The future of virtual reality in simulation training for nurses at workplaces

A literature review

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Abstract:

Today, there is an acute shortage of competent nurses around the world. As technology advances at a rapid pace, virtual reality (VR) has entered the market to train nurses both in schools and in the workplace. This thesis focused on virtual reality-based simulations for nurses at the workplace and was carried out as a literature review. Three research questions were set: What are the advantages and disadvantages of VR simulations for nurses at workplaces, and what does the future look like ten years from now? The material was collected using Arcada Libguides databases and Google Scholar from 2009-2020. Fifteen studies were finally selected for the literature review that dealt with nonimmersive virtual reality, i.e., a virtual reality created without a head-mounted set, as well as virtual reality made with a headset. Patricia Benner's From Novice to Expert theory and Kurt Squire's Designed Experience theory were used as the theoretical framework for the literature review.

Based on the results of the literature review, it became clear that VR simulations are an effective way to teach nurses new skills, as well as retaining them. One of the best aspects of VR simulations is the realistic environment that combines hands-on skills and knowledge. Many nurses find it fun and enhancing learner autonomy. VR hardware also comes cheaper in the long run than traditional simulation and is easy to access. However, VR simulations can cause motion sickness and nausea to the user. One of its major disadvantages is also that it storages large amounts of data, and it needs constant upgrading. A single VR device is also expensive.
In the future, VR simulations for nurses at workplaces are expected to increase and will be used, for example, on standard testing of the staff. Advances in technology make it possible to create avatars in the system so that the whole multi-professional team could participate in the simulation together. Verbal interaction between individuals within the simulation is also thought to be possible in the near future. VR hardware is also thought to become cheaper as its use becomes more widespread, and new products enter the market.

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CONTENTS

Figures

Tables

FOREWORD

We would like to thank our supervising teacher Heikki Paakkonen for good advices and support. We would like also to thank our classmate Sampo Sorvisto who helped us to access some of the articles used in this thesis.

1 INTRODUCTION

The concept of virtual reality, or "immersive reality" (VR), refers to a computer-created artificial world that completely obscures the view of the real world (Zhu, E., Hadadgar, A., Masiello, I. & Zary, N. 2014, 3). This world can also be created artificially, for example, with a smartphone. The use of virtual reality requires virtual reality glasses specifically designed for its use. These can also be called frames or eyelets. The wearer of the glasses moves in a virtual environment and controls objects with hand-held motion controls. This gives the user the feeling that he is genuinely interacting with the virtual environment. (Pelargos et al. 2017, 2.)

In addition to virtual reality, it is essential to be aware of the concepts of augmented reality (AR), mixed reality (MR), and a combination of these, extended reality (XR). The term "augmented reality" (AR) refers to a technique in which different sensations are added to a real scene with the help of a computer. More commonly, an image produced using a computer or smartphone is added to the actual view. (Tikka 2001, 3.) The concept of "mixed reality" (MR) refers to a picture of the real world into which three-dimensional characters and objects have been brought. These can be viewed and processed from different angles. In daylight, virtual objects in augmented reality are hologram-like transparent, whereas in combined reality they are stable. (Pelargos et al. 2017, 2.) "Extended reality" (XR) refers to a combination of all the above and is a kind of umbrella concept incorporating the concepts mentioned earlier.

There is an increased need for qualified nurses in the future, as the population ages. It is estimated that worldwide, the number of people over the age of 60 will double by 2050. At the same time, the education of nurses is taking place in an age of ever-accelerating technological development, and its promotion is essential in the future. Technological advances support integrated, safe, high-quality, knowledge-based, evidence-based care, and education. (Global strategic directions for strengthening nursing and midwifery 2016–2020, 2016) Here is where the virtual reality steps in. It is expected to increase in education exponentially over the next five years (VR in Education: How Virtual Reality Has Transformed School Teaching in 2019, 2019), and in health care market sector it is estimated to reach $30,40 billion worldwide by 2026 (Bajpai, 2020).

Virtual reality has been extensively studied from different perspectives in medical specialties. For example, in psychiatry, the effect of virtual reality has been investigated in the treatment of acrophobia, the fear of heights (Rothbaum et al. 1995). Based on the results, the researchers concluded that those exposed to virtual reality phobia were able to reduce their fear of height. Promising results have also been obtained using virtual reality in the treatment of traumatic stress disorder (Botella et al. 2015). Virtual reality has also been able to be applied in the training of various operational processes in the operating room. The approach was considered meaningful. (Kleven et al. 2014) Some research results show that virtual reality is not yet a very widely used method in healthcare. One reason may be the feeling of nausea caused by virtual reality, although it is little caused by current quality devices (Kleven et al. 2014).

In the future, further research is needed on the applicability and effectiveness of technologies in the teaching of various subjects.

2 BACKGROUND

2.1 What is virtual reality?

“Virtual reality (VR) is an artificial environment that’s immersive enough to convince you that you are actually inside it.” (Rubin, 2020) A photograph is an artificial environment, as well as a video game. “A video footage of the room you are sitting in right now could be an artificial environment, but it is not where you physically are.” (Rubin, 2020) At its simplest, VR content can be produced as a 3D model on a standard computer where headsets are not needed. This kind of virtual reality is called "nonimmersive" VR. It is already used in schools because of its ease of use. (Simpson, 2002)

“However, your senses can be manipulated so that you perceive the virtual world to behave the same way you perceive a real life.” (Rubin, 2020) In order to do that, two

illusions need to be maintained. The first is depth in the world, and the second is that a person can look and move anywhere wanted to within it, just as in real life. These illusions are achieved with an accelerometer/gyroscope combination, which is a motion sensor embedded in a VR headset. A VR headset is a head-mounted device that provides virtual reality for the user, through which the user experiences the sense of being PRESENT. For example, in illusive VR simulation, a person is standing in an operation theater; the person should be able to bend over the operating table, like in real life. Within turning the head, a person should see colleagues standing next to the patient, or even walk towards the surgeon to hand him a lancet. (Rubin, 2020)

The first VR (Virtual Reality) device was introduced publicly in 1950 by an inventor Morton Heilig. It was a little private movie theater that included smells and vibrating chairs beside the typical cinematic experience with sounds and images. Before that, VR was used in flight simulators to train pilots. Today VR is widely used everywhere, for example, in designing architecture or in education. (Virtual Reality Society, 2020)

2.2 Simulation based learning in nursing

For the past twenty years, nurses have been learning clinical skills and judgment through made-up cases, called simulations. Mannequins used in simulations have long roots starting from the 1960s when a physician Michael Gordon presented his invention, Harvey doll. It was able to simulate certain cardiac conditions for students. Nowadays, these kinds of high-tech mannequins are widely used in health care education, and they can demonstrate various diseases and conditions. Even some clinical skills can be practiced, for example, inserting an intravenous line. (Bauman, 2012.)

Simulations are usually organized in a dedicated simulation laboratory. The laboratory has tried to create, for example, a hospital-like or home-like environment, depending on what is being practiced and in which environment the learners are to be placed. The simulation scenario includes the goal, background information (e.g., patient information, and other information relevant to training) and a schedule where the simulation

should be performed with its final discussion. One of the essential parts in simulations is the final discussion, where the simulation is aggregated together. It contains a self-reflection where participants get to tell themselves which performance went well and what was missing. Often, the performance is also evaluated by the teacher. (Aebersold, 2018)

A successful simulation takes the participant to another reality, leaves a mark on the memory, and evokes emotions. It can be used to study, for example, three-dimensional perception, social interaction with different people, technical skills, and team leadership. It can be used to create implausible situations, for example, a skill essential to nurses; how to act in a situation of sudden violence. (Blomgren, 2015)

The goal of the simulations is that the application of the information learned from it is automatic when the real situation arises. When it manages to evoke emotions, especially a little stress, the learning situation is the best. Increasing self-confidence is one of the best aspects of simulation because when a person is self-confident, it enhances overall performance. (Blomgren, 2015)

2.3 Virtual reality in health care education

VR simulation is used already in healthcare education in some parts of the world. VR simulation is getting spread quickly due to its advantages over screen-based learning. According to Jack Pottle, VR provides a safe and enjoyable learning environment for learners. Besides, this allows the learners to make mistakes and learn without putting a patient's life in danger. From an institutional standpoint, repetition and cost of VR, are what attracts them to this new technology. Many studies have been done on the cost-effectiveness of VR. (Pottle, 2019)

Like every technological invention, VR will continue to expand. Many institutions believe in the future; VR will allow them to make a benchmark to ensure clinical competency across healthcare systems for healthcare professionals. In addition, VR will let learners do scenarios even at home with a multiplayer option. The use of voice and hand control in VR is another possibility. The most exciting breakthrough will be the use of Artificial Intelligence in VR. The use of VR in the future is set to change our learning

experience beyond recognition. (Pottle, 2019) See the Figure 1 below for virtual reality in use.

Figure 1. Virtual reality in use. a) Nursing student wearing a virtual reality headset. b) Performing a cardiac examination on a virtual patient. c) Projecting a virtual reality experience on multiple screens for group learning. d) Pupil responses to light in a virtual patient. Pottle 2019.

At the Indiana university simulation center Columbus nursing students and nurses who already work in hospitals receive advanced training using different technology for example, using a high-fidelity mannequins and Virtual reality technology. VR was first introduced during 2018 at the university, the safe learning space experience has attracted users from the beginning. The ability to replicate real-life situations and subjects have promoted the nursing education at the university. (Indiana University, 2020)

According to the director of the game design program at the school, “At the highest level, virtual reality is about entering completely into a crafted space, a place made by humans. What the technology allows is for digital artwork and sound to replicate any type of 3D environment, then present that to your eyes and ears in an intimate way.” (Indiana University, 2020)

2.4 Virtual reality simulation training for nurses at workplaces

Many workplaces have clinical teachers who arrange training for the employees. Nurses can take a part to the education and polish their skills (for example in CPR training) as well as gain new information. This promotes life-long learning journey and is counted as in-service. Some bigger hospitals offer extra hours for employees that are struggling with skills. (Chang & Daly, 2012)

Virtual reality simulations help newly graduated nurses acquire their first skills on a safe environment with a virtual patient and allows healthcare professionals to sharpen their knowledge by practicing virtually. This helps them to be prepared to manage a patient when the situation arrives. By facing a situation, one learns to master skills which are not possible to learn during a traditional simulation, as the simulations might scare a newly graduated or a shy person in nature will not be productive. Virtual reality simulations can provide various types of scenarios with different characters as it is generated in a computer. The immersive effect gets the full attention of the user which makes the user productive. A simulation can be carried out with proper gears and a VR simulation platform for example MedicActiV is a virtual reality platform by SimforHealth, it is compatible with the HTC Vive, Samsung Gear VR and the Microsoft Hologens. (MedicActiV: Virtual simulation platform for the training of health professionals, 2020)

Figure 3. MedicActiV Virtual Reality simulation platform for healthcare professionals. SimforHealth 2018.

2.5 About this study

There are studies made about the VR simulations for nurses at workplaces. Previous studies have conducted in over 11 years and they have shown that due to better technology and network, VR has been taking its place as an educational tool in health care. This study will be focusing in the future of VR simulation training for nurses at workplaces and presents some VR simulations used there today. Current and future advantages of VR simulation training will be discussed as well as the barriers it faces.

3 THEORETICAL FRAMEWORK

In this study, Patricia Benner's From Novice to Expert theory was used as well as Kurt Squire's Designed Experience theory. Both theories are essential basis for describing and interpreting the phenomenon of virtual reality simulation training for nurses at workplaces.

Benner has studied expertise and clinical reasoning in nursing for more than 30 years. She was mostly interested in a question about what real practice in nursing is and how nurses are learning it. She believed that nurses are learning at work from past experiences they have faced and using those experiences in their clinical judgements. (Snowden, Donnell & Duffy, 2014) In the report of her inquiry called From Novice to Expert: Excellence and power in clinical nursing practice, Benner presented an idea about five levels of mastery in nursing. They are novice, advanced beginner, competent, proficient and expert. (Snowden, Donnell & Duffy, 2014) See the Figure 3. for further explanation of the mastery levels.

In the Designed Experience theory, Squire argues that teachers should have closer attention to video games. They are creating virtual simulations where learners can build their knowledge by "doing and being." It is troublesome for health care professionals to learn work-life dilemmas and cases by a traditional didactic model and be able to reflect it. Focusing on work-life related experiences was also what Benner wanted to disclose in her theory. Designed experience gives a learner a possibility to test their skills and knowledge in a safe environment where making mistakes is allowed. (Bauman, 2013; Squire, 2006)

Collective playing experience through serious games brings together team members, and it can be a powerful experience for individuals. Nurses can reflect the experience

together, not by break room conversation about individual experiences faced in working-life. (Bauman, 2013)

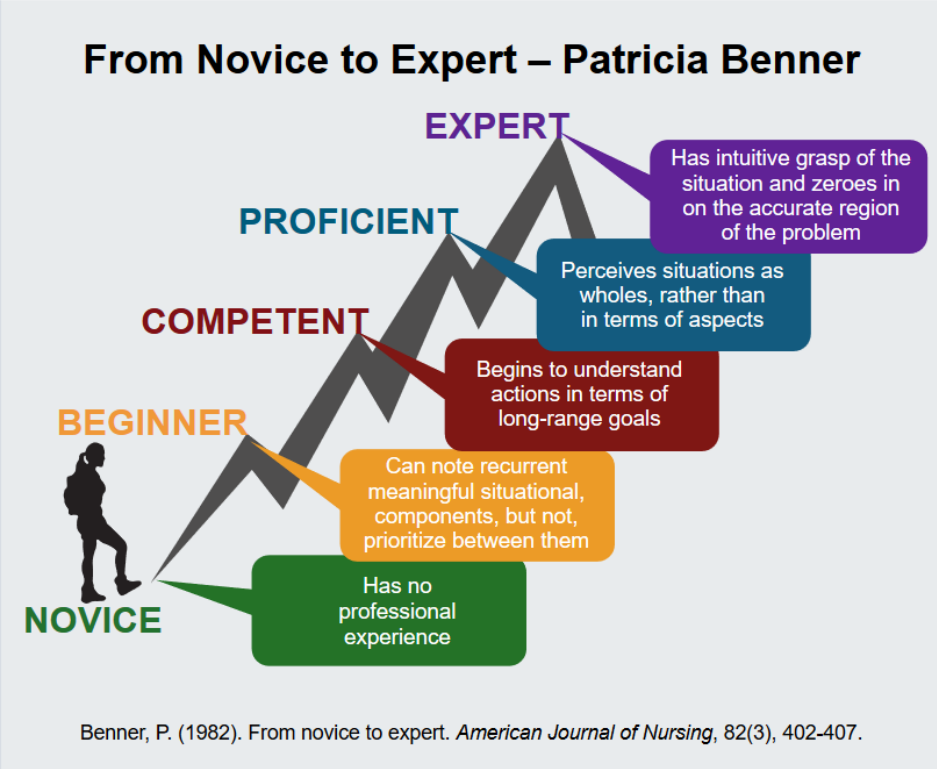

Figure 3. Benner's five stages of expertise. (Valderbilt University)

4 AIM AND RESEARCH QUESTIONS

The goal of the study is to determine, different types of VR simulation technology for nurses' education is used around the world and whether it is useful in training nurses at workplaces. The aim of the study is to review the literature regarding the future of virtual reality simulation training for nurses at workplaces by looking at in depth the current systems of virtual reality simulation trainings used in the field. Additionally, advantages and disadvantages are discussed.

The research questions of this study are:

- What are the advantages and disadvantages of virtual reality simulation training for nurses?
- What is the future of virtual reality simulation training for nurses at workplaces in 10 years?

5 METHODOLOGY

This study was conducted as a literature review and the method of analysis was inductive content analysis. The scientific articles were collected through Arcada's database search engines like PubMed, EBSCO and Sage. The data collection was conducted by setting guidelines on different criteria to answer the research questions. See the Table 1. for exclusion and inclusion criteria.

The search words for EBSCO "*Virtual reality* AND *nurses*" (n= 277), "*VR* AND *nursing education*" (n=262). For Sage the search words used were "*virtual reality* AND *nursing*" (n=4849). Search words "*virtual reality* AND *nursing education* AND *simulation*" (n=1179) and "*virtual reality* AND *nursing*" (n=331). were used for PubMed. The articles were selected by reading through the abstracts and the contents of the articles. See the Figure 4. for inclusion and exclusion criteria. Time frame which has been used during the search process was set for 11 years 2009 - 2020.

Additionally, the articles which have been chosen for this literature review are focused only VR simulation education on graduated nurses at their workplaces. Many articles dealt with the training of nursing students using VR simulation, those articles were excluded. To expand the literature review, studies that did not use VR glasses in simulation were included as well those that used. See the Table 2. for chosen studies.

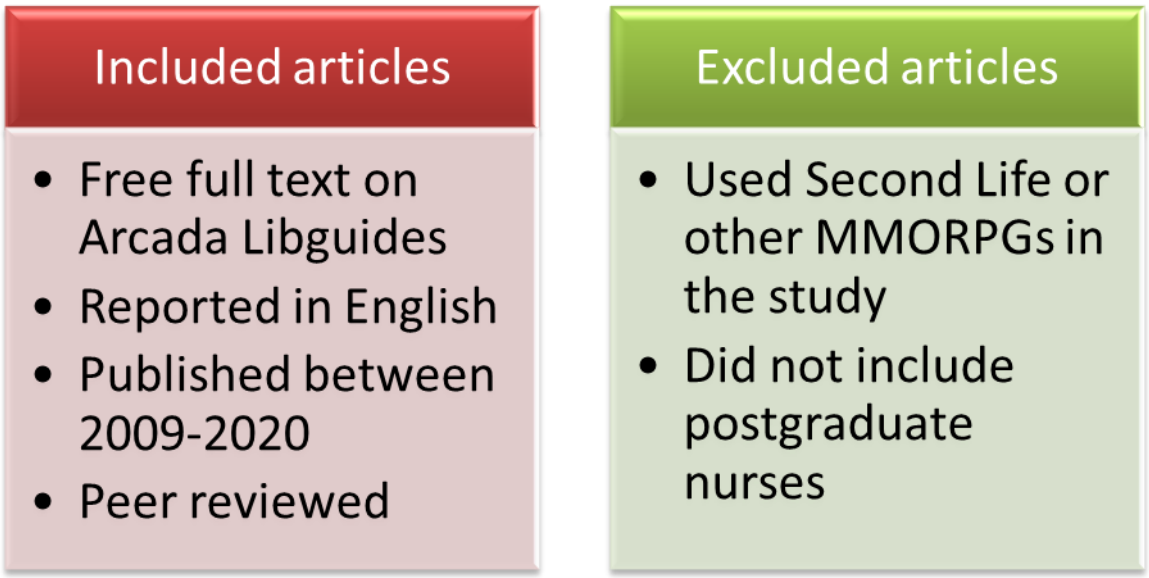

Figure 1 Inclusion and exclusion criteria

Table 1 Chosen articles

	Author(s)	Title	Journal (year, volume, pages)	Method	Sample	Results
1	Forsberg E. et al.	Clinical reasoning in nursing, a think-aloud study using virtual patients – A base for an innovative assessment	Nurse education Today 2014; 34 p. 538-542	Qualitative descriptive design. Think-aloud method.	30 registered nurses (10 from neonatal intensive care, 4 from ER, 8 from pediatric wards, 6 from health-care centers, and 2 from school health-care centers).	Virtual patients encourage to think systematically. It enhances clinical reasoning and decision making.
2	Ghoman S. et al.	Serious games, a game changer in teaching neonatal resuscitation? A review.	Arch Dis Child Fetal Neonatal Ed. 2020; 105, p.98-107.	Literature review	12 games (4 boardgames, 5 video games, 3 VR games)	Overall knowledge improved when playing any of the games.
3	Wong M. et al.	Clinical instructors' perceptions of virtual reality in health professionals' cardiopulmonary resuscitation education	SAGE Open Medicine 2018, Vol 6:1-8	Interpretative thematic analysis of interviews	30 CPR instructors were surveyed about their views of health professionals' CPR education and virtual reality for health professionals' CPR education, before and after interacting	Current CPR education is inadequate due resources and practice opportunities, according to inter-viewed instructors. VR enhances fidelity, engagement, resource conversation, and memory.

					with a CPR virtual reality simulation.	
4	Khan R. et al.	Virtual reality simulation training for health professions trainees in gastrointestinal endoscopy (Review)	Cochrane Database of Systematic Reviews 2018, Issue 8.	Literature review	-18 trials included (421 participants; 3817 endoscopic procedures). Randomized and quasi-randomized clinical trials analyzing VR endoscopy simulation training versus other endoscopy training methods.	VR simulation helped participants to complete procedures more independently and enhanced visualization of colon and oesophagus. No conclusive evidence compared to traditional patient based training or other methods.
5	Dorozhkin D. et al.	OR fire virtual training simulator: design and face validity	Surg Endosc-. 2017; 31(9): p. 3527–3533	Institutional review board approved study Questionnaire	Together 49 subjects (trainees, practicing surgeons, anesthesiologist and nurses)	VR OR fire simulator is an effective and useful training method according to result of questionnaire. 67% of the subjects chose the virtual reality OR fire simulator over traditional training model.
6	Gaggioli A. et al.	Experiential Virtual Scenarios with Real-Time Monitoring (Interreality) for the Management of Psychological Stress: A Block Randomized Controlled Trial	J Med Internet Res 2014. Vol. 16, issue. 7, p. 1	A block randomized controlled trial	121 participants (61 teachers and 60 nurses)	VR system reduced perceived stress remarkably and increased coping skills of a person.
7	Kyaw B. et al.	Virtual Reality for Health Professions Education: Systematic Review and Meta-Analysis by the Digital	J Med Internet Res 2019. Vol. 21, issue. 1, p. 1-13.	A systemic review and meta-analysis	31 studies (2407 participants who were all health care professionals or students)	VR improves marginally postintervention knowledge scores when compared with traditional learning or other types of learning, for

		Health Education Collaboration				example, online or offline digital education. VR improves cognitive skills compared to other learning methods.
8	Fleming M. et al.	Virtual Reality Skills Training for Health Care Professionals in Alcohol Screening and Brief Intervention	JABFM July–August 2009 Vol. 22, No. 4	A randomized controlled trial	102 health care professionals (10 physicians; 30 physician assistants or nurse practitioners; 36 medical students; 26 pharmacy, physician assistant, or nurse practitioner students)	Trial showed VR to be as follows: • Realistic • Fun and interactive • Refreshing and innovative • Improvement of alcohol screening skills
9	Baumann S. et al.	Using Simulation to Enhance Global Nursing	Nursing Science Quarterly 2018, Vol. 31(4) 374 – 378	Literature review	20 studies	VR invites nurses and student nurses to discern new patterns, take charge of their learning, and build multiple iterations to facilitate the processing of new and different information and "realities." Study found that VR and other technologies are allowing experienced practitioners in their home countries to provide training and capacity building in remote and resource-poor communities.
10	Bracq M-S., et al.	Learning procedural skills with a virtual reality simulator: An acceptability study	Nurse Education Today 79, 2019. p.153–160	Acceptability and usability study	The simulator training system was tested with a convenience sample of 16 non-expert users and 13 expert scrub nurses from the neurosurgery department of a French University Hospital	This VR simulator designed to teach surgical procedures can be widely used as a tool in initial or vocational training.

11	Howe J., et al.	Development of Virtual Simulations for Medical Team Training: An Evaluation of Key Features	Proceedings of the 2018 International Symposium on Human Factors and Ergonomics in Health Care. 7(1), p. 261-265	Narrative review	Review included 27 articles as relevant to elaborate on five key features identified as critical to development of virtual environments for MTT: automated assessment, task fidelity, interface modality, virtual teammates, and adaptability.	Helps compare individual and /or team performance and provides an opportunity to look at user´s behavior/activity pattern.
12	Choi K-S., et al.	A virtual reality-based simulator for learning nasogastric tube placement	Computers in Biology and Medicine, 2015. Vol. 57.p. 103-115	Quantitative study	A virtual reality-based training simulation system is proposed to facilitate the training of NGT placement.	It has been positively evaluated by nursing professionals, who have stated that the computer-generated forces are similar to those perceived in real NGT placements.
13	Javaid M. & Haleem A.	Virtual reality applications toward medical field	Clinical Epidemiology and Global Health, 2019. p. 1-6	Literature review-based analysis	81 articles in total used for the review.	VR is used effectively for better surgical technique. It creates detailed virtual models of a patient's anatomy. It helps physicians to effectively move around and view virtual 3D images from different angles.
14	Dubovsky S., et al.	A preliminary study of a novel emergency department nursing triage simulation for research applications	BMC Res Notes, 2017. 10(15), p. 1-12	Questionnaires and scales	Ten experienced female ED triage nurses (mean age 51)	Nurses perceived their work on the simulation task to be equivalent to their workload on the job in all aspects except for physical exertion. Consistent with the workplace, variability in performance during triage reflected subject skill and experience and was correlated with comfort with the task. Time to perform triage corresponded to the time required in the ED and virtual patients were prioritized appropriately according to severity.
15	Abelson J., et al.	Virtual operating room for	The American Journal of Surgery, 2015. Vol.	Pilot study	33 participants (OR team) carried out the simulation.	It is feasible to simulate the OR environment using VR and replicate a

		team training in surgery	210, No. 3, p. 585-590			standardized surgical crisis scenario.

5.1 Data analysis

Granheim & Lundmans`s (2004) qualitative approach is used to analyze 15 articles for this study. The authors used a qualitative approach. Below are the steps followed for the data analysis.

1. Firstly, the authors went through each article as a whole to get an impression of the data.
2. With the help of an inductive approach, the data was read repeatedly. The authors took relevant notes at the same time related to the research questions.
3. Notes and relevant data were highlighted in the reading process.
4. Then the notes were reduced and coded.
5. These codes were then combined to formulate categories.
6. Furthermore, the authors (NV and VAC) independently analyzed the data and compared and discussed the categorization together until an agreement was reached.

5.2 Ethical consideration

Good scientific practice should be cherished when producing scientific content. Honesty, diligence, and accuracy are maintained when conducting research. Ethical and criteria-based research, data acquisition and evaluation methods are preferred. Openness and accountability in the publication of scientific communications. The research done by others is respected by correctly referring to it. This gives the other person's study the respect and visibility it deserves. The necessary study permits will be obtained, and in some areas an initial ethical estimate will be made. Finally, the study reports and

mentions funding and other links in the study. This contributes to the transparency of research. (Tutkimuseettinen neuvottelukunta, 2012)

In a scientific inquiry, conducting ethically sounding research is one of the most important principles (Kjellström, Ross and Fridlund, 2010). Ethical considerations are essential in writing a dissertation, and it helps prevent fabrication, falsification, and plagiarism in a research study. (Tutkimuseettinen neuvottelukunta, 2012)

To protect the integrity of the research, the authors utilized the Thesis Guide of the Arcada University of Applied science while writing the thesis. By using the guidelines, the authors were able to avoid fabrication, falsification, and plagiarism. Therefore, the pieces of literature used here are referenced and cited according to the instructions. The authors used secure databases to collect the sources, which Arcada University of Applied Sciences recommended. Moreover, the authors' ensured to avoid conflicts of interest and any biases.

6 RESULTS

The results are gathered below. Inductive content analysis was used as a method of analysis. Themes are the research questions presented earlier in this study. Head categories were chosen according to authors' discussions and main findings of the articles.

Table 2 Theme, head categories and sub-categories used in data analysis

Theme	**Advantages**			**Disadvantages**			**Future**		
Head categories	User related	Technology related	Work-place related	User related	Technology related	Work-place related	User related	Technology related	Work-place related

Sub-categories	Autonomy, retain skills, knowledge, visualization skills, hands-on skills, great fun, decision making	Interaction, realistic, modern, easy to use, safe, feedback system	Low cost, flexible, easy to access, reproducible	Motion sickness, anxiety, game addiction	Complex system, scoring/feedback system, low workload, extensive software support	Expensive system, consistent updating of gear and system, time-consuming	Revisioning knowledge	Avatars needed, multiple subject interaction, becomes more realistic, cheaper technology	Tool for education, flexibility to other areas, standard testing
Unit of analysis	1,2,3,4,5,6,8,7,9,12,13,15	1,2,3,4,6,8,9,10,12,14,15	2,3,9,10,12,15	2,10	1,3,6,10,13,15	1,2,5,6,11,13	3	4,6,11,12,13,14	1,3,4,8,10,11,12,13,14

6.1 Advantages

The findings showed a lot of advantages of virtual reality used in simulation training for nurses at workplaces. These advantages were categorized in relation to user, technology and workplace.

6.1.1 User-related

These results from selected studies showed related the users that the most significant benefit in virtual reality training is better visualization skills (1,2,3,4,5,6,13,12). Structural visualization of human anatomy using 3D helps to perform better in simulations (5,16). Cognitive skills (3,7,12), as well as knowledge improvement (7,8,9,14), were also found to be one of the most significant benefits in VR simulations. Many users pointed out VR simulations to be fun (1,3,8). Clinical reasoning and decision-making (1,3,5), along with user autonomy (2,9), as well as skills maintenance (15), were mentioned in a few studies.

6.1.2 Technology-related

The most significant findings in technology-related advantages were that VR simulations are realistic. It creates a sense of a real situation (1,8,9,12,14,15). Another significant benefit was the ease of use of the simulations (2,3,15) and interactivity between the

user and the simulation (1,3,8). A couple of studies revealed that the devices' built-in feedback system makes possible for accurate monitoring of user progression (2,6). The use of the latest technology in simulation-based teaching is modern (1,8) and practicing without real patients is safe (12,15).

6.1.3 Workplace-related

The low cost of organizing VR simulations compared to other types of simulations is the biggest workplace-related advantage (2,3,9,10,12,15). Another benefit of VR simulations, according to the findings, is the flexibility of teaching in always so busy health care sector (2,12). VR simulations are easy to access (2) because there are many companies that produce them, and it does not need as much equipment as in traditional simulations. Repeating the simulation countless times is also a notable advantage for workplaces (15).

6.2 Disadvantages

The finding revealed several disadvantages of virtual reality simulation training for nurses at workplaces. These disadvantages were categorized related to the user, technology, and workplace.

6.2.1 User-related

The greatest user-related disadvantage, according to the findings, was motion-sickness and dizziness, which is due to the creation of a depth vision of the hardware and the orientation of the gaze along with the movement (2,10). Anxiety about the difficulty of the simulation and its sense of reality was evident in the findings (2). Studies have also revealed concerns about game addiction that VR simulations can cause (2).

6.2.2 Technology-related

Complex VR system was the major disbenefit in technology-related VR simulation disadvantages according to the findings. Users needed help with the controller mechanism and simulation system (1,3,6). The second most significant disadvantage was the

scoring or feedback system. Studies have shown that they were inaccurate or that it was easy to get good scores from the simulation with little effort (1,3). This is related to the third disadvantage found, low workload. In a few studies, users felt that the workload put into the simulation was too low, and the simulation was, therefore, not challenging enough (10,15). Much space to storage data is also needed for VR simulations (13).

6.2.3 Workplace-related

The most significant drawback in workplace-related VR nursing simulations is that the single gear is expensive. It was revealed in several studies (1,5,6,11,13). VR simulations were also found to require frequent hardware and software upgrades (2).

6.3 Future

Little results were found about the future from virtual reality simulation training for nurses at workplaces. These findings were categorized in relation to user, technology and workplace.

6.3.1 User-related

According to the findings, VR will be used widely in the healthcare sector for revisioning knowledge of the staff. It is essential to maintain crucial skills (3).

6.3.2 Technology-related

In the future, more avatars will be seen in VR simulations (4,11), so that the entire team can participate together in the simulation in the VR world (11,14). Findings also show that in the future, VR simulations will be more realistic (12,13) and that the simulations will place more emphasis on verbal communication rather than text-based communication (14).

6.3.3 Workplace-related

Findings show that in the workplace in the future, VR simulations will be used to a greater extent to support employee training (3,4,8,11,12). It has the potential to expand into other areas (1,8,10,14), for example, to standard testing of the staff (8).

7 DISCUSSION

This section reviews the results and presents reflections made by authors of the thesis.

7.1 Advantages of virtual simulation training for nurses at workplaces

The first research question about the advantages of virtual simulation training for nurses at workplaces was answered by multiple studies. According to those studies, the significant advantage from users perspective was better visualization skills (Choi et al., 2015; Dorozhkin et al., 2017; Forsberg et al., 2014; Gaggioli et al., 2014; Ghoman et al., 2020; Javaid & Haleem, 2019; Khan et al., 2018; Wong et al., 2018) knowledge improvement (Baumann et al., 2018; Dubovsky et al., 2017; Fleming et al., 2009; Kyaw et al., 2019) as well as cognitive improvement. (Choi et al., 2015; Kyaw et al., 2019; Wong et al., 2018) Other user related findings revealed that virtual reality simulations at workplaces are great fun (Forsberg et al.,2014; Fleming et al., 2009; Wong et al., 2018), but also retain skills (Abelson et al., 2015) improve autonomy of the learning (Bauman et al., 2018; Ghoman et al., 2020) and decision making (Forsberg et al., 2014; Dorozhkin et al., 2017; Wong et al., 2018).

Technology related advantages of findings showed that virtual reality simulations for nurses at workplaces are; realistic (Abelson et al., 2015; Baumann et al., 2018; Choi et al., 2015; Dubovsky et al., 2017; Fleming et al., 2009; Forsberg et al., 2014), interactive (Fleming et al., 2009; Forsberg et al., 2014; Wong et al., 2018), modern (Fleming et al., 2009; Forsberg et al., 2014) and easy to use (Abelson et al., 2015; Ghoman et al., 2020; Wong et al., 2018). Other findings revealed that virtual reality simulations are also safe (Abelson et al., 2015; Choi et al., 2015). The build-in feedback system of the simulation enhances learning (Gaggioli et al., 2014; Ghoman et al., 2020).

Workplace related advantages according to result were low cost (Abelson et al., 2015; Baumann et al., 2018; Bracq et al., 2019; Choi et al., 2015; Ghoman et al., 2020; Wong et al., 2018), flexibility of learning (Choi et al., 2015; Ghoman et al., 2020), easy to access (Ghoman et al., 2020) and reproducible (Abelson et al., 2015).

Nurses' work emphasizes the perception of, for example, anatomy. A virtual 3D world simulation can create an accurate anatomical model with all its blood vessels and tendons. It allows for a more detailed inspection, combined with simultaneous hands-on action. This kind of overall learning is not possible with traditional mannequin simulations or plastic copies of anatomical models.

The realistic atmosphere created by the game can cause a little stress, which often makes a person act at their best. This was particularly evident in a study by Ghoman et al. (2020), in which midwives and nurses were taught to resuscitate a newborn using virtual realism. The child’s crying in the simulation brought the feelings of many nurses to the surface and stressed them out.

An authentic-feeling environment where patients and staff communicate to the user of the simulation makes them immerse themselves in the simulation and, at best, make it feel like real life. This is especially true in VR simulations, which use VR glasses placed on the eyes, as this brings particular depth perception to the simulation. Even though the patients in the simulation seems very realistic, it is much safer than practicing with real patients. In VR simulations, there is also no risk of accidentally breaking a thousand-euro doll or other equipment used for training.

The hardware required for VR simulation is significantly cheaper and easy to access than the equipment used to maintain traditional mannequin-based simulations. It will also become cheaper in the long run because the clinical teacher's resources are not consumed as much. The inner world of VR simulation takes care of teaching the user, but someone who knows the hardware, and knows how to guide users in its technological implementation, is needed to be present.

The scoring/feedback system built into the device helps nurses in individual learning by bringing autonomy. The staff can take more responsibility for personal learning and set, for example, the difficulty level as well as use more time in the system. It makes training fun and exciting, which also could be described by the term gamification. According to the Cambridge dictionary, gamification as a term means "the practice of making activities more like games in order to make them more interesting or enjoyable". The simulation can easily be repeated several times and does not bind itself to time or place. This gives both nurses and employers more freedom and flexibility to plan the timing of the simulations as well as the place.

7.2 Disadvantages of virtual simulation training for nurses at workplaces.

The research question on disadvantages of virtual reality simulation training for nurses at workplaces was answered among many studies. According to those studies, many participants said that visual discomfort was the main drawback, others expressed feelings of disorientation (Bracq et al., 2019) some VR users reported motion sickness and dizziness (Ghoman et al., 2019) as well as anxiety about the difficulty of the simulation and game addiction due to VR simulation (Ghoman et al., 2019). Because of the complexity of VR system, users needed help with the controller mechanism (Forsberg et al., 2014; Wong et al., 2018; Gaggioli et al., 2014). Inaccurate scoring system as well as low workload were not challenging enough for users (Abelson et al., 2015; Bracq et al., 2019; Forsberg et al., 2014; Wong et al., 2018). High amount of storage data needed for VR simulation (Javaid and Haleem, 2019) as well as expensive gears and the need of frequent upgrade (Ghoman et al., 2019).

User related disadvantages of results showed that virtual reality simulations for nurses at workplaces caused fatigue after longer use, headache, eyestrain, difficulty focusing, difficulty concentrating, fullness of head, and blurred vision. Even though users admitted feeling discomfort while using virtual reality simulations, according to the acceptability and usability study by Bracq et al; users rated feeling of discomfort as low (Bracq et al., 2019). Furthermore, another study reported that "up to 60% of VR users report motion sickness and dizziness". (Ghoman et al., 2019) "Although technical developments will lead to improvements in the quality of head-mounted devices (HMD) in the near future,

simulator sickness remains an issue." (Bracq et al., 2019). According to Bracq et al., and Ghoman et al., user discomfort might limit the application of VR simulations in the future.

Technology related disadvantages of virtual reality simulations for nurses at workplaces caused anxiety on performance during a VR simulation, difficulty to use the controller mechanism, complexity of VR system, poor feedback system, low workload and need of high amount storage space. Anxiety on performance and difficulty while using the VR simulations was reported by users with no previous experiences. Many studies did not mention this as a major obstacle for providing a good learning environment. The authors believe that nursing profession includes different age groups and the amount of technological awareness differ among different age groups, thus this should be considered as a disadvantage. The complexity of VR simulation is difficult to measure as different types of platforms are being tested and difficulty ratio varies among the procedures to be learned. The virtual reality simulation of nasogastric tube placement had a more complex procedure and equipment which the users found difficult to operate initially. According to Gaggioli et al., 2014, 1 out of 4 nurses rated the difficulty of the provide technology as "high".

Poor feedback and low workload were an issue many users felt during virtual reality simulations. Low workload does show among some studies with basic 3D environment in a VR simulation. Users also pointed out the feedback system gives high scores even though the users made several mistakes. Furthermore, technological disadvantage of VR includes storage issues if the user wants to save his/her data to the system. As the data can be in high amount the storage space needed is higher if the user requires to follow his/her achievements. This requires the workplaces to setup more data spaces.

Motion sickness, discomfort complexity and other issues can be a factor which might lead to choosing another alternative for educating nurses in workplaces. The challenges and the difficulties of using a VR system in workplaces could have a negative effect on choosing VR as a tool for educating nurses at workplaces.

7.3 Future of virtual reality simulation training for nurses at workplaces.

The future of virtual simulation training for nurses at workplaces has been discussed only in a few numbers of the studies used in this literature review. According to Wong et al.,2018, VR will be used widely in the healthcare sector for revisioning of knowledge of the staff. Many studies among them agree that VR has potential to expand at workplaces for employee trainings (Choi K-S et al.,2015; Fleming M. et al.,2009; Howe J. et al.,2018; Khan R.et al.,2018; Wong et al., 2018) and could expand into other areas such as standard testing of the staff (Bracq et al., 2019; Dubovsky S. et al.,2017; Forsberg E. et al.,2014; Fleming M. et al.,2009). Entire team participation with more avatars available (Howe J. et al.,2018; Khan R.et al.,2018) as well as more realistic VR simulations. According to Dubovsky S. et al., 2017, VR simulations will place more emphasis on verbal communication.

According to Bracq et al., 2019, VR simulations can be used as a tool for examining nursing staffs' skills. It can also help track performance which does allow nurses to evaluate themselves and employers could facilitate extra leaning platforms accordingly.

Employee training using VR simulations is an all new level of advancement for a workplace. In traditional nurses need to take an educational course, watch a video or an ordinary simulation in a room. Using VR, employers could create different procedures and let the nurses experience a new way of learning. According Wong et al.,2018 during the CPR education nurses were less distracted and more focused which facilitated memory enhancement and clarity of content. And this could maximize the output of experienced nurses as well influence education of young learners as they are more engaged to technology. Howe J. et al., 2018 proposed the use of avatars, this could facilitate a team VR simulation which can enhance the performance of the team where different healthcare professionals could train together. VR simulations get updated frequently just like any potential technology and gets more and more realistic. Designers will continue to improve VR simulations to make the experience as seamless as possible. As the technology advances, training modules will be more enhanced. (Howe J. et al., 2018)

7.4 Discussion of results according to chosen theories

Benner's Novice to Expert theory is known to challenge the importance of theoretical knowledge in practical work. She has studied the influence of experiential learning in clinical assessment. As nurses develop to become proficient in clinical assessment, they will not be basing their knowledge or skills on the prevailing rules, but to all personal experiences from their career. (Snowden, Donnell and Duffy, 2014) It is what VR simulation products are at their best to offer their users. According to healthcare professionals, VR simulations are realistic. It is able to create a real kind of experience evenhandedly for all team members, which helps the individual but also the team to develop.

VR simulations teach the nurse to see situations as a whole, which is, according to Benner, one of the crucial differences between a competent and expert nurse (Snowden, Donnell and Duffy, 2014). VR simulation combines cognitive skills and the use of knowledge in an emotional environment. By providing an authentic experience, the gap between the novice and the expert can be narrowed. It is what Squire's Designed Experience also highlights; the importance of providing experiences in the gaming world.

Squire's theory argues that games and simulations create interaction between the user and the world of simulation. In the simulation, the user is responsible for acts and decisions. This way, the user is creating his/her own experiences within the narrative and rules of the simulation. The user becomes, as if, his/her own "author". As mentioned in the results, many VR simulations emphasized the user's decision-making in a realistic world. At their best, simulations provide the sum of experiments where the user's own goals, drives, and motivations emerge.

8 CONCLUSION

Our findings provide evidence that virtual reality brings new possibilities to healthcare by creating a virtual 3D environment for nurses to train safely and learn better. Every learner has different ways to learn and traditional learning methods cannot fulfill them all. VR could provide various leaning styles. Both novice and experienced healthcare professionals are benefited.

As both the VR technology and its application evolve, further research could facilitate a more advanced and realistic experience. The focus should be to create improved nurses and other healthcare professionals using this learning platform. According to results, developers need to take into account the fairness of the feedback system in scoring, as well as respond to traditional simulations by increasing workload. Designers will continue to improve the technology of virtual reality and learning experience will be more customizable and can be adaptable to meet unique hospital settings and safe learning environment. The cost of gears and the technology plays a crucial role but on the other hand a great investment for the future.

8.1 Strengths and limitations of this study

No made-up research results have been invented in the thesis, and other texts have not been plagiarized. When reading the sources, source criticality was remembered. Most of the references were extracted from healthcare databases, thus taking into account their authenticity, originality, and impartiality. The references are marked in the text and at the end of the thesis appropriately.

Most articles were relatively new; however, some exceptions were made. It was hard to find enough open articles for a time frame of ten years, so we decided to extend the time window to eleven years. Some of the studies were locked and could not be read in their entirety without a license in the school's database. An offer from a friend who has access to articles through the University of Helsinki was asked. He shared the articles requested.

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APPENDICES