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VIRTUAL REALITY AND ITS USE IN SURGICAL NURSING TRAINING

A literature review into the effectiveness of Virtual Reality as a new practical educational method for training Registered Nurses in surgical nursing.

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Tämän opinnäytetyön tarkoituksena oli tarkastella virtuaalitodellisuudesta saatavilla olevaa kirjallisuutta ja selvittää mikäli teknologiaa voisi hyödyntää tehokkaammin sairaanhoitajaopiskelijoiden kouluttamisessa leikkaussaliympäristössä. Tulosten keräämiseksi sairaanhoitajaopiskelijoilta kyseltiin heidän itseluottamuksestaan leikkaussaliympäristössä. Leikkaus, jota tässä opinnäytetyössä käytetään esimerkkinä, on ortopedinen polven korvausleikkaus. Tutkimustiedot perustuivat erilaisiin nettihakuihin Google:n ja NCBI:n kautta opinnäytetyön avainsanoja käyttäen. Artikkelien ja tutkimuspapereiden oli oltava mieluiten vuosien 2014 ja 2020 väliltä, tosin poikkeus tehtiin vanhempien, mutta aiheeseen liittyvien tekstien kohdalla. Artikkelit olivat vertaisarvioituja ja olennaisia tutkielman kannalta. Kerättyjen tutkimuspapereiden ja -materiaalien tulokset osoittivat, että virtuaalitodellisuusteknologia on jokseenkin tehokas apuväline kirurgisten opiskelijahoitajien koulutuksessa, vaikkei täydellinen sellainen. Virtuaalitodellisuusteknologia vaatii entistä enemmän sellaisten ongelmien selättämistä, jotka haittaavat teknologian käyttöä. Esimerkkejä näistä ovat kybersairaus ja korkeat käynnistyskustannukset. Nämä seikat myös edesauttavat oppilaitoksia olemaan tekemättä tällaista investointia. Virtuaalitodellisuus on samalla työkalu, joka ei täysin takaa menestystä opiskelijahoitajille leikkaussalissa. Lisäksi, jotta leikkaussaliopiskelijoiden itsevarmuuteen ja suorituskykyyn liittyviä ongelmia voidaan parantaa, on muille tekijöille, kuten viestintä ja itseluottamus, joissa virtuaalitodellisuus auttaa marginaalisesti sekä kokonaisvaltaisesti annettava enemmän painoarvoa. Virtuaalitodellisuus on apuväline, joka ei kuitenkaan tarjoa opiskelijoille positiivisempia ja hedelmällisempiä kokemuksia kuin mitä käytännön opetustarkoituksiin käytettävät mannekiinipohjaiset simulaatiot tarjoavat. Tämä opinnäytetyö tarjoaa yleiskatsauksen tekijöistä, jotka liittyvät virtuaalitodellisuuden käyttöön leikkaussaliharjoittelussa.

ASIASANAT:

Surgical Nursing, Virtual Reality, OR, AR, Technology, Healthcare

BACHELOR'S Thesis Abstract

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VIRTUAL REALITY AND ITS USE IN SURGICAL NURSING TRAINING

- A literature review into the effectiveness of Virtual Reality as a new practical educational method for training Registered Nurses in surgical nursing

The general purpose of this thesis was to review the literature available to Virtual Reality to ascertain if the technology has a possibility to augment or become a more effective way to train Registered Nurse students in a surgical room setting. To measure effectiveness, responses of student confidence in a surgical room setting were taken. The example of surgery to be used as the benchmark is orthopedic knee replacement surgery. The research information stemmed from different forms of internet searches on Google and NCBI using the keywords of the Thesis. Articles and research papers had to be preferably between the years of 2014 and 2020, yet some loopholes were made to text that were older but relevant to the topic. When possible, the articles were preferably peer reviewed and relevant to the thesis.

Results indicated from the gathered research papers and materials, that VR is somewhat effective in the training of surgical student nurses, yet the technology is not perfect in this situation. Virtual Reality technology requires more ironing out of the problems that plague usage of the technology such as Cybersickness and the high startup costs that drive away educational institutions from making such an investment. Furthermore, Virtual Reality is a tool that does not completely guarantee success for student nurses in the surgical room. Additionally, to improve the problems of nursing student's lack of self-confidence and performance in a surgical room, other factors need to be given a larger point of focus such as communication and self-confidence for which Virtual Reality improves upon marginally but not wholesomely. The position of Virtual Reality is a tool of improvement but not one that promises to give students more positive and fruitful experience than mannequin-based simulations for practical educational purposes. This thesis provides an overview of factors that go into Virtual Reality usage for surgical room training using different factors.

KEYWORDS:

Surgical Nursing, Virtual Reality, OR, AR, Technology, Healthcare

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LIST OF ABBREVIATIONS OR SYMBOLS

VR or V.R	Virtual Reality
R.N	Registered Nurse
O.R	Operating Room
ECTS	European Credit Transfer and Accumulation System
AR	Augmented Reality
WHO	World Health Organization
HMD	Head Mounted Display

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1 INTRODUCTION

Every year, around 400,000 surgeries are performed in Finland: ranging in different specialty fields such as orthopedics, cardiothoracic, gastrointestinal to pediatric and urological (Rautio, YLE, 2020). Surgery by its very definition is an invasive medical treatment in which the damaged part of the body or cells in the body are opened and removed (Cambridge University Press, 2020).

Surgical nursing is a specialty nursing competency albeit it a popular specializing choice for student nurses according to the search data available on the US based website Indeed careers (2020). Hence because of this reason, a great deal of basic nursing training is needed, and in some cases is a core part of the nursing curriculum, specifically in Finland. (Opintopolku, 2020). Surgical Nurses are in Finland, general registered nurses who complete their degrees in around 3.5 years and 210 ECTS according to the Finnish Nurses Association guidebook on nursing education, 2018 edition. However according to the American Academy of Medical-Surgical Nurses (AMSN, 2018) they clearly point out that “medical-surgical nurses are the most skilled and multitasker you will ever meet” and “In order to do this, they have a high-level ability of critical thinking skills, vast knowledge of different disease states, management skills and as they stay calm under pressure” (AMSN, 2018).

The world demographic is changing, as in a majority of developed nations, the age demographic is shifting towards an ever increasing median and average age means that basic health care needs are needed than before, especially in the field of surgery (UN75, 2020). Furthermore, the continuous sophistication and efficiency of modern-day surgery requires that ever more numbers of highly trained, well versed and multi role surgical nurses for the increasing demands of specialized health care. In Finland, there are some surgical wards and other specialized healthcare wards that are required to close due to a lack of properly

trained staff (Rautio, YLE, 2020). This is due to the fact that in general, surgical nursing nurse prospects require between 6-12 months of general induction to get to know the job, the roles and the ward that they will be getting to work in.

Finding newly graduated nurses who want to work in the operating room could be made easier by having the students be more confident about going for those jobs after they graduate. The view that the author holds, is that this technology could be used in the future as a teaching method to help student nurses feel more comfortable in the situations that can happen in the operating room. The reason why I wanted to choose this topic for the thesis is because I have found surgical nursing interesting due to the wide range of knowledge needed and the skills required to be successful in a surgical room. I believe that the future holds a lot in store for VR and making it a way of teaching surgical nursing students (Puljiala, 2017), can possibly lower the induction and training time required to go to a practice placement or working in the operating room and the COVID-19 epidemic has shown that, while education. The thesis will also deal with orthopedic knee replacement surgery as the main example of surgery due to the fact that this is one of the fastest growing surgical and most done procedures in Finnish surgical wards (Eurostat, 2020). As a researcher, I will review literature relating to the thesis, that has been published between the years 2010 and 2020.

2 BACKGROUND

2.1 Usage of technology in Nursing

Nursing studies and the use of technology for teaching in Finland go hand in hand. Some requirements that a student nurse is expected to know how to use by the time of graduation include: automated IV pumps, health apps, ward specific apparatuses such as dialysis machines, ECG equipment, breathing machines. This is not included in the usage of documentation software of patients used by hospitals, especially in Finland. To recognize this competent, technology and specifically up to date technology training is given to new registered nurse students. Old techniques and technology are not kept in the educational circulation and medical research articles are not preferably used if they are over 5 years old due to questions of relevancy. The field is an ever-changing technology environment, which is backed by a large percentage who support technology used in the field according to a LinkedIn article from 2019 “In a survey LinkedIn conducted last month of more than 600 nurses, an overwhelming majority — 82 percent — said they have a somewhat or very positive view of how technology is affecting patient care.” (Kutscher,2019). However, in the same article, a vocal minority also voice their dismay over the over reliance of technology and software due to a lack of human touch (Kutscher, 2019). The WHO according to their latest update guideline for European Union standards for Nursing and Midwife education, (2009) states that the RN must know the certain equipment and technology of his or her workplace at a proficient level to maintain patient security at all times. In other words, technology is a mastery that RNs are expected to be proficient at if not a master of the skill by the time of graduation.

2.2 Roles of Surgical RNs.

Surgical Nurses can have multiple roles within a surgical team. A surgical team is defined as being a complement or team that is specialized or required to perform a surgery (Torrington, 2019). For the sake of simplicity, this thesis will use the Finnish requirements to make a surgical team, as many different nations have their own legal requirements for a surgical team and whom can do what task in the O.R, yet the same principle remains across every hospital. A surgical team includes usually in Finland; A surgeon, who is MD who specializes in a certain field of surgery such as orthopedics or cardiology. The surgeon may or not be accompanied by an assistant who is also either an MD, or a specializing MD or a medical student. Also, within the OR, there must be an anesthesiologist who maintains the patient's vitals and wellbeing, during the surgery and after the surgery (Terveyskylä,2020). Within the laws of Finland (Suomen Sairaanhoidtiito, 2018), there must be at least three RNs with the required amount of surgical experience in the room. In general, these three nurses can be arranged in 3 specific but different roles. A "scrub" or instrument nurse is in charge of the instruments needed and used in the ward, while preparing the surgical room ready for any surgery that will come. Draping the patient and maintaining a sterile field during the surgery is a part of job. Finally, the most important job is to assist the surgeon during the procedure (Terveyskylä, 2020).

An anesthesia nurse, ensures the patients wellbeing and the vitals during the surgery and after the surgery, hands off and reports the patient in a Post Anesthesia Care Unit (PACU). The anesthesia nurse does a lot of co-operation work with the anesthesiologist and has to be in constant communication with the surgical team and surgeon on the vitals and the well-being of the patient throughout the surgical procedure (Terveyskylä,2020).

The circulating nurse's role is to maintain control of the surgical/sterile field and ensure the rights and care of the patient, such as the right surgery, right treatment, right patient and right post-care. They also are responsible for what happens to the surgery and its situation such as calling for more helping hands during

breaks, providing sterile working conditions and for timetabling and scheduling when surgeries happen (Terveyskylä,2020).

While these may be just some of the roles that Registered nurses have in a surgical ward or in a surgical room, there are more roles that involving nurses such as a PACU nurses who is in charge of the wellbeing and vitals of the patient post anesthesia, administrator nurses who take over roles of running a surgical unit and many other support, communication and logistical roles required in the ward (Venäläinen,2015).

2.3. VR technology and it's state in education

Virtual Reality (VR) is a technology that has so much potential since it has the ability to immerse the person's senses in a virtually simulated environment (Bardi, 2019). VR is defined as a simulated situation, environment, experience which is similar to or different from the real world (Bardi, 2019). The possibilities that are offered by the ability to simulate any type of environment for nursing studies is endless and allow for a wide-open range of areas to for students to focus. VR products and services come in many forms and is offered in many different forms such as fully immersive VR and partially immersive, in which the headset computer simulates the whole environment and equipment used in the environment or in the case of partially immersive VR, in which just some of the environment and interactive tools are simulated by the headset. AR or augmented reality, in which the fully immersive environment is assisted by real world tools and equipment. In practical sense, both can be used in some platforms and in the medical/ nursing world, a combination or capability to use both types of technology as it can allow for diversity of pedagogy possibilities (Heim, 1994). This thesis will review the use of VR and AR which will be labelled under the general umbrella term of VR.

3 PURPOSE, AIMS AND RESEARCH QUESTIONS

3.1 The purpose and aims of the literature review

The goal of this thesis is to answer and analyze how to effectively train R.N students in surgical settings using VR technology when contrasted to traditional education methods. Since in Finland the education requirements required to be a registered nurse is going towards a standardized to 180 ECTS from 210 ECTS (TUAS, 2018) (The Finnish Education and Culture Ministry, 2018) across all higher education institutions, it means the training available must be more effective and standardized due to timing and educational restraints. This kind of standardization could mean that specific nursing subjects such as surgical nursing could suffer from a lack of theory lessons or from lack of through simulation. From a personal point of view as a student, it is a very daunting task to enter a surgical room as a student during an operation due to the strict nature of the operating room with the sterility and so much knowledge that is to be absorbed in such an environment. Due to this background, this thesis will be focused primarily on answering the effectiveness of Virtual Reality technology in training nursing students only in surgical nursing and if it can replace the teaching methods in place and or work practice in the surgical room.

3.2 Research Questions

This thesis will be focused around 3 research questions, which will come to form the basis of this thesis' way of analysis and critical thinking. They are as follows:

1. Using literary data, what challenges are faced by nursing students when studying surgical nursing.
2. Using the latest in literary data, how is the state of VR technology as of present to be used as a training tool for surgical nursing?

3. Within the next 2 to 3 years, what advantages would be brought to Finnish higher education institutions switching to VR simulations in surgical nursing practicals compared to the current methods?

4 RESEARCH METHODOLOGY

4.1 Literature Review

This thesis will ascertain its information using the literature review method of investigation. According to the Royal Literary Fund (2020), “A literature review is a search and evaluation of the available literature in your given subject or chosen topic area”. This search of the topic means that the thesis will be dissecting the state of the facts and figures in the topic to come to its conclusion and present other author’s data and viewpoints to mold the conclusion. Furthermore, the collection of information means that there will be chance of remedying any forms of personal writer bias to complement and form a fully encompassing thesis.

4.2 Literature searches

The resources that would be used come from books, online research from trusted websites and well moderated authors. Some of the search engine databases such as Google scholar, PubMed and NCBI will be used as part of the main gathering areas for the sources; other search engine databases included come from Turku University of Applied Sciences’ own databases (Finna). Some keywords used in the database searches are “VR in nursing”, “surgical nursing”, “VR in surgery” and “VR training in medicine”, “nursing students in surgery”. The research sources would be kept on a Microsoft word document accessible to the of author of the thesis. During the writing of the thesis, the world situation has changed for a dramatic in such a manner that it has made the research methods solely dependent on internet databases and articles searched from the internet using such verified and scholarly articles.

Resources that were preferred were between the years of 2010 and 2020 and were highly relevant to the research questions. Furthermore, moderated articles and papers were the most sought after regarding surgical nursing and VR, however blogs, papers and opinion pieces have been included to add for more resource methods to tackle the research questions. Some resources went past the 2010 acceptable level of inclusion in the thesis, however the author regarded books and other materials relevant and hypothetical enough to be of a valid opinion still nowadays.

4.3 Inclusion and exclusion criteria of the literature

Materials that were included in the literature criteria were sources which were time relevant, meaning resources published between the years 2010-2020. Sources also had to be relevant to the research questions and preferably of scholarly background, but news articles were fine as well.

Excluded materials included blogs of people neither having a vested interest in nursing or VR technology, too old sources that could not be kept due to changing technology and sources that were more focused specifically at medicine research with not enough importance on the nursing research and the nursing aspect of work. When searching for the appropriate materials, a number of 50 sources were cited and around 100 which were possible references. When searching through data library banks, with the keywords used, a total of 892 sources were listed by PubMed and NCBI. Google scholar listed a total of 521 combined sources. However, it should be kept in mind that the sources are not automatically relevant to the research focus or questions and date factors. Furthermore, the data was generally less relevant to nursing studies and nursing pedagogy and more towards pertaining to medical pedagogy. Therefore, the literary sources that were used in the end product, were a mixture of nursing surgical studies, some surgical medical pedagogy and nursing VR based pedagogy.

4.4 Analysis of the materials

During the research phase, the materials that were particularly prized, were data sources that had numerical data due to an ability to convey a stronger argument for or against VR. Financial data was important as well numerical data regarding opinions, statistics of VR usage and other comparative numerical factors. Materials were also analyzed for what methodology they used for the paper and how they came to their perceived conclusion with their peer reviewed paper.

Lastly materials were analyzed for their fit to the research question, and how their conclusion could help answer the research questions. Key points and features were used and summarized during the analysis and used to fit the conclusions and the ability to answer the research question. Lastly in the discussion section of the thesis, there is a short, author made SWOT analysis to show different strengths, weaknesses, opportunities and threats that display the current state of VR technology.

5 RESULTS

5.1 Core topics identified.

A few topics considered vital to the thesis. These are knowledge ideas that should be known for a proper understanding of VR in surgical situations and why VR is important in the near future. Other core topics of importance include surgical room difficulties faced by nursing students and the

5.1.2 A brief history of VR

VR for a long time has been a creation by science fiction to be an exemplary beacon of technological hope (Heim, 1994). It has been featured on movies such as *Total Recall (1990)* and the *Matrix Trilogy (1999-2003)* (IMbd VR search word) (Heim,1994). VR has however, become to the extent a modern reality, pedagogical tool, a trainer for all different purposes and for different assorted entertainment uses. The first virtual reality product available for the public to enjoy was in 1956 by Morton Heilig when he created a visual 3D video, with scents and a surround sound called the “Sensorama” (Barnard,2019). By 1960 he had also created the world’s first VR head mounted display (HMD). The technology that came for it afterwards, spurred by military technologists, companies and engineers to gain an advantage for their militaries, specifically in the area of flight simulation. In 1965, Ivan Sutherland drew the blueprint for the relayed feedback HMD which is the prototypical forefather of the technology in VR and in 1968, he created the first, albeit primitive form of an HMD which was functioning even though it is for 2020 standards quite rudimentary and ancient (Barnard, 2019). By the early 1980’s, development of add on appliques to be added on to the HMD is an important applicant progression made to the force-relay abilities that can be found and available in VR technology of the 2000’s.

By the 1990’s (Barnard, 2019), video game companies were capitalizing on the opportunities that can be capitalized by the creation of VR and trying to add the

technology as a part of bring immersion and realistic abilities of gaming to the gamer. Fast-forward to the 2010's, VR technology is receiving all new kinds of buzz from big companies and financial world, is gearing up and investing in firms whose research is solely vested into VR development and research for the mass market consumer. Oculus Rift, a pioneering venture into producing a VR product for the mass market which would be bought by Facebook in 2014 (Barnard, 2019) (Haerling, 2018) for 2 billion US dollars. This buying out would signal to the rest of the firms in the field, that the race was on to develop a VR product for everyone. Sony, HTC, Oculus Rift and countless more companies are at the forefront of development. As of 2020, Sony has unveiled its platform, the Project Morpheus; HTC unveiled the world's first commercial VR, the Vive and many more companies involved are in the prototype and refinement stage (Barnard, 2019; Pottle, 2019).

5.1.3 VR functions in surgical nursing

VR technology "Unlike traditional user interfaces, to experience VR, users put on head-mounted display (HMD) which places the user inside an experience, where they can engage with the environment and virtual characters in a way that feels real" (Pottle 2019). The HMD is basically a smaller and compact, audio-visual relaying computer that when user places above their eyes on their head, displays high definition, three dimensional videos. The headsets also function as fast and lightweight computer processors that relay information in the form of audiovisual-sensory information, in real time, back to the user (Pottle, 2019) (Heim, 1994). Furthermore the 360-degree camera and image projectors allow for the user to interact with the simulated world with a full 360 or real-life panorama view. VR and AR accessories include sensor relaying gloves with which force feedback is relayed to the user's sensory in their hands so that the user can interact with the VR simulated world using their hands; joystick hand-

held devices with which simulated equipment such as the instruments needed for nursing students to learn (Bracq et al, 2019; Bardi, 2019).

The introduction of add-ons to the HMD, allows for an, as close to life simulated environments for the user, with the only issue the user has to deal with, are the minor hassles of wearing a headpiece, gloves and headphones (Jamshidi,2016). The use of VR technology allows for the learner or nurse student to fully immerse themselves to the environment that is realistic and lifelike. Doubly, the use of VR acts to create a safe environment for the student within the VR simulation immersed situation as there is zero to low possibility of causing bodily harm to a classmate, patients and lower the opportunity of self-harm due to the non-physical nature of the equipment used (Ahonen, 2018). However, using VR technology does come with some physical drawbacks of usage (Kim, 2019). According to Thomas Stoffgren, a kinesiologist from the University of Minnesota “With contemporary commercially available VR systems, the incidence of motion sickness after only 15 minutes is anywhere from 40 to 70 percent” (Kim, 2019).

Users of VR technology have witnessed the symptoms of motion sickness being more prevalent after usage which has being called “Cybersickness” (Kim, 2019). Some theories revolve around two different principles of why it occurs; on one hand, it may be due sensory overload that is being felt; the visuals that eyes feel does not match relay to the body or vice versa (Kim, 2019). Another prominent theory that is circulating, is the idea that VR usage is equivalent to the effects of poison or hallucinogenic and the body is therefore trying to get rid of its effects on the body (Kim, 2019). Other theories also proposed stipulate how the HMD sits over the head of a user and how close the visual displays are to the eyes (Kim, 2019).

What is more worrying, is the prevalence of women who experience “cybersickness” leading the technology to be labelled sexist by some news articles and experts on the field (Kim, 2019). According to Shafer et. al, their 2017 paper suggests that women are more likely than men to experience VR related cybersickness due to the physiological differences of men and women (Shafer, 2017). These are things to be taken into consideration in the analysis section of the thesis, however for the sickness, there is no proper method of treatment or prevention except for stoppage of VR usage (Shafer, 2017).

5.1.4 Modern usage of VR in nursing

As of writing in 2020, VR technology as a method of teaching surgical nursing or other forms of nursing, is available at some institutions of higher education in the United States of America, Canada and Australia such University of Montreal, University of Indiana and Flinders University. There are some other levels of higher institutions who use also VR technology to teach medicine and biology such that their students can learn anatomy and other medical related studies (UCSF Anatomy Learning Center, 2020).

For example, at the University of California at San Francisco, medical students are using a trial to learn and understand better the human body compared the use of practice cadavers, slides or textbooks. The Faculty’s use of VR allows for a more thorough examination of veins, bones, muscles and even the human cells which allows students to understand the connections and interactions between bones and muscles or zoom to microscopic levels to see cellular interactions of a body, without the need for extra cadavers or very expensive microscopes (UCSF Anatomy Learning Center, 2020). Neither does the instructor have to spend extra time teaching off of slides and allows for more freedom for the instructor to teach the students because of the immersion that the students feel. (UCSF Anatomy Learning Center, 2020; Pottle, 2019).

At the Indiana University, nursing students were until recently, still going through their simulations using very similar training techniques such as life like mannequins and actors to recreate simulated experiences in which nursing students can practice their skills. However, since 2018 they have been gradually incorporating and partially replacing the need for actors and mannequins due to being one of the first VR accredited simulation centers in the US (IUPUC, 2019). Mannequins or other forms of training method tools cannot completely fulfill different types of medical simulations that can come up. “VR technology allows instructors to develop characters by age, gender, and body type and with specific physical symptoms” (IUPUC, 2019). The use of VR has allowed for different types of simulations to be conducted with different types of environments of learning and training (Baker, 2017). In some cases, the use of VR related technology has been found to be more effective in certain environments in both nursing environments and medical environments (Haerling, 2019; Baker, 2017).

In Finland as of 2020, there are officially zero tertiary education institutions or Universities of Applied Sciences that have a nursing education which incorporates full elements of VR or AR technology to train and educate future nurses due to the phase of the technology being studied further for future educational purposes of training. Yet, a lot of universities and universities of applied sciences are in the stages of developing the technology to an extent where it is available to not only the healthcare field but to other sectors of the Finnish economy and society.

5.2 Surgical Nursing

For the purpose of this research, the example of Orthopedic knee replacement surgery was used to discuss the training and education of surgical nurses and the role of the student nurse in learning how to become a surgical nurse or to learn surgical nursing in general.

5.2.1 Surgical Nursing challenges for students

There are multiple challenges faced by any nurse who wants to become a surgical nurse. These difficulties stem from a multiple range of factors of surgical nursing and the environment for learning. Surgical nursing cannot be only be taught in theory such as how to theoretically point out the different surgical instruments or medications used in a surgery, or even perhaps talk about draping different surgery types using PowerPoint slides or videos. Surgical nursing is a discipline of nursing that requires more than most the hand talent capabilities of the nurse to be fine-tuned (Foran, 2016). However, the environment for learning in itself is a major challenge (Arabhashi, 2015). Surgical nursing requires a far more hands-on approach to the practical learning due to the environment of the job (Arabhashi, 2015). The learning environment asks a lot of the instructors as well as, the stress of the managing both a student to learn in the practice field and maintain their nursing role in the operating theatre, means that one of the two responsibilities suffer, if not both.

Medical and nursing students who go to a surgical ward, in general have a sense of uneasiness and feeling unprepared for the learning experience and in the case of medical students, that around 40% feel unprepared and uneasy when going to assist or partake in a surgery (Pulijala, 2017; Parham, 2019). It may be wrong to assume the same for nursing students, however these statistics could reflect a greater trend of student nurses in a surgical ward setting feeling somewhat similar to their medical student counterparts. In an orthopedic knee replacement surgery setting, being in any of the surgical nurse roles as a student is a lot to comprehend and learn in the same setting (Payne, 2016). According to Neshuku et al., their 2015 study found that the learning experiences of 35 interviewed student nurses and registered nurses in Namibia were woefully unprepared educationally and in working life, a lack of communication and

continuous training led to a lack of willing and able nurses in Namibian surgical wards. This study highlights that while skills can be taught, a lack of preparation and proper hands on simulated and real experience are of the priority (Neshuku, 2015). Some general themes can be then taken from these different research articles: young surgical nurses and student nurses require far more practice with their skills before entering a surgical ward for work and furthermore, a transitional period for their skills to improve (Neshuku, 2015).

Some remedies have been researched for these and one of those has been the usage of VR among many others. Other remedies include a far more focal value being placed on the communication requirements and goals of a surgical team to be effective and inclusive team members and the requirements for being a nurse in the surgical ward being altered and better suited for the situation but not lowered to jeopardize patient safety requirements and performance goals (Arabshahi,2015).

In the case of orthopedic knee replacement surgery, a surgical nurse has to be familiar with the instruments that are to be used in the surgery and what form of anesthesia is to be used during the surgery, taking into account the patient's care needs and medical factors such as age, sex, weight, duration of surgery and position in surgery among many other factors. Furthermore, it is not enough for an instrument nurse to know the instruments to be used but also what instrument boxes to take to the surgery rooms and how to handle the implant and the implant cementation equipment (see Figure 1 and Figure 2 in the Appendix). The other things that a young student nurse should also know how for some surgical teams, the surgery has become a routine due to the sheer number of surgeries of this kind being performed yearly in some countries and in Finland, where in Ottawa/Ontario province, the average wait time is 182 days for patients due to the sheer volume of the surgery being performed, means for some surgical teams a sense of factory like speed and precision when performing this

surgery (Payne, 2016). This creates a false sense of student's personal expectation and a feeling that if they do not pass the same speed and thoroughness as veteran surgical team nursing members can, they aren't cut out for the surgical ward, which is not the case (Jamshidi, 2016). Furthermore, since surgical teams have acquired years of experience with each other in a surgical and non-surgical setting, the communication is of not the utmost importance as trust and solid relationships have already been formed; the same cannot be said of a student nurse and their scope of practical training or of a new RN and their lack of experience in the surgical room (Neshuku, 2015; Jamshidi, 2016).

Surgical nursing is taught as of now, using different methods of both practical and theoretical lessons in Finland (Suomen Sairaanhoidajanliito, 2018). The theory is literature-based attempt to demonstrate what a surgical nurse is expected to know during their work or practice period in the different surgical roles; anesthesia, surgical and circulating nurse as mandated by the Finnish Nurses Union to be a complement of a surgical team. However, there is no one standard way of teaching a student nurse on how to become a surgical nurse using the practical methods (Glaser, 2016). This is where the differences start to appear. Practical surgical hands-on experience before the surgical varies from mannequins that relay information to the user in their practice, to actors reading off of a medical-surgical based script to basic mannequins and getting familiarized with the surgical instruments, anesthesia and draping materials (Glaser, 2016). The lack of uniformity between the methods of surgical practical teaching, makes it difficult to use as a threshold in comparison to VR and AR supported surgical nursing practical experience (Lea, 2020);(Glaser, 2016);(Haerling, 2018). Therefore, the thesis will work on the basis that these 3 practical works will be labelled and lumped under 'traditional' methods of surgical practical pedagogy.

5.2.2 VR in surgical settings

VR technology has been developed for use of training medical and nursing staff in surgery and other fields of medicine (Baker, 2017). However, its effectiveness can vary due to the different VR technologies and programs available in the market, and how their set up is formed. There are also a few things that need to be stamped out with VR usage for surgical training. Will the technology be using the AR side and interactive instruments and real equipment supported by a virtually simulated environment or something else that will fit the requirements of a learning focus. VR is in this case a multi-faceted technological tool that can be fixed to change and meet the different situations that the lessons or practice opportunity requires (Bracq, 2019). A teacher for example can have preset conditions that the student must prepare for and allows for the teacher to see and talk through the steps that the student should do and have open discussions with the class, for they are allowed to see the same thing through video links (Haerling, 2016; Lea, 2020).

Considering these facts, there are more ways to improve the teaching for surgical nursing and it requires the practice on verbal and non-verbal communication and a focus on multi-disciplinary teamwork which in a surgical room is at the utmost importance compared to other medical and nursing fields (Venäläinen, 2015). The use of VR as of itself is an important and multi-faceted future tool for both medical and nursing care studies, however for VR and AR to be maximized for use in nursing studies, it requires a thorough nursing competency and nursing teaching restructuring (Fukada, 2018).

Furthermore, other factors and decision makers are to be considered when using VR technology. For the technology to properly mature so that the problems of being a first-generation technology smoothens out, yet to this issue, the industry

has developed so quickly that, VR firms are working hand in hand with educational institutions and thus can better cater to the institutions' needs (Lea, 2020). Therefore, the VR developers can create programs and custom requirements for the needs of the client. However, like with any program, this custom creation cost money and time.

5.3 Effectiveness of VR

For the analysis of VR, a few literature research papers on the subject and their results were taken into consideration. Some other factors were taken into account such quantitative figures (the cost: start up and running costs) and qualitative factors how do the students feel after the usage of VR and how their performance is after being trained with VR.

5.3.1 Cost Analysis

For any program to be considered, the cost analysis in terms of dollars and cents must be also considered for VR technology to be considered. VR technology, in its current state is not a cheap piece of equipment and requires some serious capital investment and a lifetime project analysis.

VR has become affordable enough for a vast majority of the developed world's population to at least be able to try it out at the local electronic store or at an electronic exhibition (Barnard, 2019). As of 2019, Sony and Oculus can sell their VR and VR related products for around 300-400 USD dollars (Barnard, 2019). However, the purchasing of the VR HMD is not the program. The program is the application that the VR HMD runs to give the user their simulated

environment and those programmes range from 20,000 GBP to 150,000 GBP depending on the quality of the program and how specific the client wants to run the product (BBC VR Hub, 2020). A surgical VR application would be on the higher end of the spectrum (Haerling, 2018). Furthermore, the development time of the product can be months to a year and the final product is not completely guaranteed to be as promised. VR can cost a lot of money to cash strapped educational institutions (Parham, 2019), yet it does have benefits of usage compared to traditional surgical room educational methods. In a head-to-head cost analysis of, a study by Haerling, found that in 2019, virtually simulated versus mannequin-based costs of usage was 1.03USD versus 3.62USD using a cost-utility ratio. The simulated reality training does not mean Virtual Reality HMD display but an interactive 3D internet-based simulation for nursing interventions of COPD patients. Some other cost analysis found however, point to the cost of making an evacuation based Virtual Reality program with the usage of HMD and other VR based add-ons showed that the cost of having a training event with VR was 106,951USD to hold a training exercise for 34 neo-natal ICU nurses compared to 18,617USD to hold a live mannequin-based training exercise for (Farra, 2019). However, the VR based exercise includes around 106,000USD based on solely fixed cost, which is defined as cost in which does not change regardless of use and is incurred as part of the investment. The costs of usage in VR were in the study only around 300 USD which is the cost for 8.5 hours' worth of training (Farra, 2019). On the other end, the study found that the costs of planning a mannequin-based exercise was far more labor intensive, taking working hours away from the ICU nurses for the exercise and far longer in terms of doing the exercise compared to the VR which involved the nurses in charge of the exercise working hand in hand with the VR program developers. This means however, that the department owns the program and can use it whenever they want to and for a cost of the wages of the nurses taking part of the exercise (Farra, 2019). Lastly, the cost to arrange a mannequin-based exercise would be of almost similar cost as it takes more human resources to plan every time an exercise of the same caliber is done (Farra, 2019).

In short, VR costs to start up will remain high due to the development of a specific program required for the VR simulation, the headsets, the facilities, etc., while tried and tested methods such as actors and mannequins require a less amount of serious capital investment for a projected simulation. Yet, data finds that the higher amount of human resources costs required to arrange traditional simulations will cost more every single time compared to VR simulations, per single use. Furthermore, there are attempts (Parham, 2019), to create low-cost methods of VR simulation bring down the costs, specifically in oncological surgery has proven that while the costs for a dedicated VR surgical oncology program can cost over 100,000 USD, a similar albeit less dedicated program can be recreated with a tweaked Oculus Rift HMD and a computer game hardware that can bring a similar result for 1,500USD, a cost of 60x less (Parham, 2019). These sorts of breakthroughs can even allow for nursing students to learn the practical's at home, provided they have the required equipment and signify a great opportunity for people who live in areas of low resource capabilities to have access to similar abilities.

VR from a cost point of view is not a short-term investment that is expected to pay within a year, but an investment in which would repay itself back in 5-10 years of usage (Parham, 2019; Farra, 2019).

5.3.2 Outcome of VR usage

There have been multiple studies on the effectiveness of VR yet, the meaning of effectiveness is one that has a vague and unconcise meaning of what it actually is, so in this paper, the term positive outcomes and negative outcomes are to be used, using a different array of factors such as self-confidence, improved

performance, and how they personally relate their usage of VR; the qualitative and quantitative data is compiled from previous studies.

A prominent study in the field of VR and surgery by Pulijala et. al, the “Effectiveness of Immersive Virtual Reality in Surgical Training-A Randomized Control Trial” found that the self-confidence felt by new medical residents, a large minority of them do not feel confident enough in performing major surgery or even taking part of the surgical team (Pulijala, 2017). These studies gave some quite positive feedback in which the authors of this paper summarized “*The study group participants showed significantly greater perceived self-confidence levels compared with those in the control group ($P = .034$; $\alpha = 0.05$). Novices in the first year of their training showed the greatest improvement in their confidence compared with those in their second and third year.*” (Pulijala, 2017). There can be multiple reasons for this but once looking into the data, the tests subjects were split in two different; one in which control subjects received PowerPoint slides and videos as learning materials, while the VR focused group of surgeons was able to feel and view the surgery in a safe environment, free of patients and a place in which there are not just one way of looking at things. The study also found that VR has allowed for surgical students to explore different avenues of thinking in which previously would not have been explored. The creativity that is created from VR surgical training is expanding also the possibilities of treating a patient surgically and non-surgically. The study also proves that taken into consideration is patient safety and patient aftercare in a Post Anesthesia Care Unit (Pulijala,2017). This means that in general a patient can be treated in a far more holistic manner and at the same time, the surgical student is far more prepared when different situations call for the student to change a certain trained or learned routine (Pulijala, 2017). The same study found that the residents were more willing to try the VR again for other surgeries (Pulijala, 2017).

In the study by Farra et al., found that even though the costs did not necessarily justify the investment, the VR group of the study outperformed the live web based using their performance metrics and the ability of the participants to think critically, quicker and “Although many participants preferred live exercises to VR training, qualitative analyses demonstrated that participants found the VR experience realistic and engaging” (Farra, 2019). While, for some nurses the difficulty in becoming acquainted with a rather new technology, proved to be a hassle for the nurses, with further practice and getting accustomed to new technology would also see an uptick in positivity rating for the usage of VR technology as part of a future training program (Farra, 2019). Furthermore, VR’s usage presents the exercise holders to not require dedicated patient care spaces and does not require the participants of the exercise to physically present unlike at live exercises (Farra, 2019).

A study by Aim et al. (2016), on surgical teams, specifically surgeons, found that surgeons who had been using VR based simulations before entering the surgical room, were able to recognize anatomical landmarks and surgical teams were better able to recognize the instruments and with the surgeon’s technical skills improving before entering and partaking in the surgery (Aim, 2016). The analysis further promotes the training of the skills to be improved recognizably and statistically (Aim, 2016). Other positive outcomes on nursing virtual simulations, the study from Padilha et al. (2019), found that after 2 months of virtual simulations, the nursing intervention skills and better self-learning satisfaction which promoted for healthy dialogue, while on the hand, the student nurses themselves did not remark on any change of their personal perceived self-improvements in their nursing intervention skills when compared to traditional simulations (Padilha, 2019)

Other data reference points are not clear on their results coming back regarding the positive outcomes or negative outcomes from VR usage. The results and

conclusions of Kaldheim et al. (2019) found that from a compilation of data based on four different sources, the data pointed out to an inconclusive finding of nothing available to be in favor or against simulated scenarios being an effective tool to train perioperative nurses. In a French study for scrub nurses using VR, Bracq et al (2019)., the study found data in which showed no statistical difference in the VR simulation between experienced scrub nurses and nursing students with no operation room experience (Bracq, 2019). While VR was being praised as a fun, learning and realistic environment building tool, the lack thereof demonstrating a remarkable change in learning and experience between the two subject groups and the uncomfortableness of the audio-visual experience outweighed the potential benefits. "There was no effect of age, gender or expertise. Workload, immersion and simulator sickness were also rated equally by all participants" (Bracq, 2019). As stated earlier in the analysis, the inability to cater to a comfortable to nursing students shows that VR cannot beat out experience in the field nor

Lastly, the usage of VR and AR based technology must be thought of what will happen to it in the future as threat or opportunity. As of writing of this paper, some companies are already specifically marketing their products for surgical nurses and perioperative nursing focuses, some specifically for the field of orthopedic surgery. Firms like PrecisionOS and Periopsim offer their latest products specifically for orthopedic surgeries simulations (Singerff, 2020), and can provide hospitals and nursing education faculties with the specific tools to train and educate RN's and students in orthopedic surgeries (Figure 3). For this reason, a SWOT analysis of the strengths and weaknesses that the technology has to offer as of now during writing and the threats and opportunities that VR/AR technology could face in the near future as a viable technology for orthopedic surgical training specifically (Table 1). There are weaknesses such as its inability to simulate a realistic orthopedic surgery in the eyes of experienced surgical nurses (Bracq, 2019) and its lack of comfortability of usage, specifically for the female sex (Kim, 2020), but this are opportunities that should and can be

changed by VR technology in the near future. Firms like PrecisionOS and investigations into making VR more comfortable to the eyes and more user friendly, show a want from the VR market to continuously improve and offer everyone and not just nursing students, a better and more realistic product.

The data available on the subject is plentiful, however the data trend shows that VR based simulations for surgical nursing ranges from negligible outcomes to overwhelmingly positive. There are however things that VR based simulations need to change for more users to be on board with the idea of using the technology on mass nursing scale. The comfortability of the users with the HMD display and figuring out how to prevent cybersickness and visual pain for the users and among other things, how to cut the cost of the investment down such that more people can access the technology.

VR, however, has more that it needs to better itself o. With a dedicated program/application, the technology can get the desired results out of the simulation that is required and offers the benefit of being repurposed for any other simulation: as long as the program is available. The ability of VR to simulate any type of surgery, under any type of condition, with any kind of patient record and history, has been something that all data sets can agree on; the versatility of the technology to do any task it is programmed to. VR and AR have still a long way to be implemented as a standard nursing training in Finland and yet, it has become a reality for many nursing students to become at least acquainted to visual 3D screen simulations on their computer screens. In general, the dataset shows the potential use of VR in the future, yet using the data available, it is up in the air whether it is functional and worth the large investment to train surgical nursing students.

6 ETHICS, RELIABILITY AND VALIDITY

According to the Finnish advisory board on research integrity (TENK) and according to their 2012 Responsible conduct of research and procedures for handling allegations of misconduct in Finland, the board has laid down the basis of the research ethics that will be adhered to, to keep the thesis honest and truthful to the best of the author's knowledge and ability. Furthermore, to promote reliability and integrity, this thesis will respect the articles' authors by referencing the work correctly (TENK, 2013). "The research follows the principles that are endorsed by the research community, that is, integrity, meticulousness, and accuracy in conducting research, and in recording, presenting, and evaluating the research results." (TENK, 2013). This thesis paper will be published on the Theses website services with other theses and thus this thesis should comply with the TENK scholarly criteria recommendations to ensure a trustable and worthy paper.

The research was conducted respectfully; There were no human factor in the research that would jeopardize ethical criterias in this research with the researcher showing respect for the subject matter, the data and the facts connected to the research. The research paper results and data were represented as best could be and as accurately as could be within the research journal source material's findings. Research questions were based on the validity of sources available and were open ended enough for a thorough and wide-ranging analysis of research sources.

The major concepts were clearly defined and identified to show the reader the what the subject matter is. Furthermore, the validity of the research questions and the sources used to try to answer the research questions, were unbiased and relevant to the questions asked. Thus, with the majority of peer reviewed literature resources, it can help to create an unbiased and free flowing analysis that did not allow for the author to lean towards one-side of the argument.

7 DISCUSSION

The literature review, is part of a larger, growing trend to create nursing and healthcare towards a more technological path, to increase patient safety and low nursing care times. The trend is already felt at the nursing student levels and sees backlash at times due to the amount that is being introduced (Kutscher, 2019). The aim of the was to produce a literature review of a technology that promises to do a lot for the nursing field (Baker, 2017) and healthcare. The topic of surgery is specifically because of the lack of Registered Nurses and other healthcare staff who cannot fill the ever-growing need for surgeries that the society needs due to a lack of training or self-confidence to enter the surgical field.

As a researcher, I found this topic to be complex; not because of the lack information, but because of the speculative nature of the data, due to a lack of general use in the field of nursing pedagogy or surgical nursing pedagogy, but also because in 5 years' time, it is possible to have completely different type of technology that allows for simulated learning to be done at home. It is also entirely possible, that the technology is not adopted on a wider level to the economies of scale being far more complex than first imagined. VR in the end of the day, is still a relatively new technology and new technologies cost money, time and require for there to be a focused way of using such technology.

Articles collected from the literature review tended to be of the medical medicine and not nursing medicine due to a lack of usage in the nursing field, however the principle remained the same and the data shows a clear trend that appears; VR in surgical or any settings work as they said they would, yet more investment, research and development of the program is needed. Other things that the data acknowledges is the need for student nurses to be given confidence

and clear communication in surgical wards. The confidence of a student is linked more likely with perceived self-happiness and ability to be self-determined successful (Neshuku, 2015). The more self-confident a (student/new graduate) nurse is and the better communication that a nurse receives as part of a surgical team, is also more likely to upkeep a positive post-surgical care recovery for patients (Neshuku, 2015; Pulijala, 2017). This is of a high importance due to a nurse's role being an advocate for the patient and responsible to the patient even outside the surgical room (WHO, 2009).

Nursing is a field that has changed in it's almost than 150 years since Florence Nightingale, yet the core has not changed which is patient care. VR can do a lot of things for nurses wishing to be surgical nurses, yet the technology is not completely proven either, yet and requires more drawing board due to development problems. Yet it is the author's personal belief that in the future, widespread technology usage is the way forward to create a better and well-educated nursing generation better than the generations that come before it. VR is one of those tools that will help the surgical nurses to earn their place with better experience in the future (see table 1).

If I were to re-examine this topic in the future, with the same research questions or similar research problems and similar to what has been produced, I would prefer to be able to be the primary source and be in charge of an experiment involving student nurses and their opinions when using VR and a control subject using the "traditional" practical methods. This would be when the technology is more mature. If this is not possible, then a study based on VR in other clinical nursing settings such as in CPR or in an emergency care setting, to ascertain if the benefit of VR in the training purposes, allows for a better patient survival rating after myocardial infarctions, etc.

8 CONCLUSION

In terms of the research questions the majority of nursing students face issues when learning surgical nursing yet the overwhelming opinion is that the surgical nursing curriculum could possibly be insufficient to meet the modern and future standards of surgical wards and that the practical lessons do harbor strong sentiments of confidence and self-belief in abilities. This may not be the truth for a majority of students, yet even if a few do not feel adequate for the rigors of surgical nursing, then there needs to be change.

Secondly, the state of VR nowadays has improved drastically in the space of 5 years from new market product or gimmick, to a serious piece of technology that has a majority of technology companies flocking to develop the technology further yet as of writing, several higher education institutions including my own (Turku University of Applied Sciences is in part of the 360ViSi EU+ program for VR procurement not only in nursing) have acquired or are in the process of acquiring VR/AR technology for usage in the nursing departments. The statement generated is that higher education institutions believe in the ability's VR technology have as a pedagogical tool, and that it is a profitable venture right now to go into.

Lastly, an overwhelming majority of users of VR find and believe in the technology's ability to change nursing studies in the future as previous chapters have discussed. The issues VR technology face as of right now have opportunities to be ironed out as the technology progresses, and Finnish higher education institutions believe it in so much, that they are investing some of their R&D money in VR technology, perhaps not for nursing but because of the other fields it could be used in. As of now, VR is marginally ahead of effectiveness compared to the traditional methods of surgical simulation training for nurses, yet the marginality could not be justified for Finnish higher education institutions for the large start up investment and R&D funds. However, in the near future, the situation could

change as distance learning becomes more and more of an educational trend, allowing for VR to be used within the home of the student, without there ever being the need for a classroom.

The results of the thesis therefore found that generally, VR technology gives a positive outcome of usage for student nurses in the surgical field. It is an “effective” pedagogical tool for teaching nursing students the different roles in a surgical room of a registered nurse and allows for a safe learning environment for students to learn, gain self-confidence to practice in surgical wards, while becoming acquainted with surgical room nursing roles. However, VR is not without its flaws. It is an expensive investment for any educational institution to start to jump into and at the same time, is still a fairly young technology that would require further development in terms of user comfortability, allowing for VR users to get acquainted to the HMD displays, while realizing the detachment from a real life into a virtual one. Furthermore, the potential ability VR to cause cybersickness is worrying for any user to jump into due the feeling of nausea and sickness that comes from the use of a technological tool. Additionally, some studies show that positivity stemming from VR are helpful to a majority of nursing students but not every student, yet other surgical nursing training factors should also be taken into factor. The keys to a successful surgical team is communication and trust. Young student nurses should be trained on how to communicate effectively as a part of a surgical team and from that, build lasting trust.

VR could be a technology which will lead the way forward into the nursing pedagogy future due to the cost saving, the long-term capabilities and also the realistic simulative capabilities. This isn't to say that VR will replace practical training, but the opportunity costs in not being a part of a VR lead field is a huge risk for educational institutions. VR technology acquisition should be very well planned and thought of within a nursing curriculum on how best to apply its greatest benefits and minimize its risks. VR technology should be best applied as steppingstone pedagogical mechanism or as part of a complement to traditional surgical nursing practical teaching methods, such as to gradually introduce working life skills and

develop nursing talent efficiently without having to worry about patient safety. VR allows for student nurses to practice their skills in the off time and better hone their talents for the surgical room so that they can thrive, because patient safety is of the most utmost importance.

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Appendix



- Figure 1. a normal, set up surgical room during a hip replacement. Note: amount of people within the surgical team, and quantity of the instrument boxes that are being used (Payne, 2016).



-Figure 2. A total knee re- placement instrument set using the Zimmer™ brand (Pinterest, 2016).



Figure 3: PrecisionOS surgical nurses training using VR technology

TABLES

<p><u>Strengths:</u></p> <ul style="list-style-type: none"> -More effective than traditional methods of teaching -Well-liked by majority of students -Large display of interest -Multi-functionality usage -Dedicated programs for nursing disciplines 	<p><u>Weaknesses:</u></p> <ul style="list-style-type: none"> -Sexist technology (Female sex being more susceptible to motion sickness) -Not comfortable to wear for longer than 15 minutes -Requires team of programmers to create a program; long term planning required -Cannot completely simulate 100% surgery -Surgical Nurses do not improve their skills dramatically (Bracq, 2019)
<p><u>Opportunities:</u></p> <ul style="list-style-type: none"> -Fast growing technology -Large investments by multiple firms and companies -Long-term investment -Potential for the technology to get cheaper as technology matures 	<p><u>Threats:</u></p> <ul style="list-style-type: none"> -Non-standardization of technology -Long-term investment -Potential changes in technology development -Expensive.

-Table 1: VR SWOT analysis

