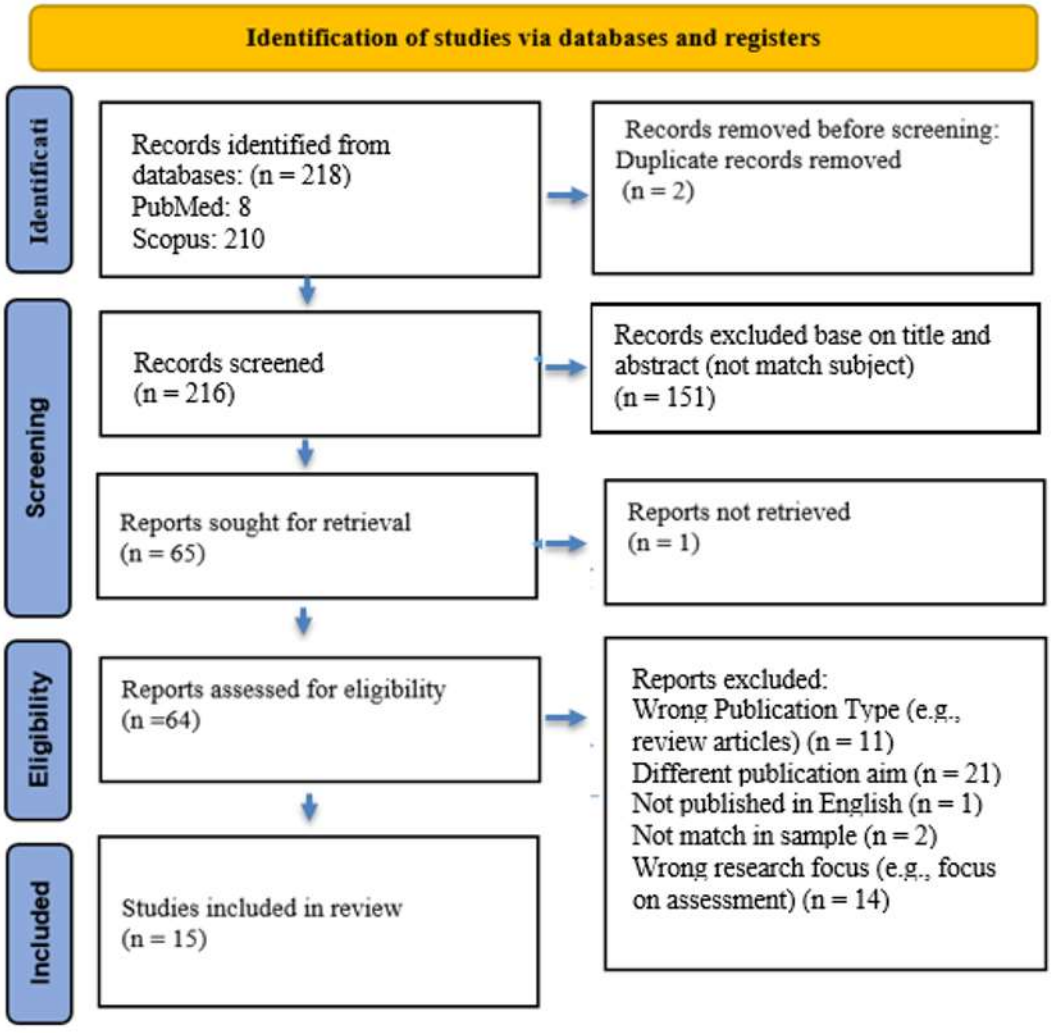


Figure 2. Flow chart of the study selection process according to the PRISMA guidelines.

Data analysis

All records were imported into the Rayyan software for analysis. After removing duplicates, titles and abstracts were screened to identify peer-reviewed articles meeting the inclusion criteria (**Table 1**). The full texts of 15 selected articles from 218 records were then assessed to identify new educational methods in patient-centered communication. Finally, a narrative synthesis was employed to summarize key findings (**Tables 2** and **3**).

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• From the 2020 until 2026	• Out of the mentioned period
• Empirical studies	• Not match research method (e.g. review)
• Research in English language	• Not in English
• All research in patient-centered communication education	• Non-health education
• Full text of the article is available	• Not access to full text

Note: This table outlines the criteria for study selection in the systematic review.

Results

The findings of this research are presented in four distinct sections. The initial portion offer a detailed historical overview of medical communications, tracing its development and significant milestones over time. The second part focuses specifically on the progression and changes in communication education within the field of medicine, examining how training methodologies and curricula have adapted to meet the evolving needs of healthcare professionals and the broader medical landscape. This section explores the various approaches utilized to enhance communication skills among medical practitioners and students, shedding light on the transformations that have occurred in this crucial aspect of medical training. The third part reports the analysis of the research that supports patient-centered education.

At the end, this study presents the common ground between these approaches from the perspective of technological advancement, communication, and education, highlighting the intersectionality of development in educational methods and communication approaches.

Table 2. Key findings about trends in health communication and education

Period	Communication Approach	Core concept and emphasize	Educational pathway	Pedagogical effects	Ref.
Ancient	Physician-patient interactions	Subjective patient interviews	Focus on clinical and technical knowledge No communication courses	Skills learned through apprenticeship	[18]
1960s–1980s	Patient-centered care	Effective patient communication	Following a medical council report emphasizing clear, sensitive, and effective patient communication, this training became standard in undergraduate medical curricula nationwide and was later adopted by US medical schools Standardized patients	Pedagogical shifts: Moving away from passive observation toward active, competency-based education, including the use of role-playing.	[11]
1980s–1990s	Interdisciplinary approach in communication	Formalization communication education in medical curricula Communication skills can and should be taught	Inter professional simulation-based training	Incorporating theories from psychology and sociology to improve patient interactions All medical schools must formally assess the quality of communication of their students	[19]
(1990s–AI age)	Digital transformation	The shift from landline/postal methods to electronic health records and mobile apps has revolutionized how providers communicate with each other and patients	Emergence of narrative medicine and humanistic approaches and focus on empathy scenario-based simulation, high-fidelity models, role-play.	Simulation & digital training emerge digital-narrative pedagogy	[20]
AI age	AI-supported humanistic communication	Tech literacy with ethical & narrative competence	Virtual reality and virtual patients simulated patient–medical practitioner conversations	Hybrid pedagogy adaption technological systems without losing human touch.	[21–22]

Note: This table summarises the historical evolution of health communication and corresponding educational approaches.
Abbreviations: AI, artificial intelligence; Ref., reference(s).

Table 3. Key findings of selected empirical studies on patient-centered communication educational methods

Title	Aim	Study design	Result	Ref.
Investigating the effects of a short narratology module on empathy and patient-centred communication in early-stage medical students: an empirical mixed-methods pilot study.	Study the effect of Narratology as a pedagogical framework for augmenting empathy and patient-centred communication in medical students.	Mixed-methods pilot study	The empathy and communication in early-stage medical students can improve following a short narratology module	[34]
Randomized controlled monocentric trial to compare the impact of using professional actors or peers for communication training in a competency-based inverted biochemistry classroom in preclinical medical education	Examined the difference between peer and standardized patient (SP) role plays in communication training	Experimental study	Role plays in a biochemistry seminar improve students' self-perceived competency. The use of standardized patient has some advantages, such as being more realistic.	[35]
Feasibility and acceptability of a virtual learning module for navigating angry conversations in clinical encounters	Examined the feasibility and acceptability of a virtual learning module for communication skills	Experimental study	Self-efficacy's scores did not differ significantly between groups. Responses to the acceptance and use of technology questionnaire indicated acceptance of VL.	[36]
Evaluation of the impact of student-led clinics on medical students' knowledge, skills, and professional growth.	Evaluating the impact of Student-Led Clinics (SLCs) on the educational and professional development of medical students	A cross-sectional pilot study	SLCs improved patient-centred care and communication skills of medical students.	[37]
Cinema as a pedagogical tool for empathy training in dental education: a qualitative study	Exploring cinema education as an innovative approach to empathy development	Qualitative study	Cinema education emerged as a valuable, resource-efficient approach to developing empathy in dental students, demonstrating potential effectiveness.	[38]
Assessment of Curricular Integration of Compassionate Communication in Pharmacy Training	To assess the impact of a novel compassionate communication curriculum including: information sharing, engaging demonstrations and videos, skill-building exercises, and self-reflection on communication skills	Qualitative study	A compassionate communication curriculum is a feasible and valuable addition to pharmacy education, fostering both compassion and collaboration.	[39]
It turns out I was wrong": a thematic analysis of medical students' reflective writing in an e-learning course on communication skills.	Examining the effect of structured reflective writing within an e-learning course on physician-patient communication	Qualitative thematic analysis	Reflective writing within our e-learning fostered students' metacognitive engagement, enhanced their awareness of communication nuances.	[40]
An innovative approach to cultural competency and spirituality education for medical students.	Improve skills in culture competency and spiritual history taking by implementing an interactive, educational session including: didactics and dyad role-playing clinical scenarios	–	The positive effect of the intervention was reported.	[41]
Enhancing dental education: Integrating technology and patient-centered learning	To evaluate the effectiveness of TEL and patient-centered learning strategies to improve clinical skills, communication, and empathy	Mixed-method	The combination of TEL and patient-centered learning strategies significantly enhances clinical skills, communication, and empathy.	[42]
Efficacy of an online communication skill training intervention on genetic counseling students' performance during standardized patient sessions	Online intervention designed in delayed and immediate intervention form to enhance students' patient-centered communication	Experimental design	Exposure to the intervention was associated with multiple, positive changes to students' patient-centered communication behavior.	[43]
Development of communication skills through virtual reality on nursing school students: Clinical trial	To study the effect of virtual reality simulator on improving communication skills	Experimental design	The virtual reality intervention outperformed the other method.	[44]
An interactive curriculum to teach person-centered contraceptive counseling	To assess the effect of the new communication curriculum including: a reference guide, 5- to 10-minute interactive online module, and a 30-minute formative standardized patient session	Experimental design	The formative session, though resource-intensive, effectively solidified students' communication skills within the new curriculum.	[45]
Effectiveness of a minimal virtual motivational interviewing training for first years medical students: differentiating between pre-test and then-test.	Investigation the effect of MI simulation for communication knowledge and skills	Single-group	A brief one-hour MI training simulation can be effective even if offered at an early stage during medical education.	[46]
I have a cough": an interactive virtual respiratory case-based module	Online interactive module including: videoconferencing software, telemedicine encounter with a standardized patient and case discussion and clinical reasoning component	–	The module improved communication skills.	[47]
Effectiveness of a communication skills training program for medical students to identify patient's communicative clues	Explores whether an ETP in CS improves students' ability to identify patients clues	Experimental design	Students in the ETP in CS demonstrated a greater ability to explore patients' perspectives through various communication methods.	[48]

Note: This table presents a synthesis of empirical studies published between 2020 and 2026 that evaluated pedagogical interventions for patient-centered communication education.
Abbreviations: Ref. reference(s); SP, standardized patient; VL, virtual learning; SLCs, Student-led clinics; TEL, technology-enhanced learning; MI, Motivational Interviewing; ETP, experiential training programme; CS, communication skills.

Trends in health communication and communication education

The Centers for Disease Control and Prevention [23] defines health communication as "the study and use of communication strategies to inform and influence individual and community decisions that enhance health" Because of the importance of establishing a long-term trusting relationship between the patient and the health care team which is essential to achieve the best outcome in improvement of the patient's health, and achieve patient satisfaction, in the 1980s, the Medical Council reported medical students should be taught to communicate clearly, sensitively, and effectively with patients [24]- a turning point in health communication education. Previously, physicians' clinical skills merely emphasized knowledge, physical examination, and so on; communication was seen as innate rather than taught. A short time later, communication skills courses began to be taught at several medical schools in the United States, taking into account patients' characteristics. This reflected an emerging view that was better than the outdated notion of ignoring patients' psychological and social contexts, which ultimately exacerbated patients' suffering [25], and introduced a perspective that distinguished between curing and healing. Curing and healing, though often used interchangeably, differ significantly. Curing focuses on eliminating a specific disease, while healing considers the patient holistically, encompassing mental, emotional, and physical well-being. Not long after this development, educational programs focusing on the development of communication skills started gaining traction and were progressively incorporated into the curricula of several medical schools located throughout the United States [26]. These courses aimed to equip medical professionals with the necessary abilities to effectively interact with patients, colleagues, and other stakeholders in the healthcare system. Like other fields, communication education has evolved from passive methods like lectures and observation to active, competency-based learning. This pedagogical shift in health communication education emphasized practical skills through innovative techniques like role-playing, moving away from traditional passive observation to foster deeper engagement, critical thinking, and real-world competencies for student success. During the 1990s, the advent of digital transformation [27] brought about a significant shift away from traditional, paper-based methods in healthcare, with a growing adoption of electronic health records. This transition marked a fundamental change in how patient information was managed, stored, and accessed. Furthermore, the introduction and proliferation of mobile applications had a revolutionary impact on the healthcare landscape. These apps provided new avenues for patients to monitor their conditions and communicate with healthcare providers, increasing convenience and accessibility in managing healthcare needs. Right around the same time, the discussion of patient-centered communication was reemerging in the medical world.

Emergence of narrative medicine and humanistic approaches: toward patient-centered communication

Narrative medicine emerged as a pedagogical and clinical response to concerns about healthcare depersonalization amid increasing digital technology integration. This approach emphasizes patient stories, socio-cultural contexts, and reflective practice, nurturing empathy, communication, and professional identity formation [9]. Educational programs incorporate narrative-based clinical training, where students learn to listen and respond empathetically to patient experiences, thereby developing professionalism—including accountability and ethical sensitivity.

Patient-centered communication approach

Patient-Centered Communication (PCC) is often suggested as an ideal approach to healthcare interactions. Although exact definitions vary, PCC generally calls for clinicians to view patients as persons with unique psychosocial contexts [28], to elicit and attend to patients' values and preferences, and to offer patients meaningful involvement in decision-making.

Pluut [29] outlined three approaches to patient-centeredness: caring, where professionals alleviate suffering and ensure compliance of vulnerable patients; empowering, where professionals advise autonomous patients to facilitate informed decisions; and responsiveness, where professionals adapt to individual patient values and needs. Patient-centered communication arose as an alternative to clinician-centered approaches, which prioritize the clinician's agenda and neglect the patient's perspective and emotions. This can lead to patient dissatisfaction, clinician frustration, and poorer health outcomes [30–32]. Patient-centered communication serves to prioritize the patient's needs and interests. Accordingly, patient-

centered interviewing elicits what is most important to patients, including their concerns, feelings, and emotions, in addition to symptoms. This approach enables the interviewer to develop a biopsychosocial understanding of the patient, moving beyond a solely symptom-focused perspective and allowing the patient to guide portions of the conversation. It also emphasizes the patient's ideas, concerns, and expectations.

In a well-known book of Fortin et al. [33] named “Smith's Patient-Centered Interviewing, an evidence-driven method," a method is described in health communication soft skills that focuses on understanding the patient's unique perspective and experience of their illness. It emphasizes exploring not only the biomedical aspects of the disease but also the patient's feelings, ideas, expectations, and the impact of the illness on their life.

This approach fosters a stronger doctor-patient relationship, leading to improved adherence to treatment and better overall health outcomes. By actively listening and responding empathetically to the patient's narrative, the interviewer gains a more comprehensive understanding of the patient's needs and concerns.

The method consists of 11 steps that lead the interview process to a biopsychosocial story, including: Step 1: Set the stages for the interview; Step 2: elicit chief concern and set agenda; Step 3: begin the interview with non-focusing skills that help the patient to express her/himself; Step 4: Use focusing skills to elicit three things: symptom, story, personal context, and emotional context; Step 5: transition to the middle of the interview; Step 6: Complete a chronological description; Step 7: past medical history; Step 8: social history; Step 9: family history; Step 10: Review of the system; Step 11: end of interview.

Patient-centered communication education

Modern medical education should train physicians to apply specialized knowledge while recognizing each patient's unique psychological, social, and material circumstances. This cooperative-deliberative model emphasizes interaction between two experts: the physician, a medical expert, and the patient, an expert on themselves. Effective communication is built on mutual understanding within a caring and dynamic relationship. This approach fosters the concept of the "empowered patient."[34]. Patient-centered communication emerged as an important historical development. The concept is associated with positive health outcomes, including early prevention and diagnosis, increased adherence to treatment regimens, and self-management behaviors, and it also reduces the number of malpractice claims [31].

In transition from knowledge-centered communication to patient-centered communication and as medical goals evolve from treating disease to maintaining lifelong health, medical education now demands biomedical knowledge, communication skills, ethical awareness, and humanistic compassion.

To study development in communication education that serves patient-centered communication, the current research conducted the second review to study new educational methods that are supported by experimental or practical research. The result is summarized in **Table 3**. The collated evidence from 15 distinct studies published between 2020 and 2026, which investigated pedagogical interventions aimed at enhancing patient-centered communication or related competencies in health education [35-49], shows that experimental design was the most commonly utilized method. Most studies were published in 2025 (n=5). Experimental design was the most commonly utilized method.

The studies indicates that in general learning experiences such as compassionate communication curriculum [40]; new Experiential Training Programme [49]; Student-Led Clinics (SLCs) [38]; Technology-Enhanced Learning (TEL) [43]; online interactive module [46–48]; and specific approaches and methods same as narrative-informed pedagogies [35]– alongside role-plays [36,42]; simulations [47]; virtual reality simulator [45]; reflective writing [41]; cinema education [38]; and technology-enhanced learning same as virtual learning module [37]; online communication skill training base on standardized patient [44] are feasible and generally effective for enhancing patient-centered communication among medical students.

The evidence, while heterogeneous in design and outcome measurement, consistently favors narrative-based, experiential, and technology-enhanced pedagogies as safe and potentially beneficial. Key findings suggest that narrative-based interventions [35, 41] and structured reflective writing in e-learning courses [41] promote metacognitive engagement and awareness of communication nuances, leading to a scenario-based approach that leverages the advantages of narrative within this learning environment. On the other hand, technology can facilitate peer-to-peer learning with authentic, culturally sensitive scenarios. Consistent with this, research has shown that peer role-playing, interactive didactic sessions, and dyad role-playing improve cultural competency in communication.

AI and patient-centered communication education

Progress in integrating technologies in communication education had reached the point that in the 2020s, narrative methods merged with digital platforms, forming hybrid pedagogies. VR, educational apps, and e-portfolios enhanced soft skills and promoted reflection. The trend should now shift toward integrating AI into medical communication education.

Holtz, Nelson, and Poropatich [31] define AI as including machine learning, advanced clinical decision support systems, and computer-driven algorithms for automated diagnoses. It can be extended to include new features in patient knowledge and communication, as well as new trends in co-creation, co-regulation, and co-learning. AI collaboration can help physicians reduce time spent on diagnosis and treatment, thereby allowing them to dedicate more time to understanding patients and providing tailored recommendations. Despite these possibilities, AI cannot replicate a physician's holistic understanding of a patient's unique individuality. Therefore, the key training point for AI in patient-centered communication is to support—not replace—the physician's empathetic engagement.

In line with this AI role in communication education, Hong and Shin [50] examined the impact of a conversational AI chatbot on medical students' patient-centered communication skills. They found that AI chatbots improved patient-centered communication skills (PCC) and learning motivation. The findings showed significant correlations between motivation, PCC scores, and chatbot perception, suggesting that improved AI perception enhances outcomes.

Liaw et al. [22] also examined the effect of an AI-powered VR system for nursing students to practice interprofessional communication with AI physicians. The result shows improved communication skills through AI-enabled Virtual Reality Simulation (VRS). Findings suggest improvements to the AI pedagogical agent's expressiveness and learner-agent dialogue instruction. The results of this study can be extended to patient-physician communication, as the learner can transfer skills to a new context, and communication skills can also be learned in an AI-generated scenario that represents real-world cases. Although the research illustrates the new role of AI in communication education, clinicians' and patients' engagement with Gen-AI, the resulting changes in healthcare communication, and the long-term impact of those changes remain unclear. To fill the gap, Hahne and Carpenter [51] conducted a review to synthesize empirical research on clinician and patient engagement with Gen-AI in healthcare communication, examining how Gen-AI detracts from or enhances the patient-centeredness of clinical communication. The results indicated that integrating Gen-AI into healthcare communication has the potential to increase clinician efficiency in interacting with patients, expand channels for patients to obtain information about their healthcare, and enhance empathy in clinical communication. However, findings also indicate variability in the potential for Gen-AI to recast the clinician as a technical supervisor rather than a humanistic care provider.

Based on the pattern of findings, it is reasonable to infer that advances in educational technology and patient-centered communication education have converged, creating an opportunity to use generative artificial intelligence to simulate scenario-based situations collaboratively.

The foundation of this collaboration is Gen-AI's abilities in simulating human cognitive functions [52], such as thinking, learning, reasoning, and problem-solving through algorithms, computing power, and data that are crucial in communication situations. Research has increasingly explored the effectiveness of these abilities compared to human ones. For example, Lim and Schmälzle [53] conducted an interesting study to analyze AI-generated health awareness messages alongside human-generated ones. Their findings showed that AI messages were similar to human tweets in content and semantics. AI messages also scored higher in quality and clarity and were equal in sentiment, reading ease, and semantic content.

Toward the Gen-AI age in health communication education

Gen-AI- Human co-collaboration: As mentioned previously, generative artificial intelligence simulates human intelligence to learn from patterns of data and create new content and ideas. With this new feature, we are witnessing the emergence of Gen-AI-supported humanistic communication in health education, same as virtual patients or physicians in authentic learning environments, which brings personalized and adaptive learning through collaboration. In human-AI co-learning, both humans and AI adapt and learn collaboratively [54]. We can therefore inquire from AI about patient-centered communication rules and learn,

subsequently posing new questions accordingly. Since patient-centered communication education involves dialogue between a patient and a doctor, and medical communication is grounded in real-world scenarios, advances in generative artificial intelligence can provide a solid basis for using this technology in medical communication education. Accordingly, the current study illustrates the practical application of defined trends and technological advances within a thematic framework, identifying a connection between patient-centered dialogue and AI-enriched scenario-based learning environments for designing effective educational interventions. Scenario-based environments were chosen for their capacity to deliver authentic [55] real-world narratives grounded in real data, patient characteristics, and situations that mirror patient-centred communication. AI-enriched situations were also selected for their potential to generate diverse scenarios that reflect human settings (**Figure 3**).

In the mentioned framework, constructivist learning, specifically situated learning theories, emphasize both social and physical settings in which learning appears. Authenticity occurs in the interaction between the learner, the learning environment, and the task itself [56].

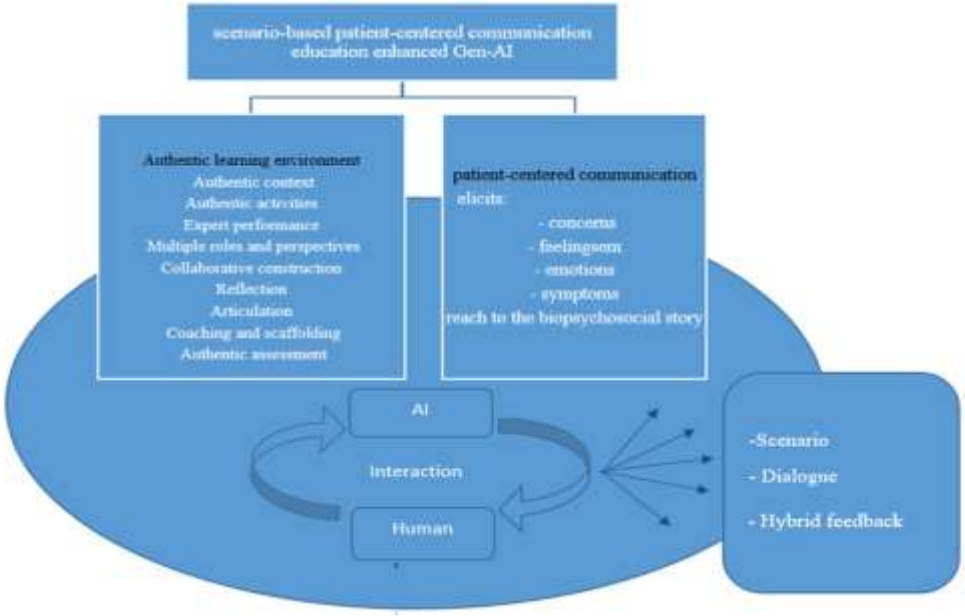


Fig 3. Conceptual framework for scenario-based learning environment in patient-centered communication enhanced by Gen-AI

Herrington et al. [57] declare nine characteristics for an authentic learning scenario, including: 1- Authentic context; 2. Authentic activities; 3. Expert performance; 4. Multiple roles and perspectives; 5. Collaborative construction; 6. Reflection; 7. Articulation; 8. Coaching and scaffolding; 9. Authentic assessment.

The use of scenario-based environments themselves provides an authentic learning situation. Narratives and stories form a large part of the strategy that could be used to create contextual and authentic environments. Navigating in the scenario and shaping the AI-human loop is the exact engagement in Authentic activities that mirrors a real-world event. Regarding access to expert performance, AI shapes its information structure on LLMs with capabilities to gather, analyze, and generate data accordingly. If we use a customized LLM, the system could be trained with expert knowledge. The main reason for using scenario-based environments in patient-centered communication education is to use situations that can represent complex real-world settings. it provides an opportunity for learners to see events and something from Multiple perspectives. In AI-supported education, the main activities included: co-construct, co-learning, and co-regulation that all of them reserve for collaborative construction of knowledge. To promote reflection, scenario-based education requires some tasks that need decision-making and problem-solving, in which reflection is crucial. Engaging in a dual loop consists of AI- human learning and generating articulation aimed at AI in all stages, playing the Coach role to provide scaffolding. The last consideration, authentic assessment, is also addressed by constructivism, which holds that learning and assessment are linked in situated learning.

The other body of the theoretical framework of the current study centers on human-AI collaboration [58]

and human-AI co-learning [59], seen as a new version or, on the other hand, the Computers as Social Actors (CASA) theory [60]. It proposes that humans apply social rules and expectations when interacting with computers, perceiving them as social entities. Social interaction includes student-machine interactions, such as computer-based scaffolding [61]. Accordingly, Generative AI (Gen-AI) can foster a social learning environment where learners and AI engage in dialogue and learn from each other. Free-form dialogue interfaces like ChatGPT facilitate continuous, human-like conversation through multi-turn interactions [62].

According to this concept, a Transformative learning environment with AI-enhanced capabilities transforms the conventional classroom into hybrid intelligence learning environments, where humans and AI collaborate [58, 63, 64]. Human-AI Collaboration establishes a new human-machine relationship in which AI acts as an active teammate, working alongside humans to achieve shared goals. This collaboration involves mutual learning. Humans learn from AI, and AI learns from human input. In this interaction, AI is commonly positioned to support team and task roles.

Discussion

Medical students, due to the curriculum's breadth, might not develop communication skills as well as other key clinical skills, such as technical knowledge and making diagnoses. In fact, Knowledge-based education often overlooks the education of communication skills, a crucial skill in healthcare. Scenario-based environments that represent holistic features of patient-physician interaction could fill the gap. In these authentic settings, applying both technical knowledge and communication skills is necessary.

On the other hand, AI offers innovative tools like advanced simulations and virtual patients to enhance the mentioned situation, providing realistic dialogue, personalized feedback, and helping healthcare professionals refine their communication skills across diverse medical scenarios. But Health communication remains largely untouched by advances in AI and Gen-AI-enriched education. This untouched status primarily pertains to AI's inherent inability to genuinely interpret deep emotional nuance and cultural context; however, AI's transformative educational potential lies not in replacing human empathy, but in generating the vast, scalable, and diverse practice scenarios necessary to address the experiential deficit left by knowledge-heavy traditional curricula. The current research, which aimed to fill the gap, tried to identify trends in health communication and health communication education for developing an appropriate instructional intervention. As an outline of this integration, the research indicates that technology's most valuable contribution to patient-centered education is enabling context-based scenarios that foster comprehensive patient-physician dialogue, taking into account the patient's emotional culture and priorities. Accordingly, scenario-based learning environments were chosen to provide authentic, real-world narratives grounded in real data, patient characteristics, and complex situations. AI-enriched situations were also selected to generate diverse, realistic scenarios. As a result, this study develops a conceptual framework for a scenario-based learning environment in patient-centered communication enhanced by Gen-AI. To move beyond abstract principles, this framework operationalizes the integration through three interconnected components: an AI-driven scenario, an interactive simulation layer for student-AI dialogue, and a hybrid feedback system.

The loop consists of: The Scenario sets the stage (e.g., a patient with chronic pain). The Dialogue forces the student to interact with the patient's biopsychosocial story. The Hybrid Feedback first reveals what the student did (AI Metrics) and then guides them to understand why it mattered (Human Debriefing). This framework, considering the subject of learning, which is patient-centered communication and is strongly dependent on the culture and characteristics of the patients and their social environment, identifies key features of learning environments by integrating situated learning theory with patient-centered communication, acknowledging the influence of patients' culture and social environment. Technological advancements are then utilized to create real-world, context-based scenarios at the intersection of these features. This framework also considers that in health communication education, AI technology offers potential advantages, including facilitating personalized learning experiences, providing objective content-based and structural feedback to students [65] in a loop between artificial intelligence and humans.

Preiksaitis and Rose’s Thematic analysis [66] revealed diverse potential applications for Gen-AI in medical education, including self-directed learning, developing simulation scenarios, and writing assistance. Specifically, Scenario-based simulation enhanced with AI provides ideal resources for medical education because Gen-AI can generate realistic and sophisticated content across various media, including text, code,

image, audio, music, and video. This presents a significant opportunity in educational settings to automate tasks, enhance decision-making, facilitate data analysis, and personalize experiences [67]. While these potential benefits are considerable, it is worth noting that much of the cited evidence on engagement and retention is drawn largely from general education research, underscoring the clear need for domain-specific empirical validation within the distinct context of health communication training.

In the same vein, researchers have indicated that Gen-AI enables learners to practice in a safe environment using realistic virtual patients and diverse clinical scenarios, including complex medical cases and joint consultations, without real-world risks [68]. Other applications include virtual inquiry systems [69] and simulations for practicing diagnoses, explaining treatment plans, and delivering empathetic care [70]. Since medical cases are authentic experiences, real-world scenarios are important in this setting. AI-generated scenarios could provide enormous cases missed for medical students in knowledge-based education.

AI algorithms create realistic medical simulations tailored to specific learner needs using patient data and history [71]. This could be an enriching learning tool for communication education.

Authentic experiences that serve patient-centered communication represent a lasting progress in the health communication trend. Technology now supports a patient-centered communication approach by educating medical students in these communication skills.

In this advanced approach, the challenge lies in designing tools that capture the nuances of human interaction, unspoken cues, and emotional undertones vital for understanding patient needs. Beyond recording conversations, the technology should identify patterns, highlight areas for improvement, and offer personalized feedback. Virtual patients, AI coaches, and data analytics are potential solutions. The aim is to provide a safe learning environment for medical students to strengthen their communication skills, fostering more meaningful patient relationships.

AI systems stimulate human cognitive functions like thinking, learning, reasoning, and problem-solving through algorithms, computing power, and data. Collaboration between AI and learners in a scenario-based environment creates immersive experiences in which learners engage with realistic content. Research accordingly indicated that students who applied the AI-enhanced platform exhibited statistically significant higher engagement rates, lower drop-off rates, and improved knowledge retention than those following a conventional learning approach [72]. In health education, when some prompts, such as patient characteristics, gender issues, communication approach, scenario type, cultural sensitivity, etc., are defined, the AI-enhanced learning environment could provide adaptive content generation in contrast to a one-size-fits-all approach for an authentic situation.

However, simulated patient-doctor conversations with virtual patients can enhance authenticity compared to any analog or digital format [73], this capacity could be enriched by Gen-AI in health communication. However, Stamer, Steinhäuser, and Flägel [74] suggest that AI applications in health communication currently have limitations in access, scenario variability, conversational flow, and authenticity. These core concerns must be considered in the next phase of this and future research. In sum, Gen-AI advancements can transform learning environments into adaptive ecosystems that learn, adapt, and adjust to the needs of students in real-time, dynamically responding to their interactions. Integrating Gen-AI tools into education offers opportunities to create authentic tasks and enhance learning experiences.

A key limitation of this article is its scope as a mini-review of health communication trends. While existing research on health communication education trends partially addresses this gap, longitudinal experimental studies would provide valuable insights for educational interventions.

Conclusion

This study, part of a larger DBR project, sought to map out the path to designing a learning environment in health communication, which ultimately led to a conceptual framework. The proposed framework of the current research integrates educational pathways, human principles, and instructional design principles in a holistic perspective to achieve patient-centered communication education. The findings trace a shift in health communication education—evolving from knowledge-centered approaches to competency-based learning, culminating in a humanistic-technological fusion that defines a new, future-oriented paradigm where AI and humanism converge in modern education based on patient-centered communication. To align with this trajectory, patient-centered communication education must strategically leverage technological innovations. Technology's most valuable contribution to

patient-centered education is enabling context-based scenarios that foster comprehensive patient-physician dialogue, considering the patient's emotional culture and priorities.This study demonstrates how patient-centered education and situated learning principles can be effectively integrated within a scenario-based environment, highlighting the instrumental role of technological advances like Gen-AI in creating such environments. According to the findings, current learning environments can use AI-generated situations to provide learners with realistic, dynamic scenarios. These scenarios, which necessitate role-playing, expose learners to transitional situations that vary in each repetition, unlike static training. Looking forward, the next phase of this DBR will utilize Gen-AI to produce high-fidelity, variable communication simulations that address the critical educational bottleneck of scalable, realistic practice. Ultimately, this fusion of humanistic pedagogy and artificial intelligence does not merely modernize training—it redefines the epistemological foundation of clinical communication, ensuring that future physicians are equipped not just with knowledge, but with the contextual empathy required for holistic patient care.

Ethical considerations

The author affirms that this review upheld the highest standards of research integrity. The author confirms that all content is original. Any verbatim or paraphrased text from prior publications has been appropriately cited. All data extracted from primary studies are reported faithfully, without selective omission or manipulation. The author has not fabricated, falsified, or suppressed any finding from the source literature.

Artificial intelligence utilization for article writing

The author used Sider (GPT-4.1 mini) to check grammatical errors and, in some cases, used DeepSeek for reference organization. After using these services, the author has reviewed and edited all parts, and assume full responsibility for all content and conclusions.

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Conflict of interest statement

There are no conflicts of interest.

Author contributions

NM wrote all parts and was responsible for the conceptualization and design of the study, data collection, analysis, and interpretation using thematic analysis.

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The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. Muraraneza C, Mtshali GN. Conceptualization of competency based curricula in pre-service nursing and midwifery education: a grounded theory approach. *Nurse Educ Pract.* 2018;28:175–181. https://doi.org/10.1016/j.nepr.2017.09.018
2. Dominguez I, Zumwalt A. Developing a practical medical educator training program: meeting a need in faculty development [version 1]. *MedEdPublish.* 2020;9:271. https://doi.org/10.15694/mep.2020.000271.1
3. Zawacki-Richter O, Marín VI, Bond M, Gouverneur F. Systematic review of research on artificial intelligence applications in higher education–where are the educators? *Int J Educ Technol High Educ.* 2019;16(1):39. https://doi.org/10.1186/s41239-019-0171-0
4. Chiu TK, Xia Q, Zhou X, Chai CS, Cheng M. Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. *Comput Educ Artif Intell.* 2023;4:100118. https://doi.org/10.1016/j.caeai.2022.100118
5. Benítez TM, Xu Y, Boudreau JD, Kow AW, Bello F, Van Phuoc L, et al. Harnessing the potential of large language models in medical education: promise and pitfalls. *J Am Med Inform Assoc.* 2024;31(3):776–783. https://doi.org/10.1093/jamia/ocad252
6. Mittal U, Sai S, Chamola V, Sangwan D. A comprehensive review on generative AI for

education. *IEEE Access.* 2024;12:142733–142759. https://doi.org/10.1109/access.2024.3468368
7. Almansour M, Soliman M, Aldekhyyel R, Binkheder S, Temsah MH, Malki KH. An academic viewpoint (2025) on the integration of generative artificial intelligence in medical education: transforming learning and practices. *Cureus.* 2025;17(3):e81145. https://doi.org/10.7759/cureus.81145
8. Simou E. The growing importance of soft skills in medical education in the AI era: balancing humanistic care and artificial intelligence. *Int Med Educ.* 2025;4(4):50. https://doi.org/10.3390/ime4040050
9. Hou Z, Chen J, Guo H. Reimagining medical education: integrating medical humanism and narrative medicine into a new educational paradigm. *Front Med (Lausanne).* 2026;13:1761177. https://doi.org/10.3389/fmed.2026.1761177
10. American Medical Association. More than 80% of physicians use AI professionally: AMA survey [Internet]. Chicago: American Medical Association; 2023 [cited 2026 Apr 14]. Available from: https://www.ama-assn.org/practice-management/digital-health/more-80-physicians-use-ai-professionally-ama-survey
11. Elendu C, Amaechi DC, Okatta AU, Amaechi EC, Elendu TC, Ezeh CP, et al. The impact of simulation-based training in medical education: a review. *Medicine (Baltimore).* 2024;103(27):e38813. https://doi.org/10.1097/MD.0000000000038813
12. McKenney SE, Reeves TC. *Conducting educational design research.* 2nd ed. London: Routledge; 2018. https://www.routledge.com/9781138095564
13. Reeves TC. Design research from a technology perspective. In: van den Akker J, Gravemeijer K, McKenney S, Nieveen N, editors. *Educational design research.* New York: Routledge; 2006. p. 52–66.
14. Plomp T. Educational design research: an introduction. In: Plomp T, Nieveen N, editors. *Educational design research. Part A: an introduction.* Enschede: SLO; 2013. p. 11–50. https://www.fi.uu.nl/publicaties/literatuur/educational-design-research-part-a.pdf#page=12
15. Yang Z, Lee YY. Challenges and opportunities of design-based research in applied linguistics: insights from a scoping review. *Res Methods Appl Linguist.* 2025;4(1):100178. https://doi.org/10.1016/j.rmal.2024.100178
16. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ.* 2009;339:b2535. https://doi.org/10.1136/bmj.b2535
17. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol.* 2005;8(1):19–32. https://doi.org/10.1080/1364557032000119616
18. Moore P, Gómez G, Kurtz S. Doctor-patient communication: one of the basic competencies, but different. *Aten Primaria.* 2012;44(6):358–365. https://doi.org/10.1016/j.aprim.2011.07.008
19. Malikhao P. Health communication: approaches, strategies, and ways to sustainability on health or health for all. In: Servaes J, editor. *Handbook of communication for development and social change.* Singapore: Springer; 2020. p. 1015–1037. https://doi.org/10.1007/978-981-15-2014-3_137
20. Nagarajappa A, Kaur S. Simulation in contemporary medical education: current practices and the way forward. *Indian J Anaesth.* 2024;68(1):17–23. https://doi.org/10.4103/ija.ija_1203_23
21. Sassi Z, Eickmann S, Roller R, Osmanodja B, Burchardt A, Tretter M, et al. Human-centered AI in healthcare: empowering patients and support persons in clinical decision-making. *BMC Med Inform Decis Mak.* 2025;25(1):431. https://doi.org/10.1186/s12911-025-03298-9
22. Liaw SY, Tan JZ, Lim S, Zhou W, Yap J, Ratan R, et al. Artificial intelligence in virtual reality simulation for interprofessional communication training: mixed method study. *Nurse Educ Today.* 2023;122:105718. https://doi.org/10.1016/j.nedt.2023.105718
23. Doyle P, Sixsmith J, Barry M, Mahmood S, MacDonald L, O'Sullivan M, et al. *Public health stakeholders' perceived status of health communication activities for the prevention and control of communicable diseases across the EU and EEA/EFTA countries.* Stockholm:

European Centre for Disease Prevention and Control; 2012. https://www.stir.ac.uk/research/publications/
24. Richards T. Chasms in communication. *BMJ.* 1990;301(6766):1407–1408. https://doi.org/10.1136/bmj.301.6766.1407
25. Fortin G, Dumont S. Goals of care conversations at the end-of-life: perceived impact of an interprofessional training session on professional practices. *J Soc Work End Life Palliat Care.* 2021;17(4):296–316. https://doi.org/10.1080/15524256.2021.1897922
26. Novack DH, Volk G, Drossman DA, Lipkin M. Medical interviewing and interpersonal skills teaching in US medical schools: progress, problems, and promise. *JAMA.* 1993;269(16):2101–2105. https://doi.org/10.1001/jama.1993.03500160071034
27. Mauro M, Noto G, Prenestini A, Sarto F. Digital transformation in healthcare: assessing the role of digital technologies for managerial support processes. *Technol Forecast Soc Change.* 2024;209:123781. https://doi.org/10.1016/j.techfore.2024.123781
28. Giusti A, Pukrittayakamee P, Alarja G, Farrant L, Hunter J, Mzimkulu O, et al. Developing a global practice-based framework of person-centred care from primary data: a cross-national qualitative study with patients, caregivers and healthcare professionals. *BMJ Glob Health.* 2022;7(7):e008843. https://doi.org/10.1136/bmjgh-2022-008843
29. Pluut B. Differences that matter: developing critical insights into discourses of patient-centeredness. *Med Health Care Philos.* 2016;19(4):501–515. https://doi.org/10.1007/s11019-016-9712-7
30. Llewellyn CD, Ayers S, McManus C, Newman S, Petrie KJ, Revenson TA, Weinman J, editors. Health care practice. In: *Cambridge handbook of psychology, health and medicine.* 3rd ed. Cambridge: Cambridge University Press; 2019. p. 323–394. https://www.cambridge.org/9781316625873
31. Holtz B, Nelson V, Poropatich RK. Artificial intelligence in health: enhancing a return to patient-centered communication. *Telemed J E Health.* 2023;29(6):795–797. https://doi.org/10.1089/tmj.2022.0413
32. Vazquez Y. *Perceived impacts of electronic health record (EHR) documentation burden on clinicians' job dissatisfaction* [dissertation]. Minneapolis (MN): Capella University; 2025.
33. Fortin VI AH, Dwamena FC, Frankel RM, Lepisto BL, Smith RC. *Smith's patient-centered interviewing: an evidence-based method.* 4th ed. New York: McGraw-Hill; 2019. https://www.accessmedicine.com/
34. Chiaramonte D. A piece of my mind. Who's afraid of the empowered patient? *JAMA.* 2008;300(12):1393–1394. https://doi.org/10.1001/jama.300.12.1393
35. Alhaidari B, Mulhall C, Condron C, Shpigelman J, Jain D, Daly MJ. Investigating the effects of a short narratology module on empathy and patient-centred communication in early-stage medical students: an empirical mixed-methods pilot study. *BMC Med Educ.* 2025;26(1):15. https://doi.org/10.1186/s12909-025-08264-7
36. Schneider A, Messerer DAC, Kühn V, Horneffer A, Bugaj TJ, Nikendei C, et al. Randomised controlled monocentric trial to compare the impact of using professional actors or peers for communication training in a competency-based inverted biochemistry classroom in preclinical medical education. *BMJ Open.* 2022;12(5):e050823. https://doi.org/10.1136/bmjopen-2021-050823
37. Shilling V, Starkings R, Fallowfield L. Feasibility and acceptability of a virtual learning module for navigating angry conversations in clinical encounters. *BMC Med Educ.* 2025;25(1):167. https://doi.org/10.1186/s12909-025-06726-6
38. Abidi SMA, Fatima SK, Lodhi BA, Nazeer AH, Ali SM, Rizvi MM. Evaluation of the impact of student-led clinics on medical students' knowledge, skills, and professional growth. *BMC Med Educ.* 2026;26(1):394. https://doi.org/10.1186/s12909-026-08755-1
39. Arora A, Kaur K, Pathiyil RS, Babar MG. Cinema as a pedagogical tool for empathy training in dental education: a qualitative study. *BMC Med Educ.* 2025;26(1):64. https://doi.org/10.1186/s12909-025-08359-1
40. Atayee RS, Mnatzaganian CL, Namba JM, Saunders IM, Higgins N, Shapiro D, et al. Assessment of curricular integration of compassionate communication in pharmacy training. *Am J Pharm*

Educ. 2026;90(3):101941. https://doi.org/10.1016/j.ajpe.2026.101941

41. Janssen L, Schick K, Pittroff SI, Reiser S, Bauer J, Berberat PO, et al. "It turns out I was wrong": a thematic analysis of medical students' reflective writing in an e-learning course on communication skills. *BMC Med Educ.* 2025;25(1):1671. https://doi.org/10.1186/s12909-025-08172-w
42. Tannous AM, Fuchs JR, Kaul P. An innovative approach to cultural competency and spirituality education for medical students. *South Med J.* 2025;118(6):313–318. https://doi.org/10.14423/SMJ.0000000000001841
43. Shah M, Shaikh GM, Khero R, Nazir M, Iqbal R, Sahito MA. Enhancing dental education: integrating technology and patient-centred learning. *RMJ.* 2025;50(3):752–755. Available from: https://www.rmj.org.pk/index.php?mno=230868
44. Lowe C, Erby L, Biesecker B, Beach MC, Joseph G, Hundert R, et al. Efficacy of an online communication skill training intervention on genetic counseling students' performance during standardized patient sessions. *Patient Educ Couns.* 2023;114:107835. https://doi.org/10.1016/j.pec.2023.107835
45. Mayor Silva LI, Caballero de la Calle R, Cuevas-Budhart MA, Martin Martin JO, Blanco Rodriguez JM, Gómez Del Pulgar García Madrid M. Development of communication skills through virtual reality on nursing school students: clinical trial. *Comput Inform Nurs.* 2023;41(1):24–30. https://doi.org/10.1097/CIN.0000000000000866
46. Tang I, Rupley D. An interactive curriculum to teach person-centered contraceptive counseling. *MedEdPORTAL.* 2023;19:11368. https://doi.org/10.15766/mep_2374-8265.11368
47. Plass AM, Covic A, Lohrberg L, Albright G, Goldman R, Von Steinbüchel N. Effectiveness of a minimal virtual motivational interviewing training for first year's medical students: differentiating between pre-test and then-test. *Patient Educ Couns.* 2022;105(6):1457–1462. https://doi.org/10.1016/j.pec.2021.09.020
48. Afonso N, Kelekar A, Alangaden A. "I have a cough": an interactive virtual respiratory case-basedmodule. *MedEdPORTAL.* 2020;16:11058. https://doi.org/10.15766/mep_2374-8265.11058
49. Moral RR, Andrade-Rosa C, Molina JD, Barba EC, de Torres LP, Martín DM. Effectiveness of a communication skills training program for medical students to identify patient's communicative clues. *Patient Educ Couns.* 2020;103(11):2384–2387. https://doi.org/10.1016/j.pec.2020.05.018
50. Hong H, Shin S. Effects of the use of a conversational artificial intelligence chatbot on medical students' patient-centered communication skill development in a metaverse environment. *J Med Life Sci.* 2024;21(3):92–101. https://www.e-jmls.org/journal/view.php?number=159
51. Hahne J, Carpenter BD. Patient and clinician engagement with generative artificial intelligence (GenAI): a scoping review of implications for patient-centered communication. *Patient Educ Couns.* 2026;145:109492. https://doi.org/10.1016/j.pec.2026.109492
52. Qudrat-Ullah H. *Navigating complexity: AI and systems thinking for smarter decisions.* Cham: Springer; 2025. https://doi.org/10.1007/978-3-031-82742-6
53. Lim S, Schmälzle R. Artificial intelligence for health message generation: an empirical study using a large language model (LLM) and prompt engineering. *Front Commun.* 2023;8:1129082. https://doi.org/10.3389/fcomm.2023.1129082
54. Koole B. Trusting to learn and learning to trust. A framework for analyzing the interactions of trust and learning in arrangements dedicated to instigating social change. *Technol Forecast Soc Change.* 2020;161:120260. https://doi.org/10.1016/j.techfore.2020.120260
55. Faulds S, Taylor A. Simulated practice learning experience in a virtual environment: an innovative pedagogical approach to practice learning for nursing students. *Nurs Rep.* 2025;15(2):61. https://doi.org/10.3390/nursrep15020061
56. Barab SA, Squire KD, Dueber W. A co-evolutionary model for supporting the emergence of authenticity. *Educ Technol Res Dev.* 2000;48(2):37–62. https://doi.org/10.1007/BF02313400
57. Herrington J, Reeves TC, Oliver R. *A guide to authentic e-learning.* New York: Routledge; 2010.

58. Kong X, Fang H, Chen W, Xiao J, Zhang M. Examining human–AI collaboration in hybrid intelligence learning environments: insight from the synergy degree model. *Humanit Soc Sci Commun.* 2025;12:821. https://doi.org/10.1057/s41599-025-05097-z
59. Lu J, Yan Y, Huang K, Yin M, Zhang F. Do we learn from each other: understanding the human-ai co-learning process embedded in human-AI collaboration? *Group Decis Negot.* 2025;34(2):235–271. https://doi.org/10.1007/s10726-024-09912-x
60. Nass C, Moon Y. Machines and mindlessness: social responses to computers. *J Soc Issues.* 2000;56(1):81–103. https://doi.org/10.1111/0022-4537.00153
61. Nardo A. Exploring a Vygotskian theory of education and its evolutionary foundations. *Educ Theory.* 2021;71(3):331–352. https://doi.org/10.1111/edth.12485
62. Le H, Shen Y, Li Z, Xia M, Tang L, Li X, et al. Breaking human dominance: investigating learners' preferences for learning feedback from generative AI and human tutors. *Br J Educ Technol.* 2025;56(5):1758–1783. https://doi.org/10.1111/bjet.13567
63. Järvelä S, Nguyen A, Hadwin A. Human and artificial intelligence collaboration for socially shared regulation in learning. *Br J Educ Technol.* 2023;54(5):1057–1076. https://doi.org/10.1111/bjet.13325
64. Molenaar I. The concept of hybrid human-AI regulation: exemplifying how to support young learners' self-regulated learning. *Comput Educ Artif Intell.* 2022;3:100070. https://doi.org/10.1016/j.caeai.2022.100070
65. Bowers P, Ryan T, Graydon K, Lau JH, Tomlin D. Healthcare educators' perspectives on artificial intelligence driven virtual patients for teaching communication skills. *Interact Technol Smart Educ.* 2026;23(1):97–112. https://doi.org/10.1108/ITSE-02-2025-0036
66. Preiksaitis C, Rose C. Opportunities, challenges, and future directions of generative artificial intelligence in medical education: scoping review. *JMIR Med Educ.* 2023;9:e48785. https://doi.org/10.2196/48785
67. Manoharan A, Nagar G. Maximizing learning trajectories: an investigation into AI-driven natural language processing integration in online educational platforms. *Int Res J Mod Eng Technol Sci.* 2021;3(12):1–10. https://doi.org/10.56726/IRJMETS18093
68. Sardesai N, Russo P, Martin J, Sardesai A. Utilizing generative conversational artificial intelligence to create simulated patient encounters: a pilot study for anaesthesia training. *Postgrad Med J.* 2024;100(1182):237–241. https://doi.org/10.1093/postmj/qgad137
69. Mir MM, Mir GM, Raina NT, Mir SM, Mir SM, Miskeen E, Alharthi MH, Alamri MMS. Application of artificial intelligence in medical education: current scenario and future perspectives. *J Adv Med Educ Prof.* 2023;11(3):133–140. https://doi.org/10.30476/JAMP.2023.98655.1803
70. Dunn AG, Shih I, Ayre J, Spallek H. What generative AI means for trust in health communications. *J Commun Healthc.* 2023;16(4):385–388. https://doi.org/10.1080/17538068.2023.2277489
71. Narang S. Artificial intelligence in medical education. *RUHS J Health Sci.* 2023;8(1):11–13. https://doi.org/10.37821/ruhsjhs.8.1.2023.11
72. Koti VM, Abhirami JS, Vinod M, Bordoloi D, Nuka ST, Mumjitha M. AI-driven gamification models for long-term educational engagement. In: *Proceedings of the International Conference on Sustainability Innovation in Computing and Engineering (ICSICE 24).* Cham: Springer; 2025. p. 73–85. https://doi.org/10.2991/978-94-6463-718-2_8
73. Jin J, Bridges SM. Educational technologies in problem-based learning in health sciences education: a systematic review. *J Med Internet Res.* 2014;16(12):e251. https://doi.org/10.2196/jmir.3240
74. Stamer T, Steinhäuser J, Flägel K. Artificial intelligence supporting the training of communication skills in the education of health care professions: scoping review. *J Med Internet Res.* 2023;25:e43311. https://doi.org/10.2196/43311