EFFECTIVENESS OF CLINICAL VIRTUAL SIMULATION ON KNOWLEDGE RETENTION, SELF-DIRECTED LEARNING ABILITY AND LEARNING EFFECT AMONG NURSING STUDENTS IN XI'AN FANYI UNIVERSITY, CHINA

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by

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LIST OF ABBREVIATIONS

CVS	Clinical virtual simulation
MOOC	massive open online courses
SBL	Simulation-based learning
VRS	Virtual reality simulation
VR	virtual reality
CSL	clinical skills laboratories
SRSSDL	Self-Rating Scale of self-directed learning ability

LIST OF APPENDICES

KEBERKESANAN SIMULASI KLINIKAL MAYA TERHADAP PENGEKALAN PENGETAHUAN, KEUPAYAAN PEMBELAJARAN KENDIRI DAN KESAN PEMBELAJARAN DALAM KALANGAN PELAJAR KEJURURAWATAN DI UNIVERSITI XI'AN FANYI, CHINA

ABSTRAK

Dengan perkembangan pesat pengajaran maklumat, simulasi maya klinikal telah digunakan secara meluas sebagai kaedah pengajaran baharu dalam pengajaran kejururawatan. Walau bagaimanapun, penyelidikan membujur yang mendalam tentang keupayaan pembelajaran terarah kendiri dan pengekalan pengetahuan adalah kurang. Kajian ini bertujuan untuk mengenal pasti kesan simulasi maya klinikal terhadap pengekalan pengetahuan, keupayaan pembelajaran kendiri dan kesan pembelajaran dalam kalangan pelajar kejururawatan. Kajian ini merupakan kajian kuasi eksperimen yang telah dijalankan dalam masa dua bulan, dari Oktober hingga November 2023. Pelajar kejururawatan tahun dua dari Universiti Xi'an Fanyi dibahagikan secara rawak kepada dua kumpulan: kumpulan kawalan (n=43), di mana kaedah pengajaran tradisional telah digunakan, dan kumpulan eksperimen (n=41), di mana gabungan pengajaran tradisional dan simulasi maya klinikal telah digunakan. Pelajar dalam kumpulan kawalan telah menghadiri kursus teori, diikuti dengan kursus amali klinikal, dan menerima bimbingan amali di makmal. Pelajar dalam kumpulan eksperimen telah menghadiri kursus teori, mempelajari dan mempraktikkan projek simulasi pada platform simulasi maya, dan kemudian menghadiri kursus amali klinikal dan menerima bimbingan amali di makmal. Pengekalan pengetahuan pelajar dinilai serta-merta, dua

minggu, dan satu bulan selepas intervensi menggunakan ujian aneka pilihan. Skala penilaian kendiri soal selidik keupayaan pembelajaran terarah kendiri digunakan untuk menentukan keupayaan pembelajaran terarah kendiri pelajar. Soal selidik penilaian kesan latihan simulasi maya digunakan untuk menentukan kesan pembelajaran pelajar kejururawatan. Pelajar kejururawatan dalam kumpulan eksperimen menunjukkan peningkatan yang ketara secara statistik dalam pengekalan pengetahuan selepas menggunakan simulasi maya klinikal serta-merta, dua minggu dan satu bulan berbanding kumpulan kawalan ($P<0.05$). Peningkatan ketara secara statistik telah diperhatikan dalam keupayaan pembelajaran kendiri pelajar kejururawatan dalam kumpulan eksperimen berbanding dengan mereka dalam kumpulan kawalan, termasuk kesedaran pembelajaran, strategi pembelajaran, tingkah laku pembelajaran, keupayaan penilaian pembelajaran dan kemahiran interpersonal ($P<0.05$). Kumpulan eksperimen mempunyai perbezaan dalam kesan pembelajaran sebelum dan selepas menggunakan simulasi maya klinikal. Lebih daripada 90% pelajar kejururawatan menyedari bahawa CVS boleh membantu dalam pembelajaran dan mensimulasikan minat untuk belajar. Lebih daripada 95% pelajar kejururawatan menyukai sistem simulasi. Sebanyak 14.6% pelajar kejururawatan memilih pilihan yang adil dalam CVS untuk meningkatkan kemahiran komunikasi mereka. Kajian ini merumuskan bahawa aplikasi simulasi maya klinikal dapat meningkatkan daya ingatan dan pengekalan pengetahuan teori dan meningkatkan keupayaan pembelajaran kendiri dan kesan pembelajaran dalam kalangan pelajar kejururawatan.

EFFECTIVENESS OF CLINICAL VIRTUAL SIMULATION ON KNOWLEDGE RETENTION, SELF-DIRECTED LEARNING ABILITY AND LEARNING EFFECT AMONG NURSING STUDENTS IN XI'AN FANYI UNIVERSITY, CHINA.

ABSTRACT

With the rapid development of information teaching, clinical virtual simulation has been widely used as a new teaching method in nursing teaching. However, in-depth longitudinal research on self-directed learning ability and knowledge retention is lacking. This study aims to identify the effect of clinical virtual simulation on knowledge retention, self-directed learning ability and the learning effect among nursing students. This work is a quasi-experimental study that was conducted in two months, from October to November 2023. Sophomore nursing students from Xi'an Fanyi University were randomly divided into two groups: the control group (n=43), in which the traditional teaching method was used, and an experimental group (n=41), in which a combination of traditional teaching and clinical virtual simulation was employed. The students in the control group attended a theoretical course, followed by clinical practice courses, and received practice guidance in a laboratory. The students in the experimental group attended a theoretical course, learned and practiced the simulation project on a virtual simulation platform, and then attended clinical practice courses and received practice guidance in a laboratory. The knowledge retention of the students was assessed immediately, two weeks, and one month after the intervention using a multiple-choice test. The self-rating scale of the self-directed learning ability questionnaire was used to determine the self-directed learning ability of the students.

The effect evaluation questionnaire of virtual simulation training was used to determine the learning effect of the nursing students. Nursing students in the experimental group showed statistically significant improvements in knowledge retention after using clinical virtual simulation immediately, two weeks and one month compared to the control group($P<0.05$). Statistically significant improvements were observed in the self-directed learning ability of the nursing students in the experimental group compared with those in the control group, including learning consciousness, learning strategy, learning behavior, learning evaluation ability and interpersonal skills ($P<0.05$). The experimental group had differences in the learning effect before and after using clinical virtual simulation. More than 90% of nursing students recognize that CVS can assist in learning and simulate interest in learning. More than 95% of the nursing students liked the simulation system. A total of 14.6% of nursing students chose a fair option in CVS to improve their communication skills. This study concludes that the application of clinical virtual simulation can enhance the memory and retention of theoretical knowledge and improve the self-directed learning ability and learning effect among nursing students.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The introduction chapter takes nursing students as the research object, focusing on the research background and problem statement of the influence of clinical virtual simulation on nursing education, followed by the research questions, research objectives, research hypothesis, significance of the study, and definition of terms.

1.2 Background of the Study

The types of teaching methods in nursing education have become more diversified with the rapid development of information technology, such as flipped classroom teaching mode, massive open online courses (MOOC), and simulation for nursing students(Beer et al., 2020; Wang et al., 2023). Clinical virtual simulation is a relatively new teaching approach in nursing education. In 2011, The American Institute of Medical Sciences & Education proposed in the report on the future of nursing that technologies and online education would help increase the number of high-quality nurses, such as advanced practice nurses and doctorate degree nurses (Mendez et al., 2020). In 2018, the Ministry of Education of the People's Republic of China, in its proposal to build five types of golden courses, including offline courses, online courses, offline and online mixed courses, virtual simulation courses, and social practice courses, pointed out that “Internet + education” and “intelligent + education” may become a new form of education in the future and vigorously encouraged Chinese university

education to explore virtual simulation templates (Wu, 2018). During the COVID-19 pandemic, Chinese universities have opened thousands of clinical virtual simulation experiments online to ensure the normal development of experimental teaching (Yang et al., 2020). Xi'an Fanyi University is located in Xi'an, Shaanxi Province, western China, covering eight disciplines: literature, economics, management, engineering, art, law, education, and medicine. The School of Nursing and Rehabilitation is one of the key secondary colleges of the university with a nursing department, rehabilitation treatment department, basic medical teaching center, and medical skills training center. More than 600 graduates have been trained, with 1,335 students. Among them, 1,133 were undergraduates. The training of nursing personnel adheres to the orientation of post competence, strengthening students' awareness of nursing service, cultivating students' clinical thinking and the ability to solve practical problems in different clinical scenarios, and focusing on cultivating high-quality medical technical and technical personnel. Through establishing the Nursing Virtual Simulation Experiment Center, the combination of virtual and real and the opening of the laboratory, students constantly practice their various nursing skills in their spare time at any time at the school hospital for internship, laying a solid foundation for entering the clinical practice. This platform has multidisciplinary clinical practice content, such as basic medicine, pharmacology, nursing skills training, and so on. During the use period, only a stable network, mobile, PC, and tablet terminals are needed to log on to this platform, which highly improves the participation of students. The platform has complete management functions, which can release various teaching activities and assign homework, after-class quizzes, courseware interaction, supervised learning, and a bilingual system in Chinese and

English. The background can also record each learning progress, score statistics, generate each experiment report, and thoroughly record the operation to facilitate students to check the omissions and fill the gaps. As shown in Figure 1, nursing students studied nasal feeding in a nursing virtual simulation experiment center.

According to the research, the development of virtual simulation in nursing from the hot keywords, namely virtual reality, simulation, and nursing education, in the past decade to the emerging keywords, namely virtual reality, knowledge, and simulation, represents the research hotspot after virtual simulation. Citation maximum clustering results include virtual simulation, virtual learning, and clinical skills. This means that various clinical virtual simulation systems suitable for nurse training are under development and will continue to be a research trend (Zhao et al., 2022). Clinical virtual simulation involves a virtual environment where students can engage in the immersive self-regulated learning of clinical nursing practices. Such simulations can provide nursing students with a safe, dynamic, and enjoyable learning environment and hospital experience through their computers (Tinôco et al., 2021). Clinical virtual simulation can also provide students with a holistic learning experience and completely immerse them in emotional scenes to improve their practical skills (Wang et al., 2015; Plotzky et al., 2021). Some studies added practical teaching content based on virtual experiments to certain open online courses (Waldrop, 2013). Through clinical virtual simulation, students can closely combine theoretical knowledge with clinical practice, reduce clinical practice time, and save laboratory resource costs. Clinical virtual simulation is extensively employed in anesthesia care, maternal and infant care, fundamental nursing, and other clinical practices; it is also widely used by nursing undergraduates,

postgraduates, and registered nurses (Li et al., 2017). Previous studies demonstrated the effectiveness of clinical virtual simulation in improving the skills, cognition, and emotions of nursing students and reported that simulation teaching is more effective than traditional teaching in developing nursing abilities (Nascimento et al., 2020; Shorey & Ng, 2021; Kuruca & Dinc, 2022).

Owing to COVID-19, teachers are forced to switch to online teaching even without adequate preparation and design to ensure routine delivery of lessons. Online nursing education requires more systematic and thoughtful teaching approaches as soon as possible (Morin, 2020). Owing to the particularity of the nursing profession, the clinical skills requirements for students are stringent. Online learning can only solve the theoretical nursing knowledge, and students' clinical skills can not be carried out effectively. The clinical skills laboratories are an essential part of the clinical skill preparation of nursing students (Wellard & Heggen, 2010). Clinical skills laboratories (CSL) management requires a lot of staff, and experimental materials and experimental apparatus also have strict requirements. The rules and regulations of the laboratory are complex. Clinical Virtual Simulation (CVS) is a relatively new teaching approach that has improved student learning outcomes in nursing education. Clinical virtual simulation in the field of nursing education in China is in the initial stage. Thus, future research is necessary to validate the effectiveness of clinical virtual simulation in various aspects (Wang et al., 2020).

Figure1.1 Clinical Virtual Simulation-Nasal Feeding

1.3 Problem Statement

Fundamental nursing courses have many clinical practice tasks, such as catheterization, nasal feeding, and so on. Nursing students will master clinical skills by learning theoretical knowledge and repeatedly practicing the skills. In the traditional teaching mode, the teacher demonstrates the clinical practice skills, followed by students practicing the skills many times. Owing to the limited teaching time and experimental site, the frequency of students' practicing is limited. It takes a long time for students to master each clinical skill. Students who learn in an environment with no opportunities for directly participating in actual training may have poor knowledge retention (Kawasaki et al., 2022). Improvement of knowledge retention and self-directed learning has been proven effective in nursing education (Lee et al., 2020). Using CVS can grant students a deeper learning experience more conducive to the

mastery of training knowledge (Wang et al., 2020). CVS not only gives unlimited practice time and no specific location to do the practice, but students can master the theoretical knowledge and clinical skills more firmly and easily within a short period.

With the rapid application of virtual simulation in the field of nursing education, many studies and literature on the use effect of virtual simulation have been published. According to the results of this study, foreign research on virtual simulation started earlier and has a wide range. Based on the number of foreign publications, the United States has the largest number of articles, followed by Australia (Zhu & He, 2023). The top 10 universities that published the most articles on virtual simulations from 2012 to 2021 were from the United States and Canada. China started virtual simulation research late, and the number of articles was small before 2016. Since 2018, the number of publications has increased significantly, which is also related to the policies issued by the Ministry of Education of China; the latter strongly encourages Chinese universities to explore virtual simulation templates (Wu, 2018). The COVID-19 outbreak 2019 has also accelerated the application and research of online virtual simulation. However, some studies analyze the current situation of virtual simulation through bibliometric analysis and suggest that most of the published literature lacks international cooperation (Cant et al., 2022). The foreign literature has several contents in emotion, communication, psychological nursing, and other nursing humanities contents, but a lack of in-depth longitudinal research exists on knowledge retention time (Foronda et al., 2020). CVS has been widely used in medical universities and hospitals in China. However, other Chinese research directions have evaluated the effectiveness and learning satisfaction after using CVS, which remains in the preliminary exploration

stage. More comprehensive and systematic studies are needed in knowledge retention and specific nursing humanities content.This is the first time Xi'an Fanyi University has imported the clinical virtual simulation project, and one of the nasal feeding projects was selected to test the effect of CVS in three aspects: knowledge retention, self-directed learning ability, and learning effect.

1.4 Research Questions

1. Are there significant differences in knowledge retention (immediate, two weeks, & one month) between traditional teaching methods and the combination of traditional and CVS teaching methods among nursing students at Xi'an Fanyi University?
2. Are there significant differences in self-directed learning ability between traditional teaching methods and the combination of traditional and CVS teaching methods among nursing students in Xi'an Fanyi University?
3. What are the learning effects of using CVS among nursing students at Xi'an Fanyi University?

1.5 Research Objectives

This study aimed to determine the effect of CVS in nursing education regarding knowledge retention, self-directed learning ability, and learning effect among nursing students at Xi'an Fanyi University.

1.5.1 Specific Objectives

i. To compare the knowledge retention time (immediate, two weeks, & one month) of the traditional teaching method and the combination of traditional and CVS teaching methods among nursing students at Xi'an FanYi University.

ii. To compare the self-directed learning ability of nursing students at Xi'an FanYi University with the traditional teaching method and the combination of traditional and CVS teaching methods.

iii. To determine student learning effects using CVS teaching methods among nursing students at Xi'an FanYi University.

1.6 Research Hypotheses

1. There are significant differences in knowledge retention (immediate, two weeks, & one month) between the traditional teaching method and the combination of traditional and CVS teaching methods among nursing students at Xi'an Fanyi University.

   H_0 = There are no significant differences in knowledge retention between the traditional teaching method and the combination of traditional and CVS teaching methods among nursing students at Xi'an Fanyi University.

2. There are significant differences in the self-directed learning ability between the traditional teaching method and the combination of traditional and CVS teaching methods among nursing students at Xi'an Fanyi University.

   H_0 = There are no significant differences in the self-directed learning ability between traditional teaching methods and the combination of traditional and CVS teaching methods among nursing students at Xi'an Fanyi University.

1.7 Significance of Study

In the international arena, extensive research has been conducted on CVS in the field of nursing education. As the next generation of nursing professionals, Generation Z has become the main force, and with the rapid development and application of virtual simulation, the educational effectiveness of Generation Z nursing students using CVS has drawn attention from education scholars. This study selected nursing students as the study scope. Currently, enrolled nursing students are Post-Millennials (1995 – 2010), also known as Generation Z, as they may have access to smartphones and the Internet from birth, which can directly impact their educational style (Iberdrola., 2020). With the development of the times, generations have become increasingly dependent on smartphones, and Generation Z was different from their previous Generation Y, where the Internet completely swept through their education, life, and social intercourse. This situation led them to spend more time on electronics and the Internet than any previous generation. This phenomenon also enriches the way they acquire medical knowledge. Just using a smartphone is like owning a library that you can browse through with unlimited textbooks. Due to the bombardment of information in their life, they hope to maximize their time and resources to obtain customized learning experiences and feedback. Generation Z also prefers an independent practical experience with their desire to be flexible in education. Teaching Generation Z's nursing students also needs to adopt the cultivation method of involving participatory, active learning methods, and web-based simulation teaching will also be suitable (Eckleberry et al., 2018; Elenga & Krishnaswamy, 2022). In CVS, as one of the methods for online practical teaching in nursing, examining its teaching effectiveness contributes to refining relevant theories

related to the practical teaching effects of virtual simulation, thus enhancing the understanding of CVS among nursing education scholars. Furthermore, it involves a multifaceted analysis of issues within the CVS application and proposing corresponding improvement measures to enhance teaching effectiveness, reduce laboratory manpower and material costs, and promote the application of online practical teaching in nursing. This study will explore the effect of CVS on knowledge retention, self-directed learning ability, and learning effect. This study's findings may be useful for future studies and facilitate the application of CVS in nursing education.

1.8 Definition of Terms

1.8.1 Clinical Virtual Simulation

CVS is a virtual environment that provides immersive self-regulated learning of clinical nursing practice. The nursing student will have a safe, dynamic, and enjoyable learning ambiance as a real-hospital experience with a computer screen（Jéssica et al., 2021). Nursing students operate it by using a computer to gain access to training clinical nursing programs.

1.8.2 Knowledge Retention

Knowledge refers to the body of truths or facts accumulated over time, the cumulated sum of information, its volume and nature in any civilization, period, or country. Retention refers to the persistence to perform a learned behavior (facts or experiences) after an interval in which no performance or practice of the behavior has occurred. This study refers to the knowledge learned after using the CVS, which was

stored and measured using the test containing ten questions at three-time points: immediately, two weeks, and one month after the CVS is used.

1.8.3 Self-directed Learning Ability

Self-directed learning refers to the process in which individuals take the initiative in diagnosing their learning needs, formulating learning goals, identifying resources for learning, choosing and implementing learning strategies, and evaluating learning outcomes (Knowles, 1975). This study refers to an assessment of the self-directed learning ability among nursing students after using CVS. This study uses the self-rating scale of the self-directed learning ability (SRSSDL) questionnaire to measure self-directed learning ability.

1.8.4 Learning Effect

Learning refers to a relatively permanent change in behavior resulting from past experience or practice. The concept includes the acquisition of knowledge. Effect refers to a change that somebody or something causes in somebody or something else; a result (EFFECT|definition—Oxford Advanced Learner's Dictionary, 2023). This study refers to an evaluation of the learning process after using CVS.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review in research is a method used to share the results of other studies in the same field of a study done (Creswell, 2003). This study searched the literature through electronic database search primarily through Pubmed, Web of Science, EMBASE, the Cochrane Library, and CINAHL. The keywords for searching relevant articles were clinical virtual simulation, virtual reality, knowledge retention, self-directed learning, and learning effect. No limitation exists in the publication date. This review intended to provide a comprehensive narrative synthesis of previously published information related to relevant concepts of CVS. This chapter summarizes the history of simulation and its development in medicine, the application of virtual simulation at home and abroad, the large-scale application of CVS during the COVID-19 epidemic period, and the current research status of the effect of CVS in nursing teaching. The last chapter presents the study's chosen theoretical and conceptual framework.

2.2 History of Simulation in Medical Education

The long history of simulation can be traced back to aviation and military applications. The flight simulator was first used in its simulated form in 1920. Simulated war games were also developed initially on large computer systems designed for military applications (Aebersold, 2016). When pioneer David Gaba applied aviation crew resource management to anesthesia courses, simulation was used for the first time in medical education. Simulation is widely used in nursing education, from standardized

patient to Resusci Annie and computer-based (Rosen, 2008). In 1975, Shannon defined simulation as designing a model of a real system and experimenting with the behavior to understand the system or evaluate the various strategies that make the system work (Ingalls, 2011). During inclement weather, simulators emerged to address safety concerns for pilots and crew. Similar to nursing education, nursing students use virtual simulations to meet patient safety needs.

2.3 Simulation-Based Learning

With the rapid spread of computers and mobile phones, a variety of new teaching methods have emerged in nursing education, such as Podcasts (Wang et al., 2023) and Simulation-based mock codes (Andreatta et al., 2011). Telehealth has been suggested to be an important part of future clinical practice (Wijesooriya et al., 2020). Computer-based programs translate what students have learned into positive experiences in the simulation laboratory (Donovan et al., 2018). Simulation-based learning (SBL) has become an established teaching method for teaching clinical nursing skills (Sundler et al., 2015). SBL is a framework of system constructivism with a learner-centred and problem-oriented learning environment to participate in the learning process and develop an understanding of reality (Kriz, 2010). The most common guiding theories in SBL are Kolb's Experiential Learning Theory (ELT) and the NLN/Jefferies Simulation Theory (Aebersold, 2016). The current standard SBL method is high-fidelity simulation (HFS) (Hanshaw & Dickerson, 2020; Lei et al., 2022) and virtual-reality simulation (VRS). HFS provides learners with a high level of interactive and realistic experience by using full-scale computerized patient simulators (Hanshaw & Dickerson, 2020).

VRS means that in a 3D computer environment, the user interacts with the virtual environment by using an avatar without the effect of real life (Tamilselvan et al., 2023). The main types of VRS are desktop virtual simulation and immersive VR. Desktop virtual simulation involves interacting with the virtual world using computing devices such as a monitor, mouse, and touchpad. Immersive VR uses sensory devices, such as a head-mounted display, to provide auditory and visual stimulation during an immersive VR experience (Choi et al., 2016). While using the desktop virtual simulation, the physical discomfort, such as dizziness, is reduced in immersive VR, which provides an interesting and immersive learning experience (Birbara et al., 2020). Desktop virtual simulation is as effective as face-to-face simulation (Liaw et al., 2023). Studies have shown that the effect of using desktop virtual simulation is location-independent and that use at home is just as effective as in class (Makransky et al., 2019).

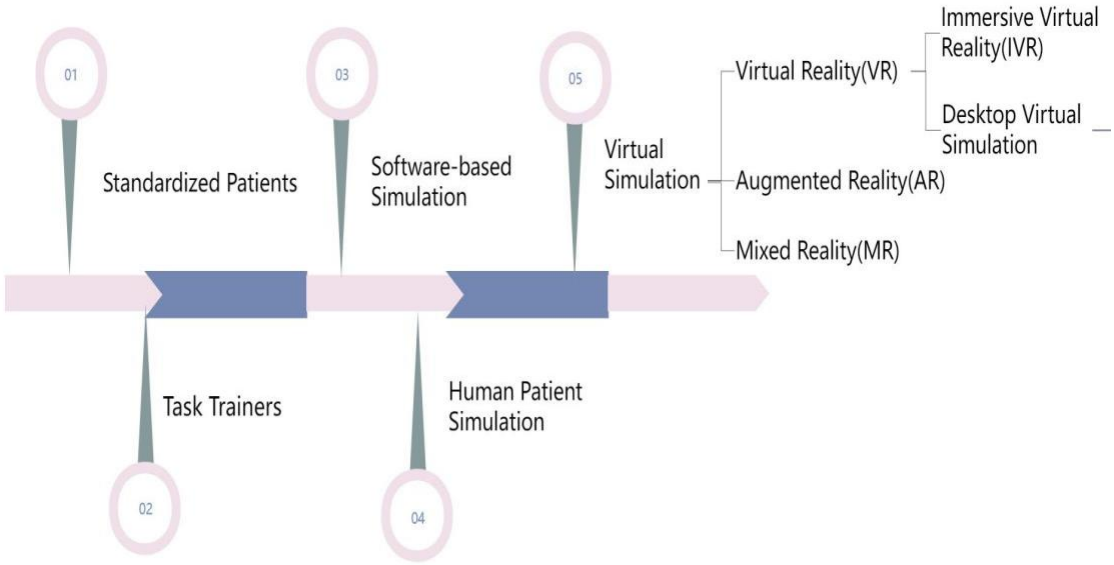

Figure 2.1: The Historical Development of the Simulation

2.4 Application of Virtual Reality Simulation in China and Abroad

2.4.1 Application of Virtual Reality Simulation Abroad

The concept of the Metaverse presented indicates the arrival of the era of digital experience, which refers to digital media such as smartphones and the internet digital earth as the new world. It has now been applied to various industries, especially digital healthcare, and can improve healthcare professionals' ability to provide care and interact with patients (Kim et al., 2023). The education industry provides a new model of social space, a higher degree of freedom of creation and sharing, new experiences, and high immersion. Nurses can be trained anywhere with Internet connectivity through the use of Metaverse. Even with geographical or economic constraints, the latter makes it easier for nurses in poor communities to obtain standardized and consistent training with nurses in highly urbanized or affluent areas. Metaverse allows nursing students to focus on individual needs by providing customized simulations. The integrated education approach of Metaverse and ChatGPT can provide nursing students with a more immersive and productive learning experience (Sharma & Sharma, 2023). Some shortcomings, such as privacy problems, persist due to collecting and processing personal information, identity confusion for students, and not adapting to the real world. The metaverse universe is divided into four categories: augmented reality (AR), lifelogging, mirror world, and virtual reality (VR). The most diverse and actively used technology in education is VR. It is based on interaction activities between avatars that reflect the user’s ego to build a virtual world with digital data (Kye et al., 2021). Common VR use cases abound.

For example, the Roblox remote education tool was launched in 2006; students use an avatar to make their own VR games or participate in various creative experiences. Zepeto, launched in 2018, is also a representative universe platform in South Korea, creating 3D avatars, communicating with other users, and educating role-playing through multiple maps (Kye et al., 2021). The University of Colorado opens a virtual lab called Physics Education Technology (PhET) interactive simulations. It creates a game-like virtual environment that can simulate real-life scenarios, which students can access online, download, and save. Based on its highly interactive, animated, and easy-to-use characteristics, it is widely used in physics teaching to help students obtain a deeper understanding of physics concepts (Banda & Nzabahimana, 2023).

Virtual reality simulation (VRS) is widely used in nursing education. Many countries have reported the application effect analysis of VRS in nursing education. For example, Second Life, an online, highly interactive, multi-user virtual environment, was launched in 2003, and tens of millions of people are registered as members. Millions of people worldwide meet and interact here. By entering the virtual world of "islands" maintained by hundreds of universities, users can navigate to designated islands, view information and videos, and visit virtual copies of real-world medical facilities. Users can experience simulated physical examinations and medical interventions, interact with virtual patients, and participate in simulated exercises. Second Life allows teachers and students to interact in virtual classrooms and lecture halls when used in distance learning programs. The results of established Second Life programs suggest that most results were positive regarding learning goals. It effectively promotes teamwork and allows them to test treatments without realistic consequences. Nursing students found

Second Life more conducive to exploring conflict than traditional classes and were interested in attending continuing education and lectures in the virtual world (Benham-Hutchins & Lall, 2015). The University of Minnesota School of Nursing collaborates with companies to develop web-based interactive games that allow nursing students to participate in real-life scenarios and improve their practical skills (Wang et al., 2015). Practical skills are learned through experience; now, researchers are working on how to learn practical skills through the Internet. Stanford University, Harvard University, Milton Keynes Open University, and other universities have added practical teaching content based on virtual experiments to the massive open online courses (MOOC), such as based on the virtual world and education game software personalized autonomous experiment (Waldrop, 2013).

2.4.2 Application of Virtual Reality Simulation in China

In 2013, China launched the construction of a national virtual simulation experimental teaching center (Li et al., 2013). By 2015, 200 national virtual simulation experimental teaching centers had been established, among which 25 were medical disciplines, accounting for 12.5% (Zu et al., 2015). In 2021, a total of 1,500 courses will have been certified as national first-class courses in virtual simulation experiment teaching; additionally, 191 courses are in Agriculture, forestry, and medicine, accounting for 26.24%, among which seven courses are in nursing. Among these courses, medical universities accounted for 12.50%. Medical universities hold a positive attitude toward virtual simulation experiment teaching and strive to solve the problems and deficiencies of traditional teaching through virtual simulation experiment teaching. The selected projects' top five provinces are Jiangsu, Beijing, Guangdong, Shaanxi, and

Hubei. Shaanxi Province ranks fourth regarding the number of recognized projects in China. The other four provinces are in southern and eastern China, and only Shaanxi Province is in western China. It is also related to the large number of universities and higher education ability in Shaanxi Province, which can further assist the construction and application of virtual simulation in teaching (Su et al., 2023). Especially during the COVID-19 epidemic, Chinese universities have shared thousands of virtual simulation experiment projects online to ensure the normal development of experimental teaching (Yang et al., 2020).

Chengdu Medical College takes MOOC as the platform and school-enterprise cooperation as the basis; it established a medical virtual simulation laboratory, where the clinical simulation laboratory primarily focuses on skill training and video demonstration, which can carry out more than 30 experimental projects (Huang., 2014). Fenyang College of Shanxi Medical University and a scientific and technical corporation joint research and development of a virtual simulation teaching system using a 3D simulation learning system through embedded animation to enable the entire rich system content to realize the real 3D interaction scene. The fundamental nursing course adopted the traditional teaching mode and took the virtual simulation training as an auxiliary means of experimental teaching to promote the change in teaching mode (Li et al., 2017).

2.5 Introduction of the Clinical Virtual Simulation

The Lopreiato research group created the Healthcare Simulation Dictionary in 2013, which became an important reference for simulation terminology. The creation of

the dictionary helped the communication of healthcare simulation researchers in teaching, education, research, and other activities. In this dictionary, the definition of simulation is proposed as follows: a simulation involving real people operating simulated systems. Virtual simulations may include surgical simulators used for on-screen procedural training and are usually integrated with haptic device (s) (Foronda et al., 2020). CVS is an innovative teaching and learning technology strategy to provide immersive nursing practice self-adjustment learning in a virtual environment, reproduce the real-life experience in a safe, interactive, real-time feedback way, and have a dynamic and fun learning atmosphere. CVS is a kind of virtual simulation and tends to prefer the teaching of clinical practice. Although VRS is now widely used, the equipment required to operate desktop CVS is more straightforward and cheaper than that of immersive VR and can be used on a large scale without limiting the number of users and location (Bueckle et al., 2021). Therefore, desktop CVS is used in this research.

Virtual simulations can assess students' clinical competency and support nursing students' learning in medical courses (Coyne et al., 2021). Combining case demonstration and CVS can highly improve the clinical teaching effect of nursing undergraduates (Ge et al., 2021). The clinical practice of checking whether CVS can replace the number of choices is also proposed (Foronda et al., 2020). In a randomised experimental study, SBL is more effective than traditional teaching strategies in developing nursing capacity, highlighting statistically significant results in improved cognitive and psychomotor skills, decreased stress levels, and increased confidence (Nascimento et al., 2020). Many researchers have also proposed a research direction

that compares the learning results of virtual simulation with traditional teaching. Exploring whether measuring virtual simulation knowledge is transferred to nursing clinical practice for the wide application of CVS is also important (Foronda et al., 2020).

CVS uses virtual, augmented, mixed, and screen-based platforms to provide clinical skills simulation and training. Implementing CVS involves the following several steps: selecting the appropriate hardware and software (depending on VR, AR, MR, or screen-based platform), designing a virtual environment, and creating an interactive experience in that environment (Umoren & Schmolzer, 2023). An example is the CVS of nasogastric tube; the patient in the hospital cannot eat normally due to the disease and may choose enteral nutrition to supplement the patient's daily diet. Enteral nutrition is nutritional support given via the alimentary canal or any route connected to the gastrointestinal system (i.e., the enteral route), including oral, sip, and tube feeding using nasogastric, gastrostomy, and nasogastric jejunostomy. The most common modality is the nasogastric tube.

Nasogastric tube feeding is the insertion of a tube into the stomach, intestines, or other portions of the gastrointestinal tract to allow for the passage of food products, medications, and gastric emptying. The duration of the nasogastric tube ranged from several days to three weeks (Judd, 2020). In blind placement, the tube enters from the nose, passes through the throat and oesophagus, and reaches the stomach. The pharynx is the esophagus and trachea's starting point, where the nurse is at risk of inserting the wrong position. Studies have shown that 2% of patients have misplaced nasogastric tubes in the respiratory tract, causing severe pneumothorax consequences and even death (Sparks et al., 2011). This technology has high requirements for nurses, and

nursing students must be proficient. In traditional teaching, nursing students can only practice on the simulation person but cannot see the internal situation of tube placement. Using clinical virtual simulation, students can intuitively see the anatomical diagram of the tube using animated simulation patients.

2.6 Clinical Virtual Simulation Effect to Knowledge Retention

The knowledge learned by medical students is divided into conceptual and procedural knowledge. Conceptual knowledge refers to medical theoretical knowledge, while procedural knowledge refers to the medical practice series. This part can be learned through repeated practice and simulation (Augustin, 2014; Schmidmaier et al., 2013). Hermann Ebbinghaus's study shows that the new facts we acquire tend to be forgotten over time if we learn them only once. The forgetting process follows the forgetting curve (Ebbinghaus, 1885). Retention of knowledge in nursing studies decreases over time, which affects subsequent practice, as shown by studies of various processes in human anatomy and drug dosage calculation (Narnaware & Neumeier, 2020; Tabassum & Ahmed, 2021). Several studies have attempted different strategies by changing the sequence of LBL-PBL-clinical practicum (Lin et al., 2022), flipped classroom through near-peer education (Golaki et al., 2022), game-based learning (Tavares, 2022), and interpolation problems in the podcast (Weinstock et al., 2020) to improve knowledge retention.

VRS can also improve knowledge retention (Rourke, 2020). Adding simulation training before beginning clinical rotations can improve student knowledge acquisition and retention (Cecilio-Fernandes et al., 2019). A student-centered approach to active

learning improves knowledge retention, especially for post-millennial students (Toohey et al., 2016). The knowledge retention period is up to 12 months through e-learning and at least four months through the use of the VR simulator (Snyder et al., 2010; Taha et al., 2018). With time, CVS has also reported the length of knowledge retention. Studies show that CVS improves knowledge retention over time (2 months) and improves students' knowledge retention and clinical reasoning ability by 20.4%（Padilha et al., 2019). This article on measurement of knowledge retention is limited to immediate and 2.5 months after the intervention, and CVS provides a more promising approach than traditional human model-based practice (Liaw et al., 2014). The research direction should focus more on helping nursing students retain their knowledge (Tamilselvan et al., 2023). This study also proposes a longitudinal study of the learning retention generated by CVS to improve the scientific level of virtual clinical practice (Foronda et al., 2020). In light of these promising results, the researcher would evaluate the effect of knowledge retention with a prospective research method.

2.7 Clinical Virtual Simulation Effect to Self-directed Learning Ability

In 1975, Dewey first proposed that the teacher should act as a facilitator and instructor of learning and defined self-directed learning as which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes (Knowles, 1975). Self-directed learning is closely related to active experimentation (Svein, 2020). Self-directed learning ability is very important for improving knowledge and skills and is also an important part of lifelong learning in

career development (Wong et al., 2021). Studies have shown that gamification can improve students' self-learning abilities (Gutierrez-Puertas et al., 2021). CVS combined with network teaching can improve nursing students' independent learning ability (Liu et al., 2019). A portion of the research also supports using CVS as a complementary tool to help nursing students master key steps in clinical practice (Pamela et al., 2015). The research believes that CVS can effectively break through the difficulties in practice skills, teaching in practice ability, and clinical thinking and strain ability through the teaching method of clinical scene simulation and immersive simulation technology scenario.

2.8 Clinical Virtual Simulation Effect toward Learning Effect

Various teaching modes can affect students' learning process. In nursing education, many teaching methods, such as PBL and CBL, have been proven effective and satisfactory and have increased learning ability (Cen et al., 2021; Trullas et al., 2022). Game elements will strengthen students' learning attitudes and behavior, positively impacting learning outcomes (van et al., 2021). The operation mode of the game in the clinical virtual simulation also increases the interest in learning and students' immersion and shortens the process of theory to practice and classroom to clinical practice. Students have a good learning effect and high satisfaction (Meng et al., 2020). Studies have shown that SBL can increase nursing students' confidence, improve learning satisfaction and decision-making ability in clinical settings, and reduce anxiety (Mulyadi et al., 2021; Oliveira et al., 2022). Some studies have shown that SBL can improve cooperation ability and interest in learning, but the difference is insignificant

between nursing students in developing self-confidence, critical thinking, satisfaction, and traditional teaching methods (Li et al., 2022). SBL is effective in nursing education, particularly in the psychomotor domain (Kim et al., 2016). CVS can improve students' learning satisfaction (Padilha et al., 2019). In nursing practice, the morals and ethics of students are also the focus of cultivation, and this aspect must also be considered in the simulation process (Honkavuo, 2021). However, network problems, power outages, technical difficulties, and other situations also cause students to have a negative attitude toward the E-learning mode (Gullu et al., 2022). The mildly positive attitudes toward e-learning also reduced technology addiction among nursing students (Guven & Sonmez, 2021). The satisfaction of medical students with E-learning is also inconsistent in different regions, with satisfaction being significantly higher in developed countries than in developing countries (Abbasi et al., 2020). The greatest barriers to using e-learning occurred in the first year of nursing undergraduate; with increasing age, the lowest barriers occurred in the fourth year (Diab et al., 2020).

2.9 Theoretical and Conceptual Framework

2.9.1 Theoretical Framework

This study adopts NLN Jeffries Simulation Theory as the theoretical framework, which consists of the following seven elements: context, background, design, simulation experience, educational strategies, participants, and outcomes (Adamson, 2015; Jeffries et al., 2015). The theory was initially constructed as a simulation model for nursing education. However, with recent amendments based on an in-depth literature review and reorganization, the framework was published as a mid-range