

Clinical Skills Training of Metaverse-Based Learning: A Systematic Review

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Abstract

Due to technological advancements, the metaverse has become a frequently discussed topic. In the educational field, there is an increasing focus on clinical skills training through the use of the meta-universe. This paper aims to investigate the present status, methodologies, outcomes, and future prospects of clinical skills training that utilise the meta-universe. Through systematic searching, screening of relevant literature, and comprehensive analysis of included studies, we have discovered that meta-universe-based clinical skills training offers numerous benefits, including improved learning outcomes, enhanced student interest and reduced costs. However, there are also several challenges associated with this approach, including a high technological threshold and a lack of unified standards and evaluation systems. Future research should focus on exploring the effective application of metaverse technology in clinical skills training while maintaining objectivity. It is important to use clear and concise language, avoiding unnecessary terminology, and ensuring a logical flow of information with causal connections between statements. Additionally, consistent formats and conventional structures should be followed, including common academic sections. Language should be clear, objective and value-neutral, avoiding biased or emotional language and sticking to common sentence structures. Grammatical correctness and precise word choice are also essential. Finally, it is important to maintain a formal register, avoiding colloquialisms, contractions, informal expressions, and unnecessary jargon.

Keywords: Clinical Skills Training, Virtual Reality, Metaverse-based Learning

Introduction

Clinical skills training is an integral aspect of medical education, playing a vital role in the professional development of medical students and ensuring patient safety. Nonetheless, traditional approaches to clinical skills training still suffer from high costs, time and space constraints, and uncooperative patients. With the development of science and technology, researchers are increasingly interested in utilizing meta-universe methods for clinical skills training. The meta-universe describes a virtual, three-dimensional area that users can utilise to create virtual roles, interact and communicate. Meta-universe usage in education can offer students a more lifelike and exciting learning experience, amplifying the impact of learning.

Previously, surgical interns trained to master their skills by practising on patients in an operating theatre. However, the potential for learning in the operating theatre has become increasingly restricted owing to legislation that limits the workweek, along with the imposition of medicolegal and federal regulations, and the pressure exerted by health service administrators to perform as many operations as possible. Moreover, heightened awareness of medical malpractice issues has diminished the previous willingness to train inexperienced surgeons in the operating theatre. As a result, virtual training can enhance trainees' learning and support surgical training by offering a secure environment for practice under the supervision of trainers (Christodoulou et al., 2014). This paper aims to conduct a systematic review of research on meta-universe-based clinical skills training, examining its current status, methods, outcomes, and prospective developments.

Background

Meta-universe technology originated from virtual reality technology. After several decades of development, it has been widely applied in fields such as entertainment, social interaction and education. Specifically, in the education sector, the use of meta-universe technology in clinical skills training can improve learning outcomes and interest levels while providing a more realistic and immersive experience for the students. Meta-universe-based clinical skills training has the potential to improve cost-effectiveness, reduce time and space constraints, and encourage patient cooperation - all of which are significant advantages. An innovative model of mentored practice was implemented in Argentina to support health care providers in managing patients suffering from chronic, complex diseases around the world, thereby reducing underservice and disparities between remote areas and large urban centres. It utilises virtual technology to exchange knowledge between healthcare professionals and specialist mentors via academic medical centres (Luna et al., 2022).

Purpose of the Review

This paper aims to conduct a systematic review of relevant studies on meta-universe-based clinical skills training while exploring their current status, methodologies, results, and future trends. This review seeks to answer the following three questions: Through the thorough examination of pertinent literature, we will gain insight into the strengths and challenges of such training and provide references and lessons for future research.

QS1 What is the definition of meta-universe?

QS2 Importance of clinical skills training?

QS3 Advantages of clinical skills training using meta-universe technology?

Methods

This systematic review utilises the PRISMA methodology, which includes four distinct stages: identification, screening, eligibility, and inclusion, illustrated in Figure 1. PRISMA has gained widespread popularity among researchers due to its comprehensive and adaptable nature. The purpose of this review and its systematic process will be outlined below.

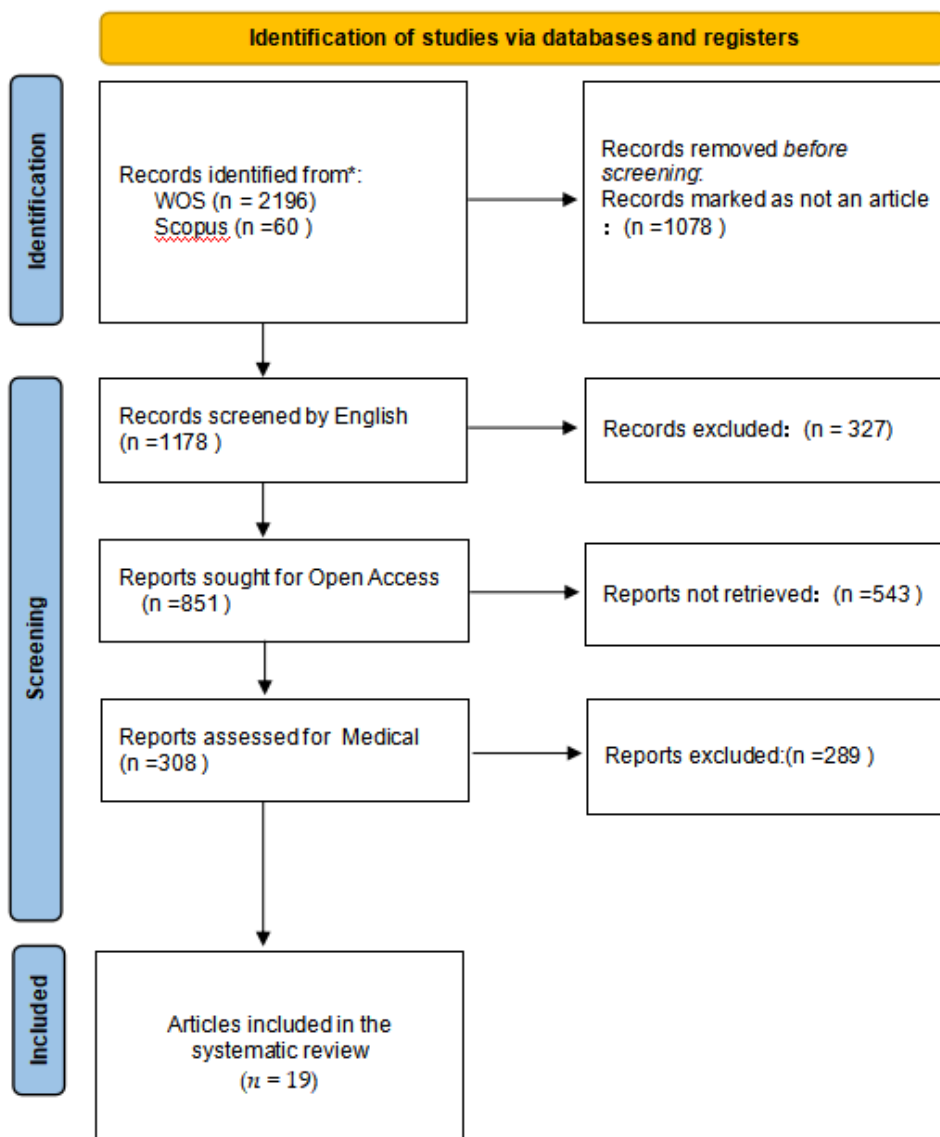


Figure 1. PRISMA systematic review adapted from (McKenzie et al., 2020)

Identification

This initial phase of the systematic review involved adhering to PRISMA guidelines to identify relevant publications. To aid in this, two selected databases, Scopus and Web of Science (WOS), were consulted for this investigation. The review structure was carefully considered when devising the key phrases for this study, which focuses on the terminology related to Metaverse-based learning and the training of clinical skills.

Table 1

The search string used in this study.

Database	Search String
Web of Science (WOS)	TI=("clinic skills training"or"clinic training"and "Metaverse learning"or"Metaverse-based learning"or"virtual learning"or"virtual-based learning")
Scopus	TITLE-ABS-KEY("clinic skills training"or"clinic training"or"clinic skills" or"medical skills"and "Metaverse"or"Metaverse-based"or"virtual"or"virtual-based")

Screening

After identifying the articles, the screening process was initiated, with the initial step involving the removal of articles that did not conform to standard article format, those which were not written in English, or were lacking open access. This resulted in the removal of 2,237 articles, leaving 308 articles that were eligible for further screening. These 308 articles underwent further scrutiny, with the evaluation based on their title, abstract, and keywords to ensure relevance to clinical skills training and meta-universe. During the screening phase, 289 articles were eliminated as they did not pertain to the aim of this study. The inclusion and exclusion criteria depicted in the subsequent diagram were then utilised to screen the remaining 19 articles. The screening conditions are shown in Table 2.

Table 2

Inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Journal Articles	Conference proceedings, review articles, book chapters, research reports
Written in English	Not written in English
Medical related	Not Related to Medical

Quality

Following the aforementioned screening process, the remaining 19 pieces of literature pertain to clinical skills training and the metaverse. These works offer extensive comprehension and insight into the subjects, encompassing topics such as the utilization of metaverse technology for clinical skills training and its effect on enhancing healthcare professionals' skills and patient care. Furthermore, this literature could investigate alternate uses of the metaverse in the healthcare sector, for instance, genetic counselling, military medical care, rehabilitation service etc. (Arjunan et al., 2021; Goodwin, 2014; Siu et al., 2016; Afshari et al., 2022).

Table 3

Summary of the selected studies

Study	Year	Database	Source Type	Find
B. J.Jones	2022	WOS	Journal Article	<ul style="list-style-type: none"> - Flipped learning with gamification aims to improve student engagement, motivation, and attainment. - The structured active learning approach requires participation to progress and contributes to the end-of-term assessment. - The structured active learning approach resulted in higher levels of engagement and participation compared to the standard approach. - The structured active learning approach led to improved grade profiles in assessments. - Gamification is one approach

Table 3 Cont.

Study	Year	Database	Source Type	Find
OD Otuyemi	2023	WOS	Journal Article	<p>to increase engagement in flipped learning.</p> <ul style="list-style-type: none"> - The structured active learning method reduced assessment load for students and allowed them to use tutorial and virtual learning environment work as evidence of achieving learning outcomes. <p>The study concludes that the experiences of dental students and their preparedness for VL were moderate, and the challenges identified need to be addressed to improve the effectiveness of VL in dental education.</p>

Mitra	2022	Scoups	Journal Article	The results showed that all participants completed the assessments without any adverse events, demonstrating the feasibility and safety of virtual fall-risk assessments. Additionally, 22% of FTSTS assessments and 55% of RTT assessments met the criteria for high fall-risk designation. The study highlights the potential of
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Table 3.Con.

Study	Year	Database	Source Type	Find
				virtual assessments to improve fall-risk assessment in PD patients, providing valuable information for both clinical care and research.
				<ul style="list-style-type: none"> - Critical programs have struggled to maintain contact with foreign patients due to movement restrictions and decreased access to healthcare facilities. - Priorities should be carefully considered and less urgent engagements may be suspended or canceled to allocate funding toward programming with a greater impact. - Virtual collaboration has become necessary due to COVID-19 restrictions and multiple information technology platforms exist to deliver content. - Virtual events can broaden the audience and add diversity to an event, but they can also be hindered by poor attendance and
Chelsea B.	2022	Scoups	Journal Article	

Table 3.Con.

Study	Year	Database	Source Type	Find
Ka Chun	2016	Scopus	Journal Article	<p>technical limitations.</p> <p>- When in-person engagements occur, preventive measures must be taken to ensure the safety of all participants.</p> <p>The document emphasizes the importance of understanding and quantifying surgical skill decay and developing training interventions to prevent decay. The document also discusses the skill retention theory, which proposes three stages of learning and forgetting: declarative, associative, and procedural. The document concludes by mentioning the potential of adaptive virtual reality training for surgical skills and the need for further research in this area.</p> <p>The results showed that the WAVE training was successful without technical difficulties and the students expressed a strong desire for more WAVE training in the curriculum. The document concludes that the WAVE</p>
Maj Craig	2014	Scopus	Journal Article	

Table 3.Con.

Study	Year	Database	Source Type	Find
Peter	2015	WOS	Journal Article	<p>platform represents a significant technological advancement in simulated military medical training.</p> <p>The study concludes that robot-supported training leads to more efficient movement execution, particularly in persons with more marked upper limb dysfunction, but larger studies are needed.</p> <p>The document emphasizes the unique position of genetic counselors in industry to provide remote training opportunities and increase exposure to different roles.</p>
Aishwarya	2021	Scopus	Journal Article	

Anneliese	2014	WOS	Journal Article	<ul style="list-style-type: none"> - Many organizations use quality improvement collaboratives (QICs) to facilitate PCMH implementation - Virtual QICs are becoming more popular due to cost reduction and increased reach - The study surveyed participants in a virtual collaborative to understand its effectiveness and identify areas for improvement
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Table 3.Con.

Study	Year	Database	Source Type	Find
Seerab	2022	WOS	Journal Article	<p>The COVID-19 pandemic led to a surge in the usage of virtual learning platforms in dental education. Zoom was the most popular virtual platform used for dental education. The main advantages of virtual education were affordability of time and convenience and comfort of learning from anywhere. The dominant challenge faced was internet connectivity issues. The majority of dental faculties and practitioners preferred virtual education as an adjunct to conventional education.</p> <ul style="list-style-type: none"> - Patient safety is a significant concern, especially in pediatrics. - The goal of the study was to develop a virtual learning environment for medication administration in pediatrics and neonatology. - The virtual environment consisted of five themes: rights of medication
Alayne Larissa	2020	WOS	Journal Article	<ul style="list-style-type: none"> - Patient safety is a significant concern, especially in pediatrics. - The goal of the study was to develop a virtual learning environment for medication administration in pediatrics and neonatology. - The virtual environment consisted of five themes: rights of medication

Table 3.Con.

Study	Year	Database	Source Type	Find
Janaína	2021	WOS	Journal Article	<p>administration, medication administration steps, medication administration routes, medication calculation, and nonpharmacological actions for pain relief.</p> <ul style="list-style-type: none"> - The virtual learning environment was validated by expert judges and evaluated by undergraduate nursing students. - The experts positively validated the virtual environment, and the students considered the content suitable, although some adjustments were necessary. - The virtual learning environment is an effective educational tool for teaching medication administration in pediatrics and neonatology. - The Brazilian prison system faces shortcomings in infrastructure and investments, leading to problems related to human rights, healthcare, and criminality rates. - STIs, including syphilis, HIV, and tuberculosis, are prevalent among the prison population.

Table 3.Con.

Study	Year	Database	Source Type	Find
				<ul style="list-style-type: none"> - Public policies and education are important in addressing the healthcare needs of persons deprived of liberty. - The "Healthcare of Persons Deprived of Liberty" course is offered through Brazil's Unified Health System's virtual learning environment. - The course aims to train healthcare professionals and raise awareness among the general population about the healthcare challenges in the prison system. - The report provides a descriptive analysis of the course data and a

				<p>repository of participant data for further research.</p> <ul style="list-style-type: none"> - AVASUS is a free and open distance education platform of the Ministry of Health in Brazil. - The study analyzed data from AVASUS, CNES, CBO, and a questionnaire. - 76.2% of course participants recommended AVASUS courses to their peers.
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Table 3.Con.

Study	Year	Database	Source Type	Find
Deepal	2022	WOS	Journal Article	<ul style="list-style-type: none"> - The quality of educational offerings motivated 81.3% of the recommendations. - 75.6% of course participants indicated that AVASUS course contents contribute to enhancing existing health services. - 24.6% of all responses mentioned that AVASUS courses were essential in offering new health services. - The COVID-19 pandemic led to a rapid transition to online learning in medical schools. - Online learning is associated with poor academic performance, mental health, and student-to-faculty relationships. - The study aimed to determine correlations between academic performance, mental health, study location, and student/faculty relationships among medical students. - Academic performance was positively correlated with mental health and relationships among

Table 3.Con.

Study	Year	Database	Source Type	Find
Mohammed A	2022	WOS	Journal Article	<p>students, and negatively correlated with the percentage of time spent studying at home.</p> <ul style="list-style-type: none"> - Mental health was positively correlated with relationships to faculty and relationships to students. - The study evaluates the psychosocial effects of virtual learning on mothers of elementary school children. - A total of 460 mothers participated in the study. - The overall stress level among mothers was moderate. - Age, diabetes, verbal abuse towards a child, and familial conflicts were significant factors contributing to high stress levels. - The consequences of virtual learning on mothers and families are alarming, with stress, abuse, and unhealthy family dynamics being strongly associated with this mode of learning. - Further investigation into the emotional and behavioral changes among this group is needed.

Table 3.Con.

Study	Year	Database	Source Type	Find
Rodolfo E.	2013	WOS	Journal Article	The results of the course show that e-learning activities can improve students' learning outcomes and performance in examinations. The document concludes by emphasizing the value of online learning resources in higher education and their ability to overcome constraints such as time, finances, and space.
Michail	2014	Scopus	Journal Article	The document concludes that workshops are a necessary component of medical training, and efforts should

Paula C.	2022	Scopus	Journal Article	be made to ensure that trainees gain the knowledge and skills imparted to them.
				The project was implemented in Argentina for atopic dermatitis (AD) and includes videoconferences, virtual classes, and an open chat. The results showed a significant improvement in the management of patients with AD, including the use of severity scores, phototherapy, and both classic and innovative treatments.

Result

After a systematic study of the literature, the following:

QS1 question is answered:

What is the definition of a meta-universe?

A meta-universe is a virtual shared space that is extended and integrated, consisting of multiple user-generated subspaces. It is a combination of physical reality, virtual reality, and augmented reality that enables users to interact, create, socialize, and entertain. Technical terms are explained when first used, and the language is clear, objective, and unbiased. The text is free of grammatical errors and follows the conventional structure and style guide guidelines. The meta-universe is a constantly evolving and dynamic realm that integrates new services and experiences.

QS2 The importance of clinical

Skills training in healthcare is crucial. Clinical skills form a crucial part of a doctor's professional competence, and are essential in ensuring optimal diagnosis and treatment of patients. Clinical skills training allows doctors to acquire comprehensive experience and enhance their abilities Otuyemi & Jebose (2023), resulting in better service delivery to their patients (Martins et al., 2020). Moreover, such training provides doctors with self-assurance and stronger decision-making aptitudes, which are crucial when handling crisis situations.

QS3 Advantages of clinical skills training using meta-universe technology?

Clinical skills training through meta-universe technology offers multiple benefits. One of these is the highly authentic simulation environment: Metaverse technology creates a virtual environment that simulates real situations involving patients and cases. This allows doctors to practice in a virtual setting, boosting their coping skills and self-confidence when working with actual patients.

Metaverse technology provides an interactive and social platform for doctors and trainees to collaborate and socialize in a virtual environment. Trainees can engage in simulated practices, exchange experiences and knowledge, promoting learning and skill development.

Furthermore, clinical skills training is easily accessible as it can be conducted at any time and location through meta-universe technology, enhancing flexibility and convenience. Doctors can arrange their learning to fit their own schedule, which increases the flexibility and convenience of their training (Husain et al., 2022).

Personalisation and customisation: Meta-universe technology can be tailored to meet the learning needs and competency levels of doctors. They can choose the learning materials and level of difficulty that match their specific situation, which improves the relevance and efficiency of their training.

Cost-effectiveness: Meta-universe technology has the potential to decrease the expenses of clinical skills training. Utilizing simulated practice and virtual environments, the costs linked with real cases and patient resources can be minimized, and the efficiency of training can be maximized (Avila et al., 2013).

Removal of temporal and spatial restrictions: the worldwide impact of recent neocoronavirus outbreaks and their spread has caused apprehension and anxiety. COVID-19 Pandemics not only pose a momentous menace to Public Health, but it also has far-reaching consequences on the worldwide economy and society. Hence, it is crucial to implement efficient strategies to address the outbreak, which includes intensifying preventive measures, elevating public health consciousness, and augmenting medical defence. At the same time, it is essential to investigate novel technologies and techniques for nurturing budding medical resources while lessening the effects on learning and training (Otuyemi & Jebose, 2023; Payne, 2022).

Discussion

Limitation

The technology of the Metaverse is still in the developmental stage and is not yet fully mature. Technologies such as virtual reality and augmented reality require further development and improvement before they can be more effectively applied to clinical skills training. Clinical skills training based on the meta-universe necessitates a considerable amount of technical, human, and material resources, making it a costly endeavour. Simultaneously, obtaining and updating relevant equipment, for example, virtual reality and augmented reality, calls for a certain amount of capital investment. Vital to clinical skills training in the meta-universe, professional trainers are necessary to provide guidance and teaching. Nonetheless, well-trained and competent trainers are still scarce and need to be attended to and nurtured. Vital to clinical skills training in the meta-universe, professional trainers are necessary to provide guidance and teaching. As a result, the aforementioned factors contribute to inferior training outcomes (Valentim et al., 2022; Jones & Sturrock, 2022).

Implication

Meta-universe technology enables doctors to practice in virtual environments, improving their clinical skills and coping abilities by simulating real patient conditions, including symptoms and signs. In addition, the technology enables surgical simulation and training so that surgical skills and proficiency can be improved in a virtual environment. Meta-universe technology can simulate different rehabilitation training situations and processes, enabling patients to carry out their rehabilitation training in a virtual environment, improving both their rehabilitation outcomes and self-care abilities (Feys et al., 2015).

Future Research

As technology continues to develop and improve, clinical skill training based on the meta-universe will become more and more advanced and widely used, and will become one of the essential methods of medical education. Simultaneously, the expense of meta-universe-based training in clinical skills will be progressively lowered, extending the

opportunity for medical establishments and individuals, including criminals, to take advantage of it (Valentim et al., 2021). Further development in technology and an amplified demand for its use have resulted in the expansion of meta-universe-based clinical skills training into more areas and applications, including psychological disorders, emergencies, and primary care physicians (Patel et al., 2022; Aljaffer, Alzahrani & Shehadah, 2022; Butler et al., 2014).

Conclusion

This paper systematically examines the relevant research on clinical skills training based on meta-universe, examining its current status, methods, findings and future directions. Meta-universe-based training offers notable benefits and extensive potential, enabling learners to experience more realistic and immersive educational sessions, enhancing learning outcomes and engagement. Nonetheless, various challenges and issues still need to be addressed. Further research is required into the optimal application of meta-universe technology in clinical skills training. Additionally, efforts to enhance research and solutions regarding related issues should be strengthened.

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