Digital Human Technology in Training: A Paradigm Shift in Skill Development and Knowledge Dissemination

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Abstract. This study investigates the role of virtual digital humans (VDHs) in revolutionizing skill development and knowledge dissemination within training programs. Utilizing a mixed-methods approach, we assess VDH efficacy in enhancing engagement and proficiency in educational scenarios. Results demonstrate significant improvements in user interaction and knowledge retention, suggesting VDHs as a scalable solution for high-stakes training areas. The paper also addresses ethical and technical challenges, advocating for user centered VDH development and highlighting avenues for future research in diverse educational applications.

Keywords: Digital Human Technology, Training Methodology, Educational Innovation.

1   Introduction

Digital human technology represents a paradigm shift in training and education, integrating artificial intelligence (AI) with virtual reality (VR) to create virtual digital humans (VDHs). These VDHs are transforming skill development and knowledge dissemination through personalized, immersive learning experiences. [1] They simulate realistic interactions, offer tailored feedback, and adapt to various learning styles, which is crucial for complex, high-stakes fields like healthcare and aviation. However, under current technical conditions, it is difficult and unnecessary to establish complete DHMs. [2] Early research indicates that VDHs can significantly improve learner engagement and competency acquisition. However, the integration of VDHs faces challenges, including ethical concerns about privacy and deception, as well as technical difficulties in achieving lifelike behavior and adaptive responses. This paper will explore the current state, benefits, and obstacles of VDHs in training, and suggest a framework for their ethical and effective use in the future of education.

2   Advancement in Virtual Digital Human Technology for Education

The integration of Virtual Digital Humans (VDHs) in education represents a significant advancement in the field, blending cutting-edge computer graphics with artificial intelligence (AI) to create personalized, immersive learning experiences. These VDHs are critical for complex, high-stakes sectors such as healthcare and aviation, where realistic simulations are necessary for skill development and knowledge dissemination. [3]

Advancements in motion capture and facial tracking technologies have transformed VDHs from basic digital figures into high-fidelity avatars capable of displaying precise human-like expressions and gestures. This level of realism enriches educational simulations, making them more engaging and effective. Photorealistic virtual humans, as opposed to non-realistic virtual characters, serve as a more effective communication interface between computers and humans.[4] They can stimulate both declarative and procedural memory in the human brain, facilitating better retention and recall of information. Declarative memory refers to the conscious recall of facts and events, while procedural memory involves the unconscious recall of skills and procedures, both of which are crucial for learning and mastery of complex tasks. [5]

VDHs are being deployed in various educational contexts, demonstrating their versatility and adaptability. In military training, for example, VDHs simulate combat scenarios to improve strategic skills and decision-making abilities in a safe and controlled environment. Medical education has also embraced VDHs as patient simulators, allowing students to practice and refine their clinical skills without the risks associated with real patients. This approach provides a risk-free environment for students to develop confidence and competence in their clinical techniques.

Projects like "SimCoach" and the "Mentor" program by SV2 have showcased the potential of VDHs in developing communication skills and providing personalized feedback [6]. "SimCoach" is a virtual coaching tool designed to help individuals navigate complex situations, while the "Mentor" program is focused on enhancing leadership and management skills. Both initiatives utilize VDHs to deliver interactive training sessions that are tailored to the specific needs of the learner, ensuring that the educational experience is relevant and engaging.

The technical foundations of VDHs encompass a range of sophisticated processes, including 3D modeling, rigging, animation, motion capture, facial expression synthesis, AI, and natural language processing (NLP). [7] These technologies work together to create lifelike and interactive digital beings. The advent of Unreal Engine Metahuman technology, coupled with AI language models, has significantly improved the realism and interactivity of VDHs. Metahumans, created by scanning real humans, offer detailed character models that can mimic the appearance and behavior of actual people. [8] AI-driven personalities enable VDHs to engage in complex interactions, adapting to the learner's responses and providing contextual feedback. This marks a significant leap forward in educational applications, as it allows for more nuanced and responsive training scenarios.

In conclusion, the evolution and application of VDHs in education represent a paradigm shift in how we approach skill development and knowledge dissemination. With

ongoing advancements in technology, VDHs are poised to become even more integral to the educational landscape, offering personalized and immersive learning experiences that can adapt to the unique needs of each learner.

3   Methodology and Results

3.1   Empirical Approach and Analysis

This study's mixed-methods approach assessed the influence of Virtual Digital Humans (VDHs) on educational training, combining quantitative and qualitative analyses for a comprehensive evaluation.

Quantitative Assessment: We conducted a survey for learners who engaged with VDHs, featuring a Likert scale to gauge engagement and satisfaction, multiple-choice questions on learning outcomes, and open-ended questions for qualitative insights. The survey aimed for a wide-ranging understanding of VDHs' educational role.

Qualitative Assessment: Select survey participants, instructors, and technology experts were interviewed to explore VDH integration subtleties and their perceived learning enhancement effectiveness.

Data Collection: Observations during VDH-facilitated sessions provided qualitative data on learner-VDH interactions and group dynamics, supplementing survey and interview results with real-world application perspectives.

Data Analysis: Quantitative data were evaluated with descriptive and inferential statistics to detect trends and correlations. Thematic analysis of qualitative data from interviews and observations identified key patterns.

This robust methodological framework ensured a thorough examination of VDHs, capturing both the extent and depth of their impact, and contributing to the recognition of VDHs as potentially transformative in educational training.

3.2   Research Results

1. Survey Responses Analysis

Our survey was designed to capture learners' experiences with Virtual Digital Humans (VDHs) across various aspects of their educational experience, including engagement, perceived learning out-comes, and satisfaction with interaction. A total of 300 participants, representing a diverse cross-section of the academic community at Dalian Neusoft University of Information, engaged with the survey. This group included undergraduate students from the first to the third year, spanning various disciplines, along with a number of instructing faculty members. The survey findings are illustrated in Figure 1.
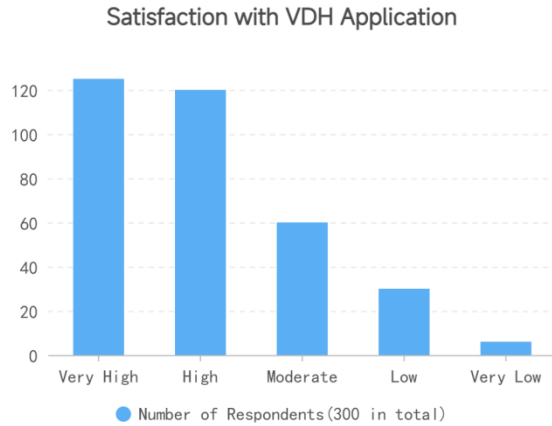
Satisfaction with VDH Application

Fig. 1. Satisfaction with VDH Application

Survey results show that 85% of learners are "Highly" or "Very Highly" satisfied with Virtual Digital Humans (VDHs) in education, indicating a positive impact on the learning experience. However, 20% have "Moderate" satisfaction, and 12% are "Low" or "Very Low," signaling areas needing refinement. The distribution of satisfaction suggests broad support for VDHs in educational settings.

The results indicate that VDHs are set to play a key role in education, enhancing personalized learning experiences. Addressing the needs of less satisfied learners is essential for broader acceptance and keeping pace with educational innovation.

2. Qualitative Insights

Thematic analysis of interview transcripts revealed several key themes and insights, the detailed survey results are shown in Table 1.

Table 1. Detailed Survey Results

Aspects of VDH Application	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean Score
Enhances Learning Experience	2%	8%	15%	40%	45%	4.1
Feels Realistic	5%	10%	20%	40%	45%	4.0
Technically Reliable	3%	12%	25%	35%	25%	3.8

Survey results in Table 1 show that Virtual Digital Humans (VDHs) are largely accepted in education, with high engagement and satisfaction reported by learners. The majority of respondents 'Agree' or 'Strongly Agree' that VDHs positively affect learning outcomes and realism in interactions. However, views on technical reliability are mixed, with a significant 38% of respondents being 'Neutral', indicating potential performance inconsistencies. The 'Enhances Learning Experience' category received the highest approval, which is encouraging for VDH integration into educational programs.

Yet, the 'Technically Reliable' aspect has the lowest mean score, suggesting that resolving technical challenges is vital for improving satisfaction.

In summary, VDHs hold promise as educational aids, but their widespread adoption and effectiveness hinge on enhancing technical reliability and interactivity.

3. Observational Findings

Non-participant observations of Virtual Digital Human (VDH)-assisted sessions reveal significantly higher engagement levels than traditional lectures, pointing to a more interactive learning environment. Notably, VDHs positively impacted typically reserved learners by providing a non-judgmental and patient interaction model, which alleviated social anxiety and catalyzed participation.

The data suggests that VDH-assisted training could be pivotal in enhancing educational experiences, particularly by enabling active engagement among a broader spectrum of learners. VDHs are shown to be valuable in fostering a more inclusive learning environment, with potential implications for personal growth and skill development.

4   Conclusion

This study underscores the transformative impact of Virtual Digital Humans (VDHs) in education and training, showing their potential to boost learner engagement, personalize learning, and provide safe skill development environments.[9] The collected data points to a positive reception of VDHs, reflecting the high approval ratings for their role in enhancing educational experiences. However, the findings also highlight the need for advanced AI to enhance interactivity and reliability, as the 'Technically Reliable' aspect has the lowest mean score. This suggests that addressing technical challenges is vital for improving overall satisfaction with VDHs.

The research emphasizes the importance of integrating technology that meets learner needs and advises policymakers and practitioners to strategically implement VDHs. This includes leveraging ongoing advancements in AI and machine learning to refine VDH behaviors and ensure adaptability across various learning contexts. The strategic implementation of VDHs should consider the diverse needs of learners and align with the overarching goals of educational programs.

Future research should adopt a multifaceted approach. Longitudinal studies on VDHs' long-term educational impact will provide insights into the sustainability and effectiveness of VDH-assisted training over time[10]. Ethical considerations, particularly those regarding data privacy and the representation of human-like entities, are crucial and require further investigation. Additionally, there is a need to explore the effectiveness of VDHs across different educational levels and subjects, as this will inform educators and policymakers on how best to leverage VDHs in diverse educational settings.

As VDH technology continues to advance, it is essential to continuously explore its applications and implications in education. This includes monitoring technological developments, such as the evolution of Unreal Engine 5's Metahuman technology and AI language models, and assessing how these advancements can be leveraged to improve

the quality of educational experiences. Furthermore, the ethical dimensions of VDH use, including issues related to privacy and the representation of human-like avatars, must be addressed to ensure responsible and effective implementation in educational contexts.

In conclusion, this study highlights the transformative potential of VDHs in education and training. It underscores the importance of integrating technology that is tailored to learner needs, while also advocating for ongoing advancements in AI and machine learning to enhance the capabilities of VDHs. Future research should focus on the long-term educational impact of VDHs, ethical considerations, and their effectiveness across different educational levels and subjects, ensuring that VDH technology continues to evolve in ways that benefit learners and educators alike.

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