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Review Article

Artificial intelligence-based empathy and compassion training in medical education: impact on patient-centered communication skill development

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Abstract The integration of artificial intelligence (AI) into medical education has opened innovative possibilities for fostering empathy and compassion among medical students. Empathy and compassion constitute foundational competencies for effective patient-centered communication, directly influencing patient satisfaction, clinical outcomes, and the overall quality of care. This comprehensive review explores the recent developments and specific applications of AI-based educational approaches, including virtual reality-based empathy simulations, augmented reality-guided patient interaction scenarios, chatbot-driven communication training, and emotion recognition technologies for real-time feedback. Unlike traditional instructional methods, AI-driven approaches offer interactive, scalable, and personalized training experiences, addressing the existing limitations in conventional empathy and compassion education. The findings highlighted significant improvements in medical students' empathetic responsiveness, communication confidence, and emotional interaction management, ultimately leading to enhanced patient satisfaction. Furthermore, this study provides practical recommendations for integrating AI-based empathy and compassion training into medical curricula and discusses strategies for overcoming potential barriers to implementation. Finally, future research directions are suggested, emphasizing the need for longitudinal studies to assess long-term effectiveness and address the ethical considerations of AI use in medical education.

Key words: Artificial intelligence; Empathy; Patient-centered communication; Education, medical

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INTRODUCTION

Empathy and compassion are fundamental values in healthcare, essential for developing therapeutic relationships between patients and healthcare providers, and critical for improving healthcare quality and patient satisfaction.[1,2] Empathetic communication is recognized as a key factor in gaining patient trust and enhancing treatment adherence, leading to positive clinical outcomes.[3,4] Consequently, there is a growing recognition that empathy and compassion should be actively developed as professional competencies in medical education.[2]

However, traditional educational approaches face challenges in maintaining and developing empathetic communication competencies.[1] Numerous studies have reported a decline in empathy among medical students during clinical

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practice, which is attributed to insufficient opportunities to practice empathy toward patients' emotional needs using existing instructional methods.[1,2] Additionally, short-term workshops or lecture-centered education often fail to translate into long-term behavioral changes, thereby highlighting the limitations of conventional pedagogical approaches.[2]

To address these limitations, novel educational approaches using artificial intelligence (AI) technologies have recently gained attention (Fig. 1).[5,6] AI-based technologies such as virtual reality (VR), augmented reality (AR), and chatbots provide students with opportunities to indirectly experience patients' emotions and practice empathetic communication repeatedly in safe environments.[3,7] According to Alieldin et al.,[7] medical students who received VR-based empathy training demonstrated a significantly improved ability to understand and empathize with patients' perspectives. Similarly, Hong and Shin[5] reported that interactions with AI chatbots in metaverse environments positively influenced medical students' patient-centered communication abilities.

The recent emergence of large language models (LLMs) such as ChatGPT has opened new possibilities for enhancing empathy and compassion in medical education.[8] Ennab[8] has suggested that ChatGPT effectively supplements clinical empathy skills while emphasizing that such technology should complement rather than replace the role of human instructors. Moreover, further research and discussion regarding long-term effects and ethical considerations are necessary.[4]

This study aimed to review and analyze the effect of AI-based empathy and compassion training on patient-centered communication abilities in medical education. Focusing on relevant research from the past 5 years (2020-2025), we employed a scoping review method to comprehensively summarize and synthesize, with the aim of mapping the body of literature in the topic area, the types of AI-based empathy and compassion education methods and how they complement limitations in traditional educational approaches. Although a meta-analytical synthesis would reveal more robust evidence-based results, we adopted a scoping review approach to map emerging trends and provide a foundation for future systematic and meta-analytical studies as the field matured. This study provides evidence on the direction and application of empathy and compassion education in medical curricula (Fig. 2).

Therefore, the review addresses the following specific research questions: 1) What is the importance of empathy and compassion in medical education? What are the limitations of traditional educational approaches? 2) What are the types and characteristics of AI-based educational methods used to enhance empathy and compassion? What are the outcomes of these educational interventions? 3) What specific effects do AI-based empathy and compassion training have on medical students' patient-centered communication abilities?

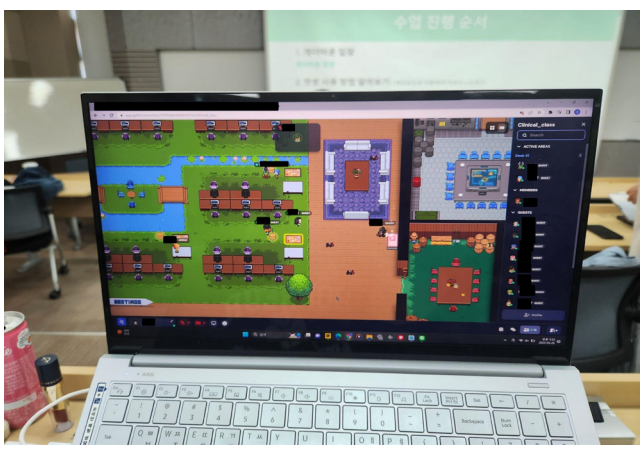

Figure 1. Application of AI-based technology. Medical students participating in a virtual learning session through a metaverse platform with their chosen avatars. AI: artificial intelligence.

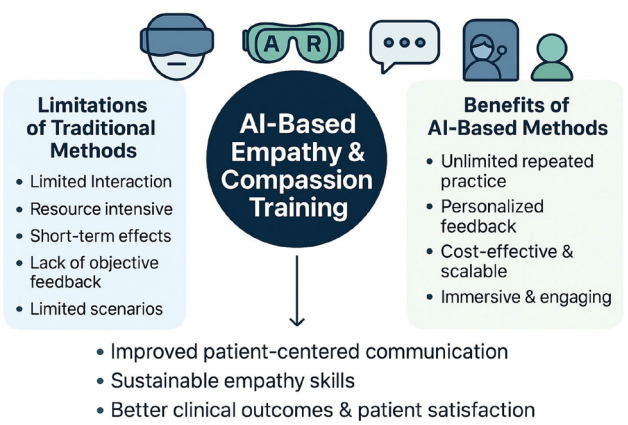

Figure 2. The importance of AI-based training in enhancing empathy and compassion in medical education. AI: artificial intelligence.

What are the implications of applying these methods in educational settings?

EMPATHY AND COMPASSION IN MEDICAL EDUCATION

To address the first research questions, "What is the importance of empathy and compassion in medical education? What are the limitations of traditional educational approaches?" the current and subsequent sections review the existing literature on the central role of these competencies in clinical practice. It also examines the constraints of conventional pedagogical methods in effectively fostering and sustaining humanistic attributes.

Empathy and compassion are core competencies in contemporary medical education.[2] Empathy refers to the ability to understand and perceive others' emotions and perspectives. In healthcare settings, it is defined as the process of cognitively and emotionally understanding patients' experiences and effectively sharing this understanding with patients.[9] Empathy primarily comprises cognitive (understanding patients' emotions and situations) and affective empathy (feeling patients' emotions together).[9]

Compassion extends beyond empathy to include intentional and active behaviors aimed at alleviating patient suffering.[10] Compassion is understood as an altruistic and ethical response that recognizes others' suffering and takes action to reduce it, including healthcare providers' active efforts to improve patients' conditions.[10] While empathy primarily focuses on understanding and empathetic responses, compassion includes practical and actionable behaviors.[11]

Various empirical studies have supported the importance of empathy and compassion in healthcare settings. Healthcare providers with excellent empathy skills can improve clinical outcomes by gaining patient trust and increasing treatment adherence.[2,12] Additionally, healthcare providers who practice compassion play an important role in enhancing patients' quality of life and reducing psychological burdens during treatment.[10]

However, traditional medical education approaches are limited in terms of adequately developing and maintaining human capabilities.[1] Consequently, the need to systematically develop empathy and compassion in medical education has emerged, which focuses on new educational approaches

Table 1. How AI-based methods complement traditional empathy and compassion training

Traditional method	Relevant AI-based methods	How AI-based method complements or extends traditional method	Evidence of additional benefit (AI-based)
Lecture-based education	Chatbots & LLMs, ITS	Offers interactive reinforcement and personalized feedback beyond static lectures, facilitating active learning	Improved learner engagement, sustained retention of knowledge, better communication skills
Role-playing	Metaverse, VR	Provides scalable, immersive, repeated practice scenarios without requiring physical presence or extensive human resources	Enhanced learner immersion, increased frequency of scenario practice, consistent empathy skill improvements
Standardized patients	VR, AR	Simulates realistic patient encounters with greater frequency and lower long-term costs, offers real-time feedback	Consistent improvements in empathy scores, better skill retention, improved non-verbal communication
Reflective writing	ITS, Chatbots & LLMs	Facilitates immediate reflective practice through interactive dialogues, provides personalized guidance for deeper reflection	Higher learner engagement, more immediate and personalized feedback, greater frequency of reflective practice
Narrative medicine	AR, metaverse	Enriches narrative experiences by combining humanistic story elements with interactive virtual scenarios, enhancing emotional engagement	Increased holistic understanding, immediate practice of empathetic behaviors, and improved emotional recognition skills

AI: artificial intelligence, LLM: large language model, ITS: intelligent tutoring system, VR: virtual reality, AR: augmented reality.

that use advanced technologies such as AI (Table 1).[5,6] This study aims to examine how AI-based empathy and compassion training can be effectively applied to medical education.

TRADITIONAL TEACHING METHODS IN MEDICAL EDUCATION

Various traditional educational methods have been used in medical schools and healthcare education curricula to foster patient empathy and compassion. These efforts aim to promote better clinical outcomes through improved patient-centered communication skills and attitudes. Studies indicate that medical students with superior empathy skills tend to excel in communication abilities and prefer specialties that require patient-centered skills.[12] Traditional empathy education primarily includes lecture-based instruction, role-playing exercises, standardized patient simulations, reflective writing, and humanistic approaches, such as narrative medicine. The characteristics and applications of each method in medical education are discussed below.

1. Lecture-based education

One of the most basic forms of empathy and compassion education is theoretical instruction delivered through lectures. It typically consists of lectures or seminars covering the concepts of empathy, importance of patient-centered care, and ethical literacy.[2] Courses on communication skills or lectures on medical ethics in the curriculum provide the definition of empathy and clinical cases, helping students understand the core elements of empathy. However, lecture-centered teaching methods alone have limitations in changing students' attitudes or forming new behaviors. This is because empathy and compassion deepen through experiential acquisition and self-reflection rather than simple knowledge transfer.[11] Moreover, relying solely on formal education and assessment risks students expressing superficial scale-appropriate empathy.[9] Therefore, lecture-based education is most effective when combined with practical and reflective activities.

2. Role-playing

Role-playing is a practical method widely used in empathy education, in which students simulate clinical situations

Table 2. Comparison of advanced technologies for empathy education in medical training

Technology type	Key features	Strengths	Limitations	Example use cases	Representative research
VR	Immersive first-person perspective, emotional identification	High immersion, realistic simulation, effective for perspective-taking	Requires equipment, some learners experience motion sickness	Experiencing mental illness, elderly care simulations	Herrera et al.[28] (2018) Lacle-Melendez et al.[25] (2025)
AR/XR	Overlays digital cues on physical space	Real-time interaction, supports physical context, low cost	Limited hardware accessibility, less immersive than VR	Eye contact training, empathy in clinical settings	Nakazawa et al.[16] (2023) Lacle-Melendez et al.[25] (2025)
Metaverse	Avatar-based social engagement	Enables group empathy training, role flexibility, multicultural practice	High learning curve, limited standardization	Team-based virtual rounds, cultural sensitivity training	Divakaran et al.[26] (2024)
Chatbots/ LLMs	Conversational AI with scenario control	Scalable, repeatable, available anytime, personalized dialogue	Lacks genuine emotional perception, limited non-verbal interaction	Patient interview simulations, counseling skill practice	Maurya[27] (2024) Ortega-Ochoa et al.[29] (2024)
ITS	Real-time learner analysis and coaching	Adaptive feedback, promotes self-reflection, AI-based scoring	Needs high-quality NLP Complex to develop	Reflective practice, communication evaluation	Ortega-Ochoa et al.[29] (2024) Furlan et al.[23] (2021)

VR: virtual reality, AR: augmented reality, XR: extended reality, LLM: large language model, AI: artificial intelligence, ITS: intelligent tutoring systems, NLP: natural language processing.

and perform patient and physician roles. This approach may take the form of drama workshops or scenario-based theaters, encouraging students to think and feel from a patient's perspective.[2] For instance, while acting out scenarios involving terminal patient care, students can indirectly experience patients' pain and emotions and reflect on their responses through peer feedback. Experiential learning helps develop cognitive and affective empathy skills. One study revealed that incorporating role-playing into communication workshops led learners to develop deeper empathy from patient and family perspectives.[13] In summary, role-playing provides students with opportunities to actively practice empathy and adjust their behavior in a safe educational environment.

3. Standardized patients

Standardized patients (SPs) are specially trained simulated patients for educational purposes that allow medical students to practice empathy and compassion through simulated consultations. Sessions with SPs provide the advantage of practicing appropriate empathetic expressions in emotionally challenging situations. Many medical education programs use SPs for communication practice, and clinical simulations have been reported to positively affect students' empathy scores and interpersonal communication skills.[2,11] One report indicated that students could improve their verbal and nonverbal expressions of empathy through feedback after simulating care scenarios involving patients with cancer and receiving direct evaluation from the perspective of patient role actors. These experiences provide students with opportunities to practice empathy before the clinical experience, helping them respond more flexibly and proficiently to empathy in subsequent actual patient encounters. However, SP practice requires resources and costs, leading researchers to explore alternatives such as virtual patients or simulators.

4. Reflective writing

Reflective writing is an educational method that encourages students to express their thoughts and feelings after their clinical experiences or interactions with patients. This includes journal-format writing, experience reports, and essays on patient narratives, allowing students to reflect on moments of empathy or the lack thereof and revisit their significance. This self-reflection process not only enhances students' self-awareness but also deepens empathy skills by helping them reinterpret situations from patients' perspectives.[11] Some studies have reported that medical students who have written reflective essays after clinical practice show an improved understanding of and empathetic attitudes toward patients' suffering. Reflective writing is widely used to promote internal learning at a relatively low cost, and its educational effects are further enhanced when combined with sharing experiences and receiving feedback in small groups.[2]

5. Narrative medicine

Narrative medicine is a humanistic approach that develops empathy through the incorporation of literature, art, and patient stories into medical education. This involves encouraging medical students to listen to or read patients' illness experiences in story form and then discuss or respond to these narratives in writing. The philosophy of narrative medicine can be summarized as understanding patients' lives and suffering through stories,[14] helping students deeply accept the human aspects beyond illness. Examples include students writing essays about their feelings after reading patients' illness memoirs or classes where students read and discuss literary works that depict doctor-patient relationships. These humanistic experiences stimulated empathy and compassion in students, enabling them to view patients holistically in healthcare settings.[9] Studies have shown that education through art and literature shows positive results in enhancing students' sensitivity to and understanding of patients.[2] Batt-Rawden et al.[15] have suggested that incorporating arts and humanities subjects into medical curricula are necessary for cultivating empathy, and that this narrative approach helps 'bloom' students' empathy 'flowers'. Therefore, narrative medicine is used as an educational method to add depth to medical students' ability to listen to patients'

stories.

6. Limitations of traditional teaching methods

Traditional methods of empathy and compassion education have several limitations. First, the effects of existing programs were primarily measured through self-assessment. Thus, numerous studies reporting improved empathy scores lack objective indicators or patient feedback-based evaluations.[11] Additionally, many educational intervention studies were conducted without control groups or only confirmed short-term effects immediately after education, failing to track long-term maintenance effects or behavioral changes in clinical settings.[10,11] A systematic literature review noted that most empathy education sessions were conducted as one-time sessions without follow-up tracking, making it unclear whether the empathy skills gained through education persist over time.[11]

Second, there are limitations to the educational content and methods. Traditional approaches often tend to emphasize only certain aspects of empathy or compassion or focus on a single teaching method, whereas the empathy skills required in actual clinical practice are complex competencies that combine cognitive understanding, emotional responses, and behavioral skills. Nevertheless, some programs consist of only specific experiential elements such as role-playing, leading to assessments of inadequacy for integrated competency developmen.[11] In this context, the recent literature emphasizes the need for multimodal learning strategies in empathy education.[2,13] Instructional design should ideally include lectures on knowledge acquisition, humanistic approaches to attitude change, practice and feedback for skill refinement, and self-reflection. Reports indicate that applying complex curricula results in greater improvements in empathy scores than applying single methods.[2]

Finally, the influence of educational environments and hidden curricula was significant. Students form attitudes toward empathy by observing the behavior of supervising professors and senior physicians in clinical practice settings beyond the formal curriculum. However, in reality, students' empathy levels may be undermined by negative role models or organizational cultures that disregard empathy.[9] Laughey et al.[9] have identified this negative, hidden curriculum as a factor that gradually erodes medical students' empathy (empathic erosion), noting that empathy acquired through formal education fails to be maintained or manifested in clinical settings. Therefore, not only the qualitative improvement of educational programs but also the cultural improvements in clinical settings and role modeling by faculty must occur together for sustainable educational effectiveness.

Because empathy and compassion are core competencies in medical education, the need for more systematic and evidence-based curriculum development has been raised,[10,12] with movements emerging to redesign the entire curriculum to be empathy-friendly. Ultimately, progress should be made toward the continuous growth of students' empathy through more holistic curricula and changes in learning environments rather than one-time education.[2] This is recognized as a challenge faced by medical educators but is ultimately a necessary path for providing patient-centered quality healthcare.

In summary, the above two sections have demonstrated that while empathy and compassion are widely recognized as essential competencies in medical education, traditional instructional approaches often fall short owing to limitations in experiential depth, scalability, and evaluation methods. These limitations highlight the need for more innovative pedagogical strategies, which are explored in the next section.

AI-BASED EMPATHY AND COMPASSION TRAINING TECHNOLOGIES IN MEDICAL EDUCATION

This section presents a synthesis of the recent innovations in empathy education supported by AI in response to the second research questions, "What are the types and characteristics of AI-based educational methods that have been used to enhance empathy and compassion? What are the outcomes of these educational interventions?" It outlines the technologies currently used, including VR, augmented/ex-

tended reality (AR/XR), metaverse platforms, conversational agents, and intelligent tutoring systems (ITS), and evaluates their educational impact based on reported outcomes.

In healthcare settings, empathy and compassion toward patients are essential for patient-centered care. However, declining empathy levels among students during their medical education have also been noted.[4] With the advancement of digital technology and AI in the 2020s, new empathy and compassion training methods using AI-based technologies, such as VR, AR/XR, metaverse, chatbots/LLMs, and ITS, have emerged in medical education. The application cases of these technologies published between 2020 and 2025 are examined below.

1. VR-based empathy training cases

VR is gaining prominence as a tool to enhance empathy by providing immersive environments. In one study, medical students who experienced the daily lives of patients with depression through VR showed significant improvements in perspective-taking and empathic care scores on empathy score subdomains.[3] The experimental group showed improved scores on the Jefferson scale of empathy (JSE) compared with the control group, indicating that indirect experiences through VR enhanced understanding and empathy for mental illness.[3] Another study evaluated immersive VR training in scenarios that helped socially isolated elderly patients with first-year medical students. Results showed statistically significant empathy skill enhancement, with an average increase of 5.94 points in the pre- and post-JSE scores, and students accepted the VR experience as a valuable empathy education tool.[7] In particular, VR characteristics such as immersion, presence, and embodiment have been identified as key elements that help understand patient perspectives and increase empathy.[7] These results demonstrate that the VR technology is effective in empathy education for healthcare providers. However, most VR empathy training is conducted in one-time sessions, which require additional research on long-term empathy improvement and transfer to actual clinical communication.

2. AR/XR-based empathy training cases

AR and XR technologies are used to cultivate empathy and communication skills. AR has the advantage of allowing learners to interact simultaneously with real environments and virtual patients by overlaying virtual information on real environments. An AR system was designed to provide real-time feedback during the care process, and training results showed that the AR group had significantly increased frequency of eye contact with patients and improved empathy scores (JSE) compared with the control group.[16] Thus, AR-based emotional expression training improved caring behaviors (e.g., eye contact and distance adjustment) and increased empathy for patients.[16] Similarly, Kobayashi et al.[17] reported positive changes such as improved empathy toward patients and increased eye contact ratios in a communication training program that combined AR simulation with AI feedback. XR technology enables virtual patient scenarios among multiple participants, even in physically separate situations. Stanford University reported that students showed learning engagement by evaluating AR-based remote collaboration simulators (e.g., CHARM) for communication training among healthcare providers as acceptable and enjoyable tools, while suggesting technical improvements.[18] In summary, AR and XR have emerged as means to effectively practice empathy among healthcare providers by breaking down the boundaries between real and virtual.

3. Empathy training in metaverse environments

Metaverse is a platform that merges XR technology, including VR and AR, with online virtual worlds. In metaverse environments, learners can participate in virtual spaces as avatars and interact with patient avatars and other learners. These social VR environments feature enhanced interpersonal communication and role-playing elements compared with simple single-user VR experiences, which are expected to be useful for developing emotional competencies. According to previous reports, using XR-based virtual patients in the VR avatar can improve physicians' attitudes, communication skills, empathy, and problem-solving skills.[19] In

metaverse environments, healthcare providers can repeatedly practice various patient scenarios while improving their skills without losing personal touch.[19] Examples include conducting patient-healthcare provider role-plays in virtual multibed wards or scenarios in which students from various professions gather in one space for virtual team-based empathy training. However, the use of metaverse remains mostly at conceptual stages or in small-scale empirical studies, with ongoing research systematically demonstrating its effectiveness. Nevertheless, metaverse is attracting attention as a collaborative and patient-centered learning environment for future medical education.

4. Empathy training using chatbots and LLMs

Conversational AI (chatbots), particularly LLMs such as ChatGPT, are used to simulate medical consultation scenarios via text or voice, enabling practical conversations with virtual patients instead of SPs. In the early 2020s, several research teams developed systems that allowed medical students to practice empathetic conversation skills by interacting with chatbots in patient-specific roles. Mendolia[20] designed an empathetic chatbot implemented with a dialogue flow-based natural language processing interface for students to practice empathetic responses to simulated patients. Such chatbots provide patient responses across various clinical scenarios, enabling repetitive learning and offering cost-efficient advantages over face-to-face practice.[20] Additionally, the latest LLM-based chatbots with natural language generation abilities can engage in rich conversations like real patients and can be used by students to practice situation assessment and empathy expression. Shorey et al.[21] reported significantly improved communication learning attitudes and self-efficacy among nursing students after the implementation of AI virtual counseling applications.

Limitations of chatbot-based empathy training have also been observed. Although the latest language models can create humanlike sentences, there is a need to distinguish between superficial sympathetic expressions and genuine emotional exchanges. Models such as ChatGPT can provide seemingly empathetic responses. However, they lack the subtle emotional empathy and nonverbal cue interpretation skills that humans possess.[22] Responses of ChatGPT sometimes appear more empathetic than those of human physicians. However, this is based on language patterns that the model has learned rather than genuine empathy.[22] Therefore, chatbots/LLMs can help students' repetitive practice as an auxiliary means but must be combined with faculty feedback or actual clinical experiences.

5. Use of ITS

ITS are AI educational platforms that provide personalized feedback and coaching based on learner performance data. Furlan et al.[23] developed a virtual patient simulator, Hepius, which combined natural language processing with ITS for clinical reasoning training. This system provides step-by-step feedback and guidance for the next steps as students conduct interviews with virtual patients.[23] A case study with 15 fifth-year medical students evaluated this AI-tutoring virtual patient as a useful tool for practicing history taking for differential diagnosis, suggesting high utilization value even in remote education situations.[23] Thus, ITS leads to effective practice by analyzing learners' communication content in real time to provide immediate corrective feedback or coaching for insufficient empathy expressions. With the development of AI-based assessment technologies, systems that automatically analyze and score students' virtual patient interview content and provide feedback have been implemented. Maicher et al.[24] have reported that when AI evaluate the communication skills of medical students after conversations with emotion-responsive 3D virtual patients, the accuracy of the computer assessment scores (87%) is similar to that of human evaluations (90%). This finding demonstrates the possibility of incorporating AI scoring and tutoring into the assessment of empathy and communication abilities. In one case study, the previously mentioned AR-based empathy training[16] improved students' eye contact and distance maintenance skills through AI image analysis feedback. In summary, ITS and AI assessments are developing in directions that further systematize empathy improvement training by identifying medical students'

individual weaknesses and providing them with personalized guidance.

This section provides an in-depth overview of AI-driven approaches to empathy and compassion training, demonstrating their potential benefits in enhancing emotional understanding, communication skills, and learner engagement. While the current findings are promising, particularly for early stage learners, further studies are required to determine their long-term effectiveness and scalability across diverse clinical and educational contexts.

EFFECTIVENESS AND LIMITATIONS OF AI-BASED EMPATHY AND COMPASSION TRAINING

This section explores how AI-supported interventions influence communication competencies such as active listening, emotional responsiveness, and clinical dialogue and addresses the third research questions, "What specific impacts does AI-based empathy and compassion training have on medical students' patient-centered communication abilities? What are the implications for applying these methods in educational settings?"

AI-based empathy and compassion training techniques that have emerged in the past 5 years have demonstrated positive effects on improving learners' empathy and communication skills. These effects are particularly pronounced among novice clinicians, such as medical and nursing students, who are just entering healthcare settings. Students who received VR/AR simulations or virtual patient conversation training reported significant improvements in understanding and empathizing with patients' emotions and adopting more patient-centered communication attitudes.[16,21] Improved empathy leads to positive clinical outcomes such as increased patient satisfaction, treatment cooperation, trust, reduced communication errors, and medical disputes.[4] However, reports also indicate no major changes with digital empathy training alone for experienced physicians or skilled healthcare providers,[4] suggesting the need for program customization according to the career level of the training targets. In addition, to complement the emotional elements of human interpersonal relationships, appropriate instructor interventions and debriefing sessions must be conducted in parallel.[7]

In conclusion, VR, AR/XR, metaverse, chatbots/LLMs, and ITS AI technologies have been actively introduced in the early 2020s into the medical education field as innovative tools to cultivate empathy and compassion. Although additional research on the long-term effects of these approaches is required, AI-based empathy training can ultimately promote patient-centered healthcare.[4] With good educational use of rapidly developing AI technology, it is possible to harmonize human empathy with cutting-edge technology. Ultimately, AI-based empathy and compassion training offers educational implications beyond improving emotional understanding and contributes meaningfully to the development of patient-centered communication by enhancing learners' ability to respond sensitively to patients' verbal and nonverbal cues and align clinical decisions accordingly.

In conclusion, our findings suggest that AI-supported empathy and compassion training can enhance patient-centered communication skills among medical learners. These results have important implications for the integration of AI tools into medical curricula, not as replacements for human mentorship but as scalable and complementary tools for experiential learning and professional development.

CONCLUSION

Various AI technologies, including VR, AR/XR, metaverse, chatbots, and ITS, provide learners with immersive and repeatable empathy training experiences, complementing the limitations of existing educational methods.[3,5,7] As a practical implication, medical educators should actively leverage these AI tools to reinforce the development of patient-centered communication skills among learners. For instance, virtual and augmented reality simulations immerse learners in realistic patient encounters, allowing them to practice empathetic dialogue and refine their responsiveness to pa-

tient cues in a safe and repeatable environment.[16,25] Similarly, LLM-based conversational agents (e.g., ChatGPT) offer virtually unlimited opportunities for learners to engage in life-like patient interviews with immediate personalized feedback, thereby honing their compassion and adaptability in communication. Moreover, metaverse platforms enable collaborative virtual role-play scenarios that heighten engagement and realism in empathy training, whereas ITS monitor learners' communication patterns and provide tailored guidance for continuous improvement.[8,19] By integrating AI applications into medical curricula, educators can significantly bolster learners' patient-centered communication competencies.

These technologies facilitate training without time and place constraints, promote self-directed learning by analyzing learners' responses in real time, and provide personalized feedback.[17,23] In particular, metaverse-based collaborative training and emotion-based feedback systems can become new standards for practice environments.[26,27] However, the verification of the long-term effects and ethical considerations of AI-based empathy training must proceed in parallel. Technology complements the role of human teachers but cannot completely replace authentic relationship formation.[4,22] Educators and researchers should build a new educational ecosystem that can realize human-centered healthcare using these tools.

While individual studies have been cited to demonstrate the effectiveness of various modalities, we acknowledge the absence of a meta-analytical synthesis owing to data limitations. This reflects the current state of the field in which the body of empirical research remains limited, with relatively small-scale studies and insufficient cumulative evidence to support quantitative aggregation or robust cross-modal comparisons. Future research should increasingly incorporate long-term study designs and large-scale datasets to strengthen the empirical foundation of this field.

CONFLICT OF INTEREST

The authors report no conflict of interest.

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