Online-Journals.org

iJAC International Journal of Advanced Corporate Learning

iJAC | eISSN: 1867-5565 | Vol. 18 No. 3 (2025) | OPEN ACCESS

https://doi.org/10.3991/ijac.v18i3.52595

TLIC PAPER

AI-Driven Avatars in Medical Training: Personalized Feedback for Enhanced Learning

Fernando Salvetti[1](✉), **Barbara Bertagni**[1], **Ianna Contardo**[1], **Roxane Gardner**[2,3], **Jenny Rudolph**[2,4], **Rebecca Minehart**[2,5]

[1]e-REAL Labs at Logosnet, Turin, Italy – Lugano, Switzerland – Houston, TX, USA – New York, NY, USA

[2]Center for Medical Simulation, Boston, MA, USA

[3]Brigham and Women's Hospital/Children's Hospital/ Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA

[4]Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, MA, USA

[5]Massachusetts General Hospital and Harvard Medical School, Boston, MA, USA

salvetti@logosnet.org

ABSTRACT

e-REAL Labs is at the forefront of educational technology, pioneering the use of intelligent avatars—also known as digital humans or embodied conversational agents (ECAs)—to enhance medical training. These sophisticated AI-driven avatars replicate complex human interactions, providing real-time, personalized feedback based on behavioral and conversational cues. This article presents an applied research project developed in collaboration with the Center for Medical Simulation in Boston, showcasing an innovative approach that goes beyond traditional feedback mechanisms. By enabling reflective dialogue and interactive learning, these digital humans foster deeper understanding and skill development. As dynamic learning partners, ECAs represent a transformative shift in medical education, offering an immersive and effective method for professional training. This AI-powered approach redefines the role of feedback in healthcare education, setting a new standard for simulation-based learning and professional development.

KEYWORDS

intelligent avatars in healthcare education, medical simulation, AI-driven feedback, educational technology innovation

1 INTRODUCTION: INTELLIGENT AVATARS FOR MEDICAL SIMULATION

At e-REAL Labs [1], we are at the forefront of educational technology, developing intelligent avatars—also referred to as digital humans—that function as embodied conversational agents (ECAs) in highly immersive training scenarios [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14]. Unlike conventional chatbots or scripted responses, these ECAs are advanced models of human cognition, perception, and interaction, enabling realistic and dynamic engagement. Designed to collaborate with medical simulation instructors, they enhance the learning experience by replicating the subtleties of human communication and pedagogical techniques (see Figure 1).

Salvetti, F., Bertagni, B., Contardo, I., Gardner, R., Rudolph, J., Minehart, R. (2025). AI-Driven Avatars in Medical Training: Personalized Feedback for Enhanced Learning. *International Journal of Advanced Corporate Learning (iJAC)*, 18(3), pp. 46–59. https://doi.org/10.3991/ijac.v18i3.52595

Article submitted 2024-10-01. Revision uploaded 2025-01-28. Final acceptance 2025-02-18.

Powered by generative AI, our ECAs deliver instantaneous, context-aware feedback by analyzing both verbal and behavioral cues from learners. This approach moves beyond conventional feedback mechanisms, offering an interactive, adaptive, and personalized learning process. By simulating intricate interpersonal dynamics, these digital humans assess instructor performance, provide actionable insights, and even facilitate reflective discussions on the quality and relevance of the feedback itself [15], [16], [17], [18].

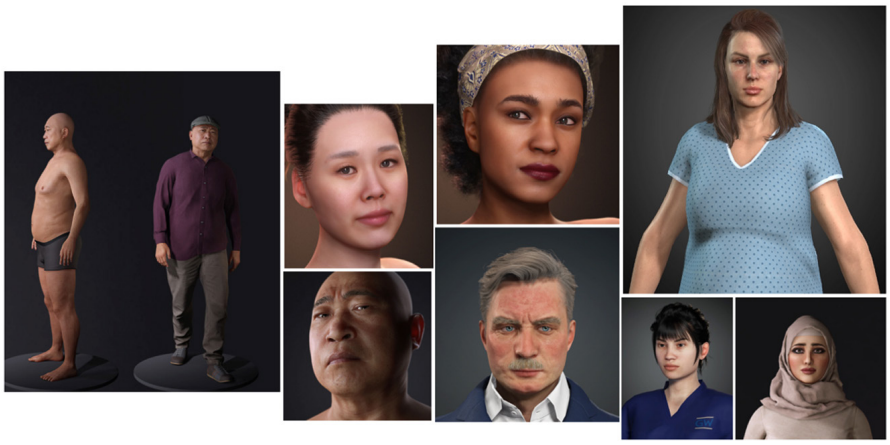


Fig. 1. Representative conversational avatars boosted by artificial intelligence, designed and developed by the e-REAL Labs

This technology not only advances the training of medical simulation instructors but also holds significant potential for broader educational practices. It marks a substantial shift in how feedback is conceptualized, delivered, and analyzed, ensuring it is both informative and a powerful driver of deep learning and professional growth. Our approach signifies a move away from static educational tools toward dynamic learning partners, establishing a new standard for AI in training and development. The intelligent avatars developed by e-REAL Labs go beyond mere technological innovations; they serve as catalysts for a profound transformation in medical simulation education.

These intelligent avatars go beyond simply mirroring human behavior—they are purposefully designed to elevate the educational landscape, serving as catalysts for innovation in teaching methodologies. By fostering an interactive learning environment, they provide medical instructors with a structured yet flexible space to refine their teaching approaches in realistic yet controlled conditions. As adaptive learning partners, these avatars offer incremental guidance, helping instructors navigate the intricacies of medical education and the art of effective pedagogy. This system is carefully calibrated to balance the security of a simulated setting and the demanding realities of clinical practice. Instructors can explore and refine their methods without the risks inherent in real-world patient care while still experiencing medical scenarios' pressures and decision-making challenges.

These avatars take a forward-looking approach and are designed to anticipate and address evolving medical training needs. Their influence on the feedback process is transformative, shifting it from a static exchange to an ongoing, interactive dialogue that actively shapes a learner's development. Instead of merely delivering feedback, these avatars facilitate meaningful discussions, enabling reflective analysis and deeper professional growth. By redefining how performance is assessed and refined, this interactive model sets a new benchmark for excellence in medical simulation and healthcare education.

2 ENHANCING THE INTERACTIVE SIMULATION EXPERIENCE WITH AN AI-POWERED FEEDBACK

Our ECAs, or conversational avatars, combine carefully crafted photo-realistic appearances with an excellent ability to generate realistic and human-like conversations as well as powerful analysis systems. They use a combination of STT (Speech to Text) and TTS (Text to Speech) technologies, which allow interaction through simple conversation: their voices can be modeled after real-life characters and can support various emotional states (see Figure 2).

Their "Brain" indeed takes into account mood, knowledge, goals, and personality to process the simulation scenario in every input, generating responses and carrying out actions thanks to various layers of NLP (Natural Language Processing) networks and the use of GPT (Generative Pre-trained Transformer) models. The appearance of the avatars is ensured by a finely customized and animated 3D photorealistic model, which uses a mix of MoCap (Motion Capture), procedural animation, and hand-made animation.

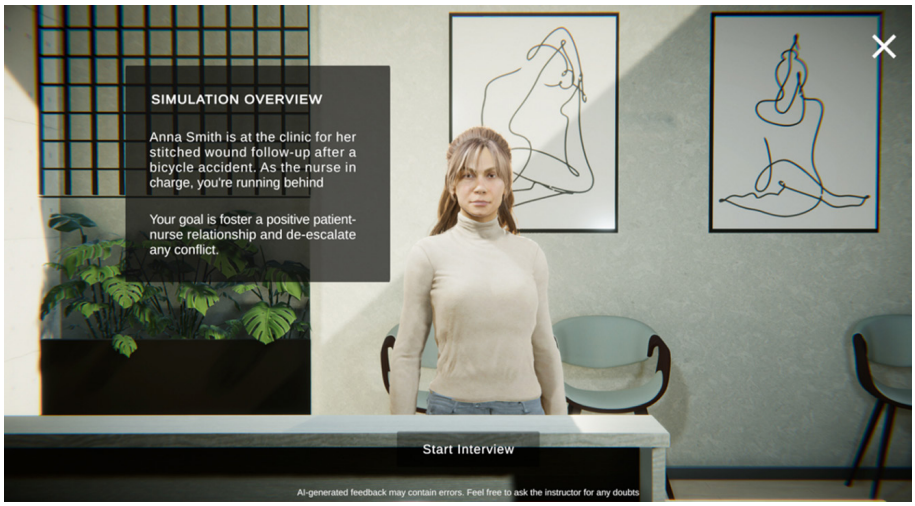


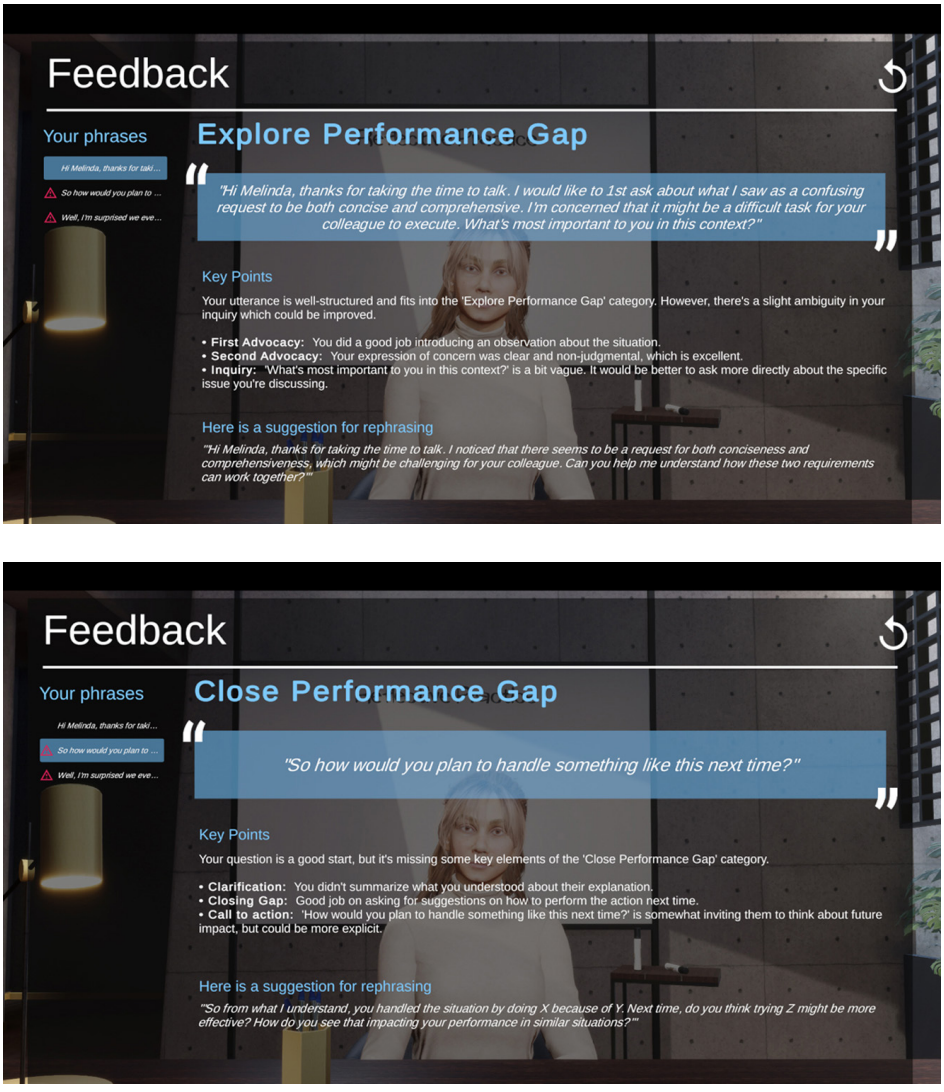
Fig. 2. Representative embodied conversational agent (ECA), or avatar, within a simulation scenario implemented by the e-REAL Labs

Moreover, the system can integrate specialized analytical tools to further process external inputs. For instance, computer vision can be employed to interpret facial expressions, assess pronunciation and linguistic accuracy, identify cognitive biases, and more. This functionality operates within a scalable framework, where each service is adaptable to the client's specific requirements and compatible with various hardware platforms. Lighter versions of these avatars can be optimized for mobile devices, ensuring broad accessibility across major operating systems.

Powered by cutting-edge generative AI, our ECAs are redefining medical training by going beyond mere interaction—they analyze, interpret, and deliver customized feedback in real time. These agents assess behavioral and conversational cues, providing immediate and context-aware responses that significantly enhance learning outcomes for medical students engaged in simulation training. Utilizing advanced Natural Language Processing (NLP) techniques, ECAs not only evaluate verbal responses but also ground their feedback in the latest medical training protocols and educational frameworks. Rather than simply indicating right or wrong answers, they synthesize performance insights, contextual understanding, and adherence to best medical practices [19–22]. For example, if a student hesitates

or follows an incorrect procedure during a simulation, the ECA can detect this deviation and provide targeted, constructive feedback to steer them toward the correct approach (see Figures 3 and 4).

This AI-driven feedback is dynamically tailored to match each learner's proficiency and progress. For those in the early stages of medical training, guidance is more structured, offering step-by-step support for mastering essential clinical procedures. As learners advance, the feedback becomes increasingly sophisticated, fostering critical thinking and decision-making that mirrors real-world complexities. Additionally, ECAs adapt their responses based on the learner's emotional state, detected through vocal tone and facial expressions. By incorporating emotional intelligence, these avatars ensure that feedback is informative and empathetic, enhancing engagement, receptivity, and the overall effectiveness of medical training.



Figs. 3 and 4. Representative immediate feedback provided by the AI system implemented at the e-REAL Labs

By providing a safe, controlled environment for students to practice and receive personalized feedback, ECAs are instrumental in building their confidence and competence. The immediate nature of the feedback also facilitates a rapid

learning cycle, allowing students to quickly assimilate corrections and understandings into their practice. This not only makes learning more efficient but also more deeply ingrained, as students are encouraged to reflect on their performance and internalize the lessons at each step of their educational journey. In essence, ECAs are not just teaching aids; they are evolving into indispensable partners in the learning process, reshaping how learners develop their clinical skills and knowledge in preparation for real-world applications.

3 AI-ENHANCED FEEDBACK AS A DYNAMIC AND INTERACTIVE COMPONENT OF THE LEARNING PROCESS

Our AI-driven ECAs redefine simulation-based learning by embedding feedback as an integral and continuous element of the training process. Traditionally, feedback in medical education has been retrospective, typically provided after a simulation exercise. While valuable, this delayed approach can create a disconnect between the learner's actions and their consequences, making it harder to internalize key lessons. In contrast, ECAs deliver real-time, contextualized feedback, fostering an interactive learning experience where guidance is immediate and actionable. This continuous cycle of action, feedback, and adaptation allows learners to adjust their behavior dynamically and comprehend the real-time implications of their decisions.

Beyond merely correcting errors, this AI-driven approach nurtures a deeper learning process, prompting learners to explore alternative strategies and refine their clinical reasoning. By fostering reflective practice, ECAs empower medical professionals to develop adaptive thinking—an essential skill in an ever-evolving healthcare landscape (see Figure 5).

Our methodology is informed by research from the Center for Medical Simulation [23], [24], particularly the concept of *debriefing with good judgment*. This model integrates structured feedback with open-ended inquiry to support learning and behavioral change. Grounded in reflective practice, this approach encourages trainees to critically analyze their clinical and interpersonal performance during simulations, strengthening their ability to learn from experience and enhance patient care.

Fig. 5. Reflective practice as a cornerstone that encourages trainees to think critically about their clinical and behavioral performance during simulations

The model developed at the Center for Medical Simulation (CMS) extends beyond simply identifying and correcting errors after simulations. Instead, it actively engages learners in a structured reflective process aimed at recognizing performance gaps, analyzing their root causes, and addressing them through targeted instruction and guided discussions. Unlike conventional debriefing methods that primarily highlight mistakes, this approach delves into the *why* and *how* behind a learner's decisions. The process begins with the identification of performance gaps, followed by an in-depth examination of contributing factors—whether cognitive, technical, or emotional. Rather than treating feedback as a one-way critique, this model fosters collaboration, encouraging learners to explore underlying issues and develop effective strategies for continuous improvement. The ultimate goal is not only immediate skill refinement but also the long-term integration of knowledge into clinical practice.

When combined with e-REAL's AI-driven embodied conversational agents (ECAs), this model is further enhanced with personalized, adaptive feedback. Unlike standardized responses, e-REAL's technology tailors feedback to align with the unique learning styles, challenges, and progression of each healthcare professional. This ensures that insights are not generic but directly applicable to an individual's practice. The platform also enables active learner engagement—allowing them to interact with the feedback, ask questions, and explore the rationale behind AI-driven recommendations. This dynamic exchange transforms the learning process from passive reception to active participation.

By facilitating interactive and contextualized learning, this approach ensures that learners engage deeply with the material and internalize critical skills in a meaningful way. Medical trainees are not just recipients of information; they critically evaluate their performance, navigate the complexities of clinical decision-making, and refine their techniques within a risk-free environment. The integration of CMS's reflective debriefing model with e-REAL's AI-powered feedback system creates a holistic learning tool that not only corrects errors but also fosters critical thinking, self-reflection, and sustained professional growth.

The integration of AI-driven ECAs into medical simulation training marks a paradigm shift in healthcare education. By embedding feedback as a continuous and interactive element of the learning process, ECAs transform professional development into an evolving journey rather than a static exercise. This approach holds the potential to revolutionize feedback delivery, making it a dynamic force that actively shapes learning outcomes and raises the standard of medical training.

Unlike traditional feedback mechanisms that are often reactive, AI-enhanced feedback functions as a proactive guide—adapting in real time to each learner's interactions and providing immediate, data-driven insights. In medical simulation, where precision, adaptability, and quick decision-making are critical, this real-time feedback becomes an indispensable tool. ECAs not only evaluate performance but also serve as responsive learning partners, continuously shaping and refining the learner's training experience. For instance, during a simulated emergency, an ECA can assess a trainee's crisis management skills and provide instant guidance on improving decision-making under pressure, optimizing teamwork, or maintaining effective communication in high-stress scenarios. This feedback is not just an observation—it is an informed, AI-driven intervention designed to reinforce best practices and encourage immediate application of learned concepts.

Equally vital is the interactive nature of AI-enhanced feedback. Learners are encouraged to engage with ECAs, probe deeper into the reasoning behind their feedback, and even challenge responses—cultivating essential skills in critical thinking and self-assessment. Given the demanding nature of medical practice,

where professionals must continuously evaluate their decisions, this interactive feedback loop becomes a powerful tool for competency development. ECAs are designed to respond with clarity and depth, ensuring that every exchange is an opportunity for deeper learning.

Additionally, this AI-powered system fosters a *learning-by-doing* approach. Learners are not passive recipients of information; they actively apply their knowledge, reinforcing skill retention through hands-on practice. The ECAs can simulate a diverse range of medical scenarios, each designed with specific objectives, challenges, and complexities (see Figure 6). Feedback is seamlessly integrated into these exercises, tailored to the learner's real-time needs and the specific learning goals of the session.

By embedding AI-driven, interactive, and adaptive feedback into medical simulation, this model sets a new benchmark for training excellence—ensuring that healthcare professionals are not only competent but also confident in their ability to navigate real-world medical challenges with precision and expertise.

Fig. 6. Representative conversational agents and scenarios

By integrating AI-enhanced feedback within the learning process and aligning it with task-oriented collaboration with ECAs, medical simulation can achieve a level of personalization and effectiveness previously unattainable. This methodology not only prepares healthcare students and professionals with the knowledge they need but also with the adaptive skills essential for navigating the unpredictable and demanding world of healthcare.

4 IMPLEMENTATION AND SCALABILITY

4.1 Integration into existing educational infrastructures

Integrating AI-driven systems, particularly embodied conversational agents (ECAs), into existing educational frameworks poses unique challenges and opportunities. Educational institutions must consider hardware and software

requirements, compatibility with existing learning management systems (LMS), and the training needs of educators and administrators.

To facilitate smooth integration, a phased approach can be beneficial:

- Phase 1: Infrastructure Assessment – Evaluate the current technological infrastructure, including hardware capabilities and bandwidth, to ensure they can support advanced AI functionalities.
- Phase 2: Pilot Testing – Implement ECAs in a controlled environment to gather insights and optimize systems before full-scale deployment.
- Phase 3: Full Integration – Expand the use of ECAs across the institution, ensuring all technical and human resources are aligned for widespread adoption.

4.2 Addressing scalability challenges

Scalability is critical for the adoption of AI-driven educational tools. To address this:

- Modular Design: Develop ECAs with scalable architectures that allow institutions to tailor functionalities based on specific needs and expansion plans.
- Cloud-Based Solutions: Utilize cloud computing to manage data and computational needs efficiently, facilitating easy scaling and updates.
- Training and Support: Establish comprehensive training programs for educators and technical staff to adapt to AI tools, supplemented with ongoing support and updates.

5 ETHICAL CONSIDERATIONS

5.1 Data privacy

The use of ECAs involves the processing of sensitive personal data, raising significant privacy concerns. It is imperative to implement stringent data protection measures:

- Encryption: Use advanced encryption methods for data storage and transmission.
- Access Controls: Ensure that data access is strictly regulated and available only to authorized personnel.
- Compliance: Adhere to local and international data protection regulations, such as GDPR in the European Union or similar regulations in Switzerland or California.

5.2 Bias and fairness

AI systems can inadvertently perpetuate biases present in their training data. To combat this:

- Diverse Data Sets: Use varied and inclusive data sets for training ECAs to reduce the risk of bias.
- Continuous Monitoring: Regularly evaluate the decisions and feedback provided by ECAs to identify and correct biases.

- Transparency: Maintain transparency about how AI models operate and make decisions to build trust and accountability.

5.3 Autonomy in learning

While ECAs can guide and enhance learning, they should not replace the human touch in education:

- Complementary Role: Position ECAs as tools that supplement, rather than replace, traditional teaching methods.
- Learner Control: Ensure that learners have significant control over their interactions with ECAs, promoting a balanced human-computer interaction.

6 EVALUATION OF EFFECTIVENESS

6.1 Measuring learning outcomes

To assess the effectiveness of ECAs, specific metrics related to learning outcomes should be established:

- Performance Improvement: Measure changes in learner performance before and after ECA integration.
- Engagement Metrics: Track engagement levels through analytics to see how learners interact with ECAs.
- Feedback Quality: Evaluate the relevance and impact of the feedback provided by ECAs on learner progress.

6.2 Preliminary data insights

Preliminary studies indicate that ECAs can significantly enhance learning outcomes by providing real-time, personalized feedback. For instance, medical students using ECAs have shown improved diagnostic accuracy and procedural skills due to the immediate and contextual feedback during simulations.

6.3 Stakeholder feedback

Gathering and analyzing feedback from all stakeholders—students, educators, and administrators—is crucial. This feedback can provide insights into the system's practical impacts, areas for improvement, and the overall acceptance of AI-driven learning tools.

By addressing these areas comprehensively, educational institutions can not only enhance the learning experience but also ensure ethical compliance and scalability of AI implementations in educational settings.

Further research is needed to explore the potential of these conversational—and artificially intelligent—digital humans. At e-REAL Labs, we're committed to this research because we envisage generative artificial intelligence as an interesting driver for education and training. A representative conversational digital human

to interact with is available by scanning the QR code below (see Figure 7) and then scheduling a meeting online:

Fig. 7. By scanning the QR code, an avatar will appear and after a short self-introduction will provide an online calendar allowing you to book a meeting to talk and test a digital human directly.

7 THE FUTURE OF AI-DRIVEN EDUCATIONAL TECHNOLOGY IN HEALTHCARE

As we look toward the future, the potential of AI-driven educational technology, particularly embodied conversational agents (ECAs), is boundless. The integration of artificial intelligence into healthcare education marks a profound evolution in how we conceive learning, practice, and feedback delivery. This transformation is not limited to medical simulations but extends into every facet of professional training, setting a precedent for how advanced technologies will shape education in the decades to come.

7.1 Expanding applications in healthcare

While this article has focused predominantly on the use of ECAs within medical simulations for training healthcare professionals, the potential applications of these digital tools extend far beyond current usage. Future implementations could involve real-time assistance during actual medical procedures, where ECAs serve as consultative partners, offering insights based on vast databases of medical knowledge. Imagine a scenario where a surgeon, during a complex procedure, could verbally engage with an ECA to receive guidance or real-time feedback on a specific technique.

ECAs could also be integrated into patient education, helping healthcare providers offer personalized instruction to patients. For example, an ECA could assist in explaining complex medical conditions or treatment plans, adjusting its language and approach based on the patient's emotional state and comprehension level, ensuring more effective communication.

7.2 Multidisciplinary expansion

The success of AI in healthcare simulation opens avenues for its adoption across various disciplines, particularly in other high-stakes, performance-critical fields. Sectors such as aerospace, law enforcement, military, and corporate leadership

training could benefit immensely from AI-driven feedback systems tailored to real-time performance monitoring and improvement. ECAs, with their ability to offer nuanced, immediate, and personalized feedback, can be adapted to simulate critical decision-making processes and high-pressure environments.

7.3 Continuous learning and professional development

The ability of ECAs to evolve with the learner is a critical advancement for lifelong education. Traditionally, healthcare professionals must complete certification programs and training sessions at periodic intervals. With ECAs, continuous assessment and learning can become the norm. Learners could regularly engage with ECAs to assess their skills, receive feedback, and identify areas for improvement, promoting a model of ongoing professional development.

The system's ability to provide adaptive learning paths based on the learner's progress would further individualize the educational experience, making it far more efficient and tailored to each professional's needs. This model would allow healthcare providers to stay at the forefront of best practices and medical innovations without needing to leave their clinical environments for extended training sessions.

7.4 Ethical and social considerations

As we advance, there are critical ethical considerations to address in the use of AI-driven avatars, particularly in healthcare. Data privacy remains a central concern, especially when dealing with sensitive personal health information. Institutions must ensure that ECAs operate within strict ethical frameworks that protect both patients and learners from potential misuse of data. Moreover, ongoing monitoring to identify and rectify biases in AI systems will be essential to ensure equitable treatment and avoid reinforcing existing disparities in healthcare.

Furthermore, while AI can significantly enhance learning, it is essential to maintain a balanced approach where human intuition and judgment are not overshadowed by technological reliance. ECAs should complement human expertise, not replace it. As these technologies evolve, educators must continue to guide learners through the complexities of real-world healthcare, ensuring that AI remains a tool for enhancement rather than a substitute for human empathy, ethics, and decision-making.

7.5 Future research directions

While early studies indicate the immense potential of ECAs in improving learning outcomes, more comprehensive, long-term research is needed to fully understand the impact of these tools across different medical disciplines and educational levels.

Future research should focus on:

- Quantitative and qualitative outcomes: Measuring how ECAs improve specific skills over time and their effects on long-term knowledge retention.
- Learner acceptance and adaptability: Investigating how different learner profiles engage with and adapt to these AI-driven systems, particularly regarding emotional intelligence, critical thinking, and adaptability.

- Cross-disciplinary applications: Expanding research to include diverse professional fields and industries, studying how adaptable the ECA model is across varying learning environments and challenges.
- Cost-effectiveness and scalability: Evaluating the financial and logistical considerations of integrating ECAs into broader educational infrastructures, including how these systems can be made accessible to a wide range of educational institutions.

7.6 A paradigm shift in learning

Integrating AI-powered ECAs into healthcare education represents a paradigm shift in how we approach learning and professional development. From static, one-dimensional feedback systems to dynamic, interactive, and personalized educational experiences, AI offers learners a future where professional growth is continuous, adaptive, and deeply engaging.

The journey has just begun, but the trajectory is clear. By embracing AI-driven avatars and the novel feedback systems they provide, healthcare education is poised to become more personalized, immersive, and effective than ever before. This shift in educational practice will not only enhance the skills of medical professionals but also improve patient outcomes, ensuring that the future of healthcare is in safe, skilled, and continuously evolving hands.

8 REFERENCES

[1] https://www.e-real.net
[2] S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*/ Pearson Education. 2020.
[3] J. N. Bailenson, *Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do*. W. W. Norton & Company, 2021.
[4] C. Becker-Asano and O. Schreer, Eds., *Virtual Humans: Today and Tomorrow*. Springer Science & Business Media, 2013.
[5] J. Blascovich and J. Bailenson, *Infinite Reality: Avatars, Eternal Life, New Worlds, and the Dawn of the Virtual Revolution*. Harper Collins, 2011.
[6] J. Cassell, J. Sullivan, S. Prevost, and E. Churchill, *Embodied Conversational Agents*. The MIT Press, 2000. https://doi.org/10.7551/mitpress/2697.001.0001
[7] C. Clavel, J. Bailenson, A. Beall, J. Blascovich, and M. Turk, "Immersive virtual reality and the developing mind," in *Artificial Intelligence in Education,* R. M. Pérez de la Vega, C. H. Maldonado, F. Del Río, and I. Perera, Eds., IOS Press, 2003, pp. 11–18.
[8] J. Comas, M. Sánchez-Marrè, and A. Berlanga, Eds., *Virtual and Augmented Reality in Education, Art, and Cultural Heritage: 5th International Conference, VAMR 2013, Held as Part of HCI International 2013, Las Vegas, NV, USA, July 21–26, 2013, Proceedings*. Springer, 2017.
[9] J. J. Diehl, L. M. Schmitt, M. Villano, and C. R. Crowell, "The clinical use of virtual reality in patients with eating disorders," *European Eating Disorders Review*, vol. 27, no. 4, pp. 331–340, 2019.
[10] R. Patel, "Designing interactive virtual humans for educational and therapeutic applications," in *Proceedings of the 2019 11th International Conference on Virtual Worlds and Games for Serious Applications,* IEEE, 2019, pp. 9–16.

[11] H. Sagha, H. Khosravi, and P. W. de Vries, "Interactive embodied conversational agents in education: A comprehensive survey," *IEEE Transactions on Learning Technologies*, vol. 13, no. 4, pp. 588–607, 2019.
[12] Y. Tazawa, K. Shimoda, and H. Kato, "Virtual reality education with a virtual human: A case study with elementary school students," in *Proceedings of the 2018 10th International Conference on Virtual Worlds and Games for Serious Applications*, IEEE, 2018, pp. 80–87.
[13] M. Tegmark, *Life 3.0: Being Human in the Age of Artificial Intelligence*. Knopf, 2017.
[14] N. Bostrom, *Superintelligence: Paths, Dangers, Strategies*. Oxford University Press, 2014.
[15] F. Salvetti, R. Gardner, R. Minehart, and B. Bertagni, "Enhanced reality for healthcare simulation," in *Recent Advances in Technologies for Inclusive Well-Being: Virtual Patients, Gamification and Simulation*, A. L. Brooks, S. Brenham, B. Kapralos, A. Nakajima, J. Tyerman, and L. Jain, Eds., Springer, Heidelberg, 2021. https://doi.org/10.1007/978-3-030-59608-8_7
[16] F. Salvetti, R. Gardner, R. Minehart, and B. Bertagni, "Effective extended reality: A mixed-reality simulation demonstration with digitized and holographic tools and intelligent Avatars," in *Innovative Approaches to Technology-Enhanced Learning for the Workplace and Higher Education*, in Proceedings of the Learning Ideas Conference 2022, D. Guralnick, M. Auer, and A. Poce, Eds., Springer, Cham, 2023. https://doi.org/10.1007/978-3-031-21569-8_35
[17] F. Salvetti, R. Gardner, J. Rudolph, R. Minehart, B. Bertagni, and I. Contardo, "Intelligent digital humans for bias-free recruitment interviews: A diversity & inclusion training program," in *Innovative Approaches to Technology-Enhanced Learning for the Workplace and Higher Education*, in Proceedings of the Learning Ideas Conference 2022, D. Guralnick, M. Auer, and A. Poce, Eds., Springer, Cham, 2023. https://doi.org/10.1007/978-3-031-41637-8_36
[18] F. Salvetti and B. Bertagni, "Enhancing inclusivity in interviewing: Harnessing intelligent digital avatars for bias mitigation," in *Advances in Digital Transformation – Rise of Ultra-Smart Fully Automated Cyberspace*, E. Babulak, Ed., London: IntechOpen, 2024. https://doi.org/10.5772/intechopen.1004393
[19] J. Hattie and H. Timperley, "The power of feedback," *Review of Educational Research*, vol. 77, no. 1, pp. 81–112, 2007. https://doi.org/10.3102/003465430298487
[20] D. J. Nicol and D. Macfarlane-Dick, "Formative assessment and self-regulated learning: A model and seven principles of good feedback practice," *Studies in Higher Education*, vol. 31, no. 2, pp. 199–218, 2006. https://doi.org/10.1080/03075070600572090
[21] V. J. Shute, "Focus on formative feedback," *Review of Educational Research*, vol. 78, no. 1, pp. 153–189, 2008. https://doi.org/10.3102/0034654307313795
[22] D. Boud and E. Molloy, "Rethinking models of feedback for learning: The challenge of design," *Assessment & Evaluation in Higher Education*, vol. 38, no. 6, pp. 698–712, 2013. https://doi.org/10.1080/02602938.2012.691462
[23] J. Rudolph, R. Simon, P. Rivard, L. Dufresne, and D. Raemer, "Debriefing with good judgment: Combining rigorous feedback with genuine inquiry," *Anesthesiol Clin.*, vol. 25, no. 2, pp. 361– 376, 2007. https://doi.org/10.1016/j.anclin.2007.03.007
[24] J. Rudolph, R. Simon, D. Raemer, and W. Eppich, "Debriefing as formative assessment: Closing performance gaps in medical education," *Acad Emerg Med.*, vol. 15, no. 11, pp. 1010– 1016, 2008. https://doi.org/10.1111/j.1553-2712.2008.00248.x

9 AUTHORS

Fernando Salvetti is with the e-REAL Labs at Logosnet, 10014 Turin, Italy; 6900 Lugano, Switzerland; Houston, TX 77008, USA; New York, NY 10013, USA (E-mail: salvetti@logosnet.org).

Barbara Bertagni is with the e-REAL Labs at Logosnet, 10014 Turin, Italy; 6900 Lugano, Switzerland; Houston, TX 77008, USA; New York, NY 10013, USA.

Ianna Contardo is with the e-REAL Labs at Logosnet, 10014 Turin, Italy; 6900 Lugano, Switzerland; Houston, TX 77008, USA; New York, NY 10013, USA.

Roxane Gardner is with the Center for Medical Simulation, Boston, MA 02129, USA; Brigham and Women's Hospital/Children's Hospital/Massachusetts General Hospital and Harvard Medical School, Boston, MA 02114, USA.

Jenny Rudolph is with the Center for Medical Simulation, Boston, MA 02129, USA; Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, MA 02114, USA.

Rebecca Minehart is with the Center for Medical Simulation, Boston, MA 02129, USA; Massachusetts General Hospital and Harvard Medical School, Boston, MA 02114, USA.