Virtual University hospital as an arena for medical training and health education

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Master Thesis

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Abstract

The purpose of this thesis is to contribute to the virtual university initiative at NTNU with some initial recommendations for the early design and development of a virtual university hospital. The findings in this thesis are based on a preliminary study and two exploratory studies using a virtual operating room (designed to recreate a real one at St. Olavs hospital) with both medical and non-medical participants. The goal of the studies has been to explore how to support educational activities at a virtual university hospital. The first participant category was represented by surgical and anesthesia post graduate nursing students who conducted role play of realistic and relevant scenarios in the virtual operating room. The non-medical participants got a virtual guided tour around in the same operating room. Both participant groups provided suggestions for further development of the virtual hospital. We have also investigated the use of Oculus Rift, a 3D VR head mounted display, as a way of enhancing presence and immersion in the virtual hospital. The thesis highlights and discusses our most important findings that are as important to include in the development of a virtual university hospital, with suggestions of future work.

Preface

This document serves as a masters thesis in Computer Science at the Department of Computer and Information Science (IDI) at the Norwegian University of Science and Technology (NTNU). The duration of this work has been from January to June 2014.

I owe a thanks to my supervisor Ekaterina Prasolova-Førland who has supervised me through a whole year. Many valuable things have been learned through discussions and meetings. I am also very glad to have been a part of submitting a paper to CRIWG 2014 as a result of the work done in my thesis.

Many thanks is also directed to my team of proofreaders, Agnieszka and Haley, and to my friends and family for support and good times.

Lastly - thanks to Trondheim, NTNU and the student community who contributed to make these five years wonderful and memorable.

Contents

List of Figures

Part I

Introduction

1   Project Introduction

1.1   Motivation

St.Olavs Hospital in Trondheim is one of the most modern university hospitals in the world which is closely integrated with the Norwegian University of Science and Technology(NTNU). The hospital's main tasks are patient treatment, teaching of patients and their relatives, research, and education for health professionals [1]. These tasks are challenging in different ways, and we are to seek new ways of supporting their goals through the use of modern technology.

Virtual reality is a technology that has come far in its development considering technical aspect such as processing power and graphics, and possibilities within collaboration and availability. It is being explored and used more and more in educational purposes, especially within health as we will see example of in the related work section. NTNU has been using the virtual world of Second Life to host their virtual campus, which has been a part of an educational course organized and lectured for some years now [34]. St.Olavs and the faculty of medicine at NTNU consider to be present with a virtual university hospital which would be available for both public and health professionals.

Two articles about our work have been published in the Norwegian research magazine Gemini.no. Our exploratory studies conducted with post graduate nursing students have gained publicity as this is a new and exciting arena for conducting training and education of both medical professionals and the public [25] [24].

The motivation in this master thesis is to explore the use of virtual reality to overcome some of the challenges that resides within the tasks of today's St.Olavs University Hospital. There is an ongoing research(within the virtual university hospital initiative) at NTNU that is intended to provide practice opportunities for medical students and nurses as well as other opportunities for a general audience through 3D virtual learning environments. Examples would be such as contact with patients, technical skills, communication and

public health information. This master thesis will contribute to this initiative by establish some guidelines of how to begin the work in designing a virtual university hospital.

1.2   Problem Definition

Focus in this thesis is to explore the possibilities and necessities in the development of a virtual university hospital. This goes further into the topic of patient interaction and communication, both in the context of providing medical treatment, giving preventive care and health information in general. We will investigate what kind of resources and activities should be included in a virtual hospital, and also if new arising technology such as 3D Head Mounted Displays enhance the experience of the user, and thereby also the educational qualities.

Collecting data is done in two ways. First by using an already developed virtual training facility where post graduate nursing students have practised on typical real life situations in this flexible, risk-free environment using 3D VR glasses from Oculus VR called Oculus Rift. The second way is by inviting persons with no professional medical background on a guided tour around in the same virtual training facility. These participants represents the two main user categories of a virtual university hospital which is medical and non-medical professionals. The aim is to give these participants an idea for what is possible in order to get their thoughts and input to use in further development of a virtual university hospital. Lastly, a research on other types of health related environments and related work is conducted in our preliminary study in order to identify existing possibilities, challenges and best practices.

1.3   Project Context

This master thesis corresponds to 30 study points at NTNU. It is conducted in in cooperation with the Faculty of Nursing at the Sør-Trøndelag University College (HiST), and with contributions of subject experts from the Department of Neurosurgery at St. Olav who was involved to provide requirements and feedback for the design of the virtual environment. I have also received great guidance from my student supervisor, Ekaterina Prasolova-Førland, from the Faculty of Social Sciences and Technology Management.

The thesis uses data and information collected from previous project thesis conducted autumn semester 2013 with the title *Virtual Operating Room for Collaborative Training of Surgical Nurses*, as well as data collected in the period of spring 2014. The abstract from our paper of the previous project thesis is copied below with the purpose to make the reader aware of the basis of knowledge this master thesis build upon. The whole paper can be found in appendix A.

1.3.1   Project Thesis

Abstract
In this paper, we present the first results of a study on exploring how to support collaborative learning of surgical nursing students in a 3D virtual world. A Virtual Operating room, resembling the one at St.Olavs University Hospital in Trondheim, Norway was created in Second Life to accommodate an educational role-play. In this role-play, the operating nursing students could practice communication with patients and cooperation in the team while preparing patients for surgery. At the first stage of the evaluation, the virtual simulation has been tested among nine postgraduate nursing students. The participants gave their evaluation and opinions in the form of questionnaires and discussion after the role-plays. Following the analysis of the data, we present a summary of the most important results in this paper. This study discovered a number of suggestions for improvement of the learning outcomes when role-playing in a virtual environment. We demonstrate that an educational simulation can be implemented with limited resources, and yet be practically useful in education of health personnel. Further research with medical and nursing students is highly applicable and feasible, and should include a larger group of participants. The next stage of our work will be the evaluation of the simulation with nurses who are on an earlier stage of their study program.

1.4   Outline

Section 1 introduces the master thesis and its context.

Section 2 explains the methods and process applied during this study.

Section 3 looks at related work in the field of virtual health learning in a

systematic way.

Section 4 introduces the previous project thesis and experienced gained.

Section 5 explains the implementation of the two exploratory studies in this thesis.

Section 6 presents the evaluation from the two exploratory studies.

Section 7 discusses the findings with regards to this thesis' research question.

Section 8 concludes the findings discussed in section 7.

Section 9 explains the limitations and suggests future work.

2   Research Methods

2.1   Introduction

In this chapter we will present the research questions, and go through the process and research methods applied during work with this thesis.

2.2   Research question

The research question is as follows:

What educational activities should be supported in a virtual university hospital, and how?

The purpose of the thesis is to identify activities and solutions that should be included in the development of a virtual university hospital. It will be based on studies of related work, from the perspective of both medical professionals as well as non-medical professionals. The research question is divided further into two sub-questions:

Sub-questions:

1. *What educational activities, for both medical students and general public, should be supported in a virtual university hospital?*

2. *What are the content, facilities and technological solutions for supporting these activities in a virtual university hospital?*

2.3   Process

The process in this thesis can be roughly divided into six phases as shown in figure 1.
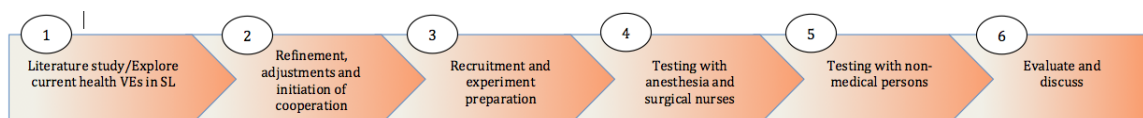
Figure 1: Process flow chart

Phase 1
This phase includes an exploration of existing health related environments

in Second Life, and an analysis of previous studies of using VWs in health education. Minor research on Head Mounted Displays were also done as this was used in experiments during this project as well.

Phase 2
Refinement of the thesis' scope were conducted in phase 2. We adjusted the test program and role plays based on feedback and experiences from the project thesis. Changes were made to improve the next experiment with surgical nursing students, and a cooperation with the anesthesia nursing students were initiated in order to include them as well.

Phase 3
Planning and preparation for the experiment with surgical and anesthesia nursing students were done in phase 3. This involved mostly administrative parts and technical set up, preparation and testing.

Phase 4
Recruited surgical and anaesthesia nursing students gathered at Campus Gløshaugen to test the virtual operating room by role playing scenarios, in addition to looking at a 3D-model of cranial nervous system.

Phase 5
Non-medical persons were invited to get a virtual tour around the operating room using Oculus Rift. This was done in order to show what possibilities a virtual university hospital can accomplish so that more ideas and thoughts could foment and be shared.

Phase 6
Analyze, evaluate and discuss the data gathered in the two experiments.

2.4 Literature study

The literature study in this thesis builds upon the study done in the previous project thesis conducted at autumn semester 2013 which focused on using Second Life(SL) as an educational platform for training health personnel like surgical nurses. This thesis, however, goes broader and looks at health related virtual environments in general. A search was conducted both in the world of Second Life as well as search engines like Google and Bing in order to discover related studies and existing virtual environments. A combination of the keywords below were used for searching:

- Second Life

- Health

- Hospital

- Education

- Virtual

- Training

- Medical

- Medicine

- Nursing

- Public

- Information

Not all of the studies regarding virtual health, education and training in Second Life had their environments open for the public in the virtual world, and some did not still exist. These were just presented through papers, blogs and pictures. The environments/places that were found and available in SL were visited and explored by using our own avatar.

2.5   Methods

This section describes the qualitative and quantitative methods used in this thesis to gather data. The methods described here were used during the two experiments conducted with a group of anesthesia and surgical nursing students, and later with a group of people with no medical background. Both of these groups experienced our virtual operating room as a facility for learning and training. The nursing students by practicing on realistic scenarios using role play, while the non-medical participants got a guided tour around the facilities(more about this in section 5). We combined both qualitative and quantitative data gathering(mixed method approach).

2.5.1   Quantitative method

The group of nurses were given a questionnaire consisting of 32 questions after the role-playing session. The questions were divided into the four topics explained below:

Questionnaire: Health-professionals

General
It included questions that covered their field of study (anesthesia or surgical nursing students), their competence in use of IT and computers, and if they had any earlier experience with Second Life or similar virtual worlds or games.

Virtual reality interface
The second topic included questions involving Second Life and the use of Oculus Rift, head mounted display(HMD) from Oculus VR. This could for instance be question about navigation in SL, the immersion experienced,if it was fun and motivational, or if the VE and role play gave a realistic feeling(especially considering the use of HMD). We also asked questions regarding cyber sickness or other positive/negative experience of using HMD to find out more how this would affect the role play.

Virtual learning and training
Most of these questions in this topic were copied from the questionnaire used in the previous project thesis autumn 2013 [16]. This was decided so one could discover possible positive or negative changes in the results, reflected by the development done in this thesis. These were subject-specific questions (using a five level multiple choice) about how much they believe role-playing in virtual operating room in Second Life would provide knowledge and skills given by the learning objectives. We added a question about 3D-model of anatomy as this was a new element in this master thesis.

Supporting facilities and tools
The purpose of the last topic was to cover the students opinion of what should be included in a virtual university hospital and how health personnel and other audience could use and benefit from this. There were mostly questions using check boxes such that the students could answer among predefined suggestions. They were, however, given open questions with the possibility to answer freely.

We created another questionnaire to use in the experiment with the group of persons with no medical background to gain their view. This consisted of 24 questions divided into four topics given below.

Questionnaire: Non-medical professionals

General
These were questions that covered gender, background, and their experiences with virtual worlds and games.

Hospital experiences

Their experiences of being a patient or a relative is an interesting aspect as this may have an impact on answers given. This section consisted of questions about former hospital stays. It was not required to answer these questions.

Virtual reality interface

This section is almost the same, although not as comprehensive as the one in the questionnaire given to the nursing students. All questions except those specifically regarding role playing(which were not conducted with this group) were used here as well.

Supporting facilities and tools

This last section dealt with their thoughts and opinions as non-medical users of a virtual university hospital. What is their interest of use, what information and resources would they want to have available, in addition to a subject about identity privacy and security.

2.5.2   Qualitative method

We used two approaches for the qualitative part of the data gathering. For the first experiment with the group of nursing students we used a screen and sound recorder application to make recordings from the nurses' role play. This resulted in four videos (from the four different scenarios discussed later) to be analysed. Secondly, a group discussion was facilitated with the group after the conducted role plays in order to get input that supplemented the questionnaire.

Additional data and analysis from the previous project thesis is included in this work as well. These are included as a summary in section 4 and will be used in the evaluation, while the whole paper can be found in appendix A.

The experiment with the group of non-medical professionals were not recorded as this was a short given tour where they just followed with an avatar and mostly observed. A short interview was conducted with every one of the participants at the end or their tour.

Part II

Preliminary study

3   Related work

3.1   Introduction

This section present some background information on virtual worlds and virtual reality in learning, and continues with studies of educational activities in related work.

3.2   Virtual worlds and virtual reality in learning

Virtual Reality (VR) have shown high potential for being a great supplement to education, which is reported by several studies [4] [27] [35]. This technology can benefit educational process due to low cost, high safety, three-dimensional representation of learners and objects, and interaction in simulated contexts with a sense of presence. Possibilities for collaboration, communication and interaction allow several different approaches in using 3D VWs as learning tool [46]. The world of education seems also to continuously expand their embrace of this type of learning as indicated by the yearly held conference of Virtual Worlds Best Practices in Education (VWBPE), which has grown to include more than 2000 attendees from 90 countries around the world(http://vwbpe.org) in short time.

There are other obvious signs of continuous expanding of virtual reality in education. There exists now several VWs to choose among to use for educational purpose, for example Active Worlds, Second Life, OpenSim and vAcademia. Even virtual courses have been designed to educate future educators to be more thoughtful and knowledgeable about the possibilities and challenges of VWs for education [38]. This seems to be a step in the right direction towards making VR an integrated part of education.

Virtual worlds can be used in combination with other virtual reality technologies, such as motion tracking, haptic devices and head-mounted displays to increase the sense of immersion and presence which further improves the experience and feeling of realism [11]. An example of educational usage is given

in a study using a virtual reality platform called ImmersiveTouch(developed at the University of Illinois at Chicago), to simulate the task of ventriculostomy catheter placement. The study reports that "the simulation platform was found to have realistic visual, tactile, and handling characteristics, as assessed by neurosurgical faculty, residents, and medical students" [19].

There are benefits of using 3D VR in healthcare education and training, for instance such as gaining first person experience, experiential and active learning as opposed to passive learning [23]. Health care workers and students may train on difficulty procedures and may test their skills with many different types of virtual patients, for instance within PBL scenarios [36]. As VR technologies are rapidly evolving, new future trends of virtual reality simulation for health care follows. This is something Ma, Jain and Anderson(2014) talks about in their book, *Virtual, Augmented Reality and Serious Games for Healthcare*, which includes location-based ubiquitous gaming, mobile apps and social media [21].

The following section will present an overview of some different virtual environments within the area of health education. Some of these are not accessible by the public or do not yet exist, but are included as they are examples of how to support learning. We have primarily focused on Second Life, and visited places available to the public(in the VW) in order to get first-hand experience. We have, however, included related studies conducted at other platform as well. The first sub-section starts with looking at different VEs and some examples of how they are used. We separate them into medical and non-medical usage. The last sub-section presents different facilities, tools and other solutions used to support educational activities in these environments.

3.3   Educational activities in virtual university hospital

3.3.1   Training of medical professionals

The Faculty of Medicine at Imperial College London(ICL) was early in establishing themselves in the world of SL [2]. They have developed a virtual hospital which contains different buildings with names such as polyclinic, well being, Long term care, staying healthy and buildings named with other health related subjects. These are located beside each other in a circle, and you are able explore all of them with your visiting avatar.

Figure 2: Welcome sign at Imperial College London

Their development of a virtual hospital seems to have the purpose of showing how this type of hospital could serve patients in the future, which is somewhat stated at a welcome sign in the starting area(figure 2). Based on articles on the internet and information communicated around on their virtual hospital area, it appears there are primarily three different applications that have been explored using this environment: training for healthcare workers, experimentation into different methods of teaching and involving the general public in learning about health care and health care planning [5] [20]. An article from CNN Technology gives an example of the first two where a senior learning technologist at Imperial College London is interviewed regarding a pilot program they conducted using this virtual facility in teaching medical students. The students are immersed in a game based learning as they pair up and get tasks to be solved in the virtual facility such as a respiratory ward [12].

USF Health at the University of South Florida has also settled inside the VW of Second Life. Some information is found at the starting point of their island. This is mostly about their university, including nursing and medicine faculties and related courses. However, a search on google with the words "USF Health second life" gave a resulting video showing a "how to get started" with Second Life and how to get to USF Health island in order to join in an virtual patient centered counseling. The video introduces a "virtual patient centred clinic" where the students are met with an immersive simulation of a standardized patient case scenario. The mentioned purpose is to give the students the possibility to practice their patient centered counseling skills by conducting interviews on virtual patients. [31]. The virtual campus therefore seems to be more than just used for student recruitment and representation of campus, although we did not find any activities or other avatars when exploring their campus.

The discipline of Surgery at the university of Sydney has their own virtual teaching hospital in SL(figure 3) where they have conducted a pilot study to explore the potential of using this for medical education [36] [37]. This virtual hospital has been created with the PBL (a teaching method used in medical education [10]) in mind, and comprises of the necessary areas such as reception area, lecture theatre, emergency room, surgical unit and hospital ward. Here the medical students can immerse themselves and collaborate with their PBL groups to solve assignments.

Figure 3: University of Sydney Second Life Hospital compound. Picture taken from [37]

A similar development has been done at the medical faculty at the university of Auckland (New Zealand), which includes many of the same type of rooms and facilities. The developers behind this states that a key element to success is to develop a comprehensive patient record data base with a wide range of clinical scenarios based on real-life examples. They practice not only on clinical skills however, but also on teamwork and communication. Therefore, other supporting facilities such as a patient ward and a nursing room are also found here in order to practice simulated patient interviews [6].

"Cranial Nerve Skywalk" is an exhibition created on the island of University of Kentucky featuring a 3D display of different cranial nerves(figure 4). This is a collaboration with the University of Western Australia(UWA) School of Anatomy, Physiology and Human Biology, where the purpose is to teach students various aspects of the cranial nervous system by using simulated 3D models. From a comment in UWAs blog on blogspot, Dr Richardson-

hatcher(one of the creators) comments: "Our healthcare professional students study 3D models of the cranial nerves to begin to demystify some of the complex routes these nerves take to reach their targets. Our undergraduates benefit from the social aspect of Second Life as they meet weekly for Team-based learning sessions with their classmates for the discussion of regional anatomy[..]" [29]. The Cranial Nerve Skywalk shows a different example of how to use a VE in educating medical professionals. As mentioned initially, virtual worlds such as Secod Life gives many possibilities with its powerful toolbox in creating any object. This could as well be 3D models of the human body or organs to be used for educating medical professionals.
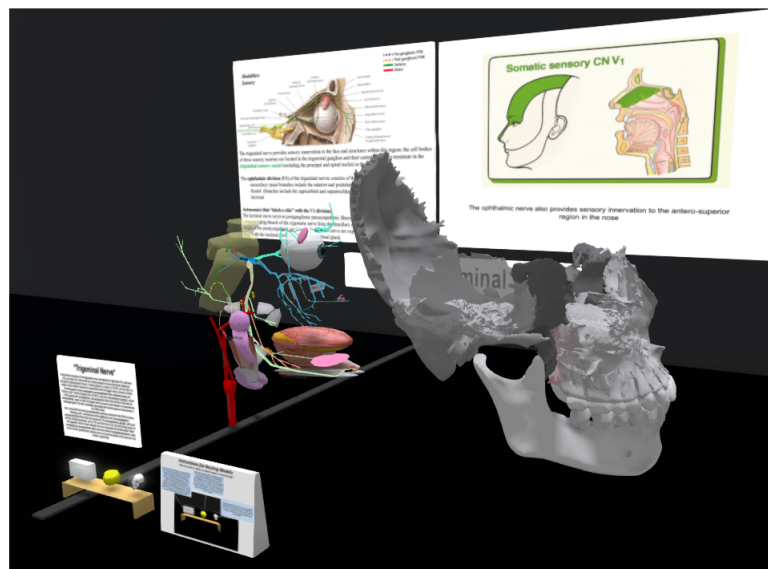
Figure 4: Cranial Nerve Skywalk

Another possible area of the application is training on disaster management on a larger scale. This often includes thousands of people which makes it hard to replicate in real life. It requires a lot of planning, preparation and drilling if it were to have any value, and it often costs a lot to conduct. The Center for the Advancement of Distance Education(CADE), a self-supporting unit within the School of Public Health at the University of Illinois in Chicago, is specialized in creating training environments and simulations for such big scale catastrophic events [8]. An example would be their Public Health Preparedness Island. This is a chain of islands that offers a variety of urban and rural environments with customized buildings, objects, and scripting tailored

to emergency scenarios. These scenarios ranges from pandemic influenza to bio-terrorism and dirty bombs [41]. These virtual health preparedness islands have restricted access in Second Life, however, an article was found including a video and a short interview with personnel from CADE, which gives a small impression of how this works [13]. We should mention that similar work has been going on at the Institute of Rural Health at Idaho State University where a group of people have been in the business of providing virtual training for emergency personnel for the past several years. Their VE, called Play2Train, is created in Second Life with support from the Idaho Bioterrorism Awareness and Preparedness Program [40]. The founder of play2train, Ramesh Ramloll, explains that by providing a virtual replica of real places and objects, Play2Train imparts a sense of plausibility within the virtual setting, allowing immersion of the participants in the virtual scenarios".

Hearth Murmur Sim is another way of organizing simulation in the world of SL. This was an environment where students walked around in a building with wards full of patients. They had the possibility to listen to real heart beats and cardiac sound in order to undergo cardiac auscultation training. Students were presented different patients in these virtual wards where each of these had audible heart beats on different locations on their chest that mirrors real life stethoscopic listening points. The heart beats vary from normal beats to more serious heart conditions, and the students were able to listen and train under calm conditions in contrast to what they may be experience if they where to do this in real hospital wards [26] [18]. This virtual place does unfortunately not exist any more, but a clip from youtube dated back to 2006 shows an avatar going around in this heart murmur sim and listens to the different patients in addition to answering accompanying questions [15].

Figure 5: Maternity ward at the virtual island of University of Nottingham

A noteworthy place in SL is the maternity ward which is located on the virtual island of Nottingham University. Students, to become midwives, can practice their skills in communication and midwifery. It is an open house consisting of equipment and artifacts to use in role playing a birth scenery or conducting demonstrations as can be seen in figure 5. This place is open for the public, and may be a good way to conduct demonstration and education in this field for both medical students and public. It is easy to find your way around this house as they have lines on the floor directing you to the correct facilities. A video tour of this maternity ward with more demonstration is available on University of Nottingham's YouTube channel [28].

A study with a different group were conducted in vAcademia 3D virtual world(http://vacademia.com/) where a simulated training environment were created in order to conduct training of medical personal managers. This study describes a simple training session where a trainee answers a pre-recorded call from potential client before choosing what to answers from a given set of textual alternatives. This simulation uses a programmed bot/npc to assist the trainee in answering. An interesting element is the feature to record these training sessions so that it can be revisited and evaluated afterwards [7].

The last and interesting example is a study conducted at Arizona State University where they designed a simulated learning platform for Advanced

Cardiac Life Support(ACLS). Active Worlds (activeworlds.com) was chosen as a platform in this study, and their virtual environment consists of elements to be used in a simulated training to teach novices the procedural aspect of ACLS. The interesting benefit shown in this study is the use of a haptic device which is connected and integrated to Active Worlds in order to simulate CPR properly. The picture below(figure 6) is from their article [30].

Figure 6: A participant performing CPR on a haptic device

3.3.2   Educating general public

We did not find many health related virtual environments directed towards education of patients and the general public. There were merely three discoveries of virtual environments with focus on public education. Two of most prominent were Health Info Island and Virtual Ability Island, two virtual islands located next to each other in Second Life. These island gives a good idea of how to share information about health care in an virtual world to the

public. The purpose of health info island is to make topics within physical, emotional and mental health accessible for the public, while virtual ability island is developed for people with disabilities or chronic illnesses [42]. A study conducted using the virtual ability island, where they aimed to explore how people with learning disabilities(PWLD) can use virtual worlds to experience a self-perceived improvement of social participation, independence and well-being. The study reports that the participants perceived that they obtained increased independence, social participation and well-being [39].

Both of these islands are maintained by Virtual Ability, Inc, a non-profit corporation located in Colorado, USA. Given from their web page, their vision is to be the leading provider of services and information for people with disabilities in online virtual worlds, and their mission to enable people with a wide range of disabilities by providing a supporting environment for them to enter and thrive in these same worlds [43].

(a) Subject: Depression   (b) Arrows guiding
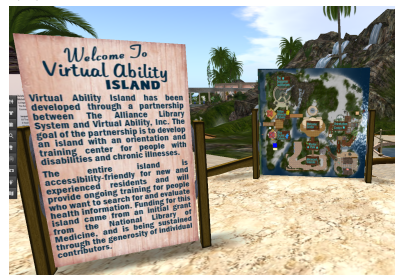
(c) Orientation   (d) Event Schedule

Figure 7: Health Info Island and Virtual ability Island

These two islands are very intuitive in that information is presented on posters which is organized and easily found. There is a great variety of information that include topics such as "health and wellness", depression, "personal health record and you", "Your brain", Chronic Illnesses, disability and more. Arrows are sometimes displayed on the ground where they point

out where to start and which direction you should walk when reading (figure 7). There were two more notable things we came across in these islands. The first was an easy tutorial of how to move and interact with artifacts which was very intuitive and well designed. The other was when we met a volunteer during our exploration. This volunteer approached and offered to be of assistant in answering questions. According to their web page, such volunteers can assist with creating a personal reading list so that one can get better educated. They organize presentations as one can see in figure 7d where a schedule, located in the middle of those two islands, displays time and date of different events.

The last example found were Imperial College London, which seem to (in some extent) direct themselves towards the general public. This was discovered when exploring around with our avatars as we saw different poster with health related news that hung visible on walls around on some of their buildings. There are two pictures below that show examples using posters to display dentist information and how to quit smoking(figure 8).

(a) Dentistry   (b) Quit smoking
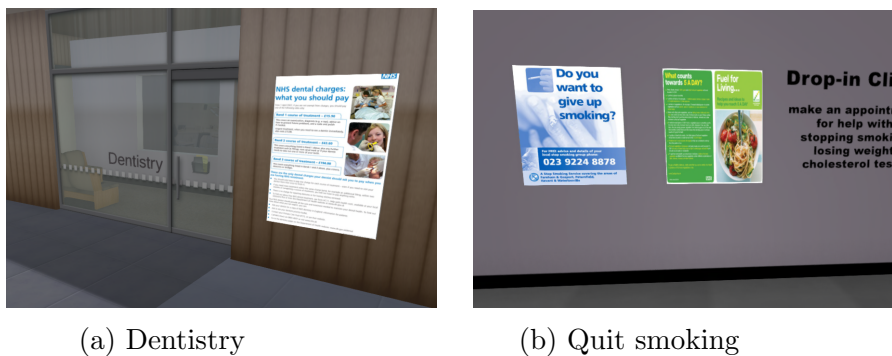
Figure 8: Information posters

3.4   Content, facilities and technological solutions for a virtual university hospital

The previous sub-section presented some related environments and their usage areas among both medical and non-medical users. The common factor for all these places is that their purpose and goals are to educate students within medicine and health, or the general public. They all have different approaches, and the sub-section below present these using a similar systematic structure taken from the paper *Place Metaphors in Educational CVEs: An Extended Characterization* [32], as this gives a clear and easy overview.

3.4.1   Virtual places: appearance

There were some difference in the appearance of the visited VEs. While some
places did not look very realistic or "medical" at all, others(and the majority)
went far in creating realistic looking medical environments such as hospital
areas similar to the real world. Which would benefit students who then get
the opportunity to train in environments they will later be using in real life.
Expose the students to a virtual re-creation of a real operating room with the
possibilities to explore and interact may contribute to preparing them, and
make them feel more confident before entering an operating room in real life.
Pictures below are from University of Auckland, and show some examples
from their facilities in their virtual hospital(figure 9).

(a) Emergency room   (b) Emergency entrance

(c) Patient ward

Figure 9: Pictures taken from [6]

Another type of example from related work would be CADE at the Univer-
sity of Illinois, who is specialized in creating real looking environments and
catastrophic events. They re-created the city of Chicago together with an
emergency scenario where public health workers can train on saving their
city from smallpox outbreak [13]. Similar example from the Norwegian Uni-
versity of Technology and Science (NTNU) is their virtual Afghan Villages
created for the Norwegian army in order to prepare soldiers for the Afghan
culture and norms [33]. The virtual village is created as an arena for this

purpose, and it is therefore logical that this to a large extent should resemble a real Afghan village, as would be the essence of this type of training.

USF Health at the university of South Florida has replicated their campus from real life in a very detailed manner. For instance the Carol and Frank Morsani Center for Advanced Health Care located at the USF Tampa Campus. Figure 10 shows a real image(taken from commons.wikipedia.org) besides an image taken from the virtual world. One can see that it is fairly detailed re-created in Second Life. This is only an example, as they have re-creations of other buildings there as well.

(a) Real Life   (b) Second Life

Figure 10: Carol and Frank Morsani Center for Advanced Health Care

Realistic appearance contributes to higher valuable learning as it is easier to adopt experience to the real world. The picture below is taken from Medill Reports in Chicago which shows an example of emergency training in the virtual city of Chicago.

Figure 11: Picture taken from Medill Reports, Chicago

3.4.2   Virtual places: structure

Many of the different places visited had some things in common. They expanded in vast areas making it time consuming to move around. Many buildings were large, making it easy to get confused and lost when inside. Some places were structured so that it was not intuitive to know which direction to move towards in order to arrive at the desired destination. It can be both frustrating and inefficient, so much that the environment would lose its purpose and value for the users. However, some places seem to cope with this by having intuitive and supporting solutions.

The SL viewer offers a world map where you can enter coordinates, click on the map or search for a place in order to teleport your avatar to a desired location. These are not appropriate alternatives if your do not know your destination or are not familiar around the island. USF Health use the solution of simple road signs where you can click on a sign to teleport to the respective location, while the Virtual ability island made their own map with place names and the same ability to teleport when clicking on a desired place. The latter is experienced to give better orientation considering the whole island. The same problem also includes when you are walking inside buildings. It is too easy to get lost and waste time trying to find your way. The Maternity Ward has found a simple solution with colored lines on the floor to guide your avatar in the right direction inside the house. A virtual university hospital should have an entrance point, similar to the one at USF Health(figure 12d),

where the visitors can start orienting themselves before walking or flying around and exploring.

(a) Road Signs

(b) Map
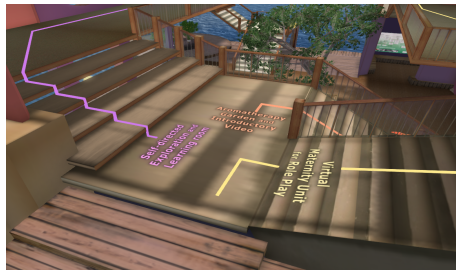
(c) Direction lines
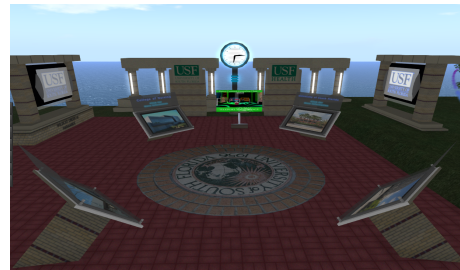
(d) Entrance point

Figure 12: Different orientations possibilities

3.4.3   Virtual places: roles, functionality and content

Facilities like reception area, lecture theater, emergency rooms, surgical unit, hospital ward etc, are some examples which may be a part of a virtual university hospital. Those different places and facilities have varying needs of supporting content depending on their role and functionality. To list all possible content we have come across in our related work study would probably lead to more or less a very large and worthless list. We will therefore present only a -few- hand picked examples that are considered the most relevant to include in an early version of a virtual university hospital. This content is regarded as great and simple solutions in order to get started with sharing information and conducting simulation. We will discuss how these examples can support facilities that are desired by our medical and non-medical participants in section 7. A list of the content is shown below, and followed by descriptions.

- Posters and Videos
- NPCs

- Heads Up Display

- Lab and medical equipment

- 3D display models

- Volunteers

- Tutorials

Posters and Videos

Posters can come in various shapes and format. They are easy to create and use, and can be put almost anywhere. It is also possible to use real images as posters such as the one seen below, an example of a poster from Imperial College London. Posters would be appropriate to use in public spaces where the purpose is to direct information towards the public. Too much of these, however, would probably be messy and disruptive and give the feeling of being in a hospital sponsored by advertising.

Figure 13: An information poster at the Imperial College London virtual hospital

Videos are, just as posters, easy to implement with the functionality given in Second Life. We first discovered this when exploring the area of Imperial College London which had a recording continuously playing at the starting area. Sound and video quality was perceived as acceptable, meaning that one could both listen and observe what was going on in the video. The picture below is from our visit to Imperial College which had a video continuously playing in the background of a lecture area. Videos would be great to use in areas such as seminar rooms, research exhibitions, at a welcome area or even in medical facilities such as in an operating room.
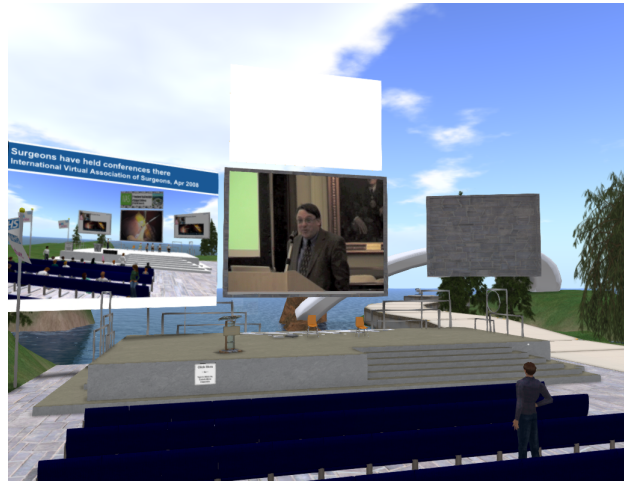
Figure 14: Video playing outside Imperial College London virtual hospital

NPCs

Non-Player Characters (NPCs) have many areas of application which can be useful. A visit to the Allied Health And Science College in Second Life gave an example of how to utilize NPC in health related matter. We found an NPC we could ask some simple questions, and one that demonstrated the use of brain scan (picture below). NPC can be used in several facilities at a virtual university hospital. For instance as a receptionist, paramedic, nurses, doctors, or even play the role of patients or audience. A benefit with using NPCs are that they can be available at any time, making a virtual university hospital operative all the time. Students can use them in training with simulated patients, and audience can ask questions and get simple guidance.
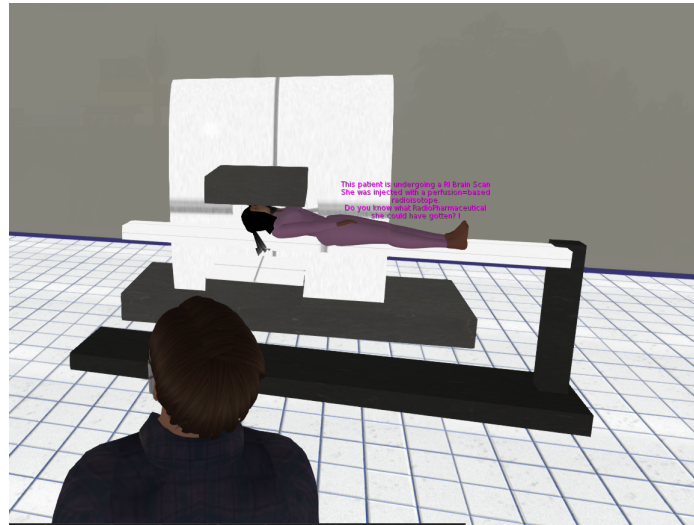
Figure 15: Example of a NPC demonstrating the Brain Scan at the Allied Health and Science College in Sl

Heads Up Displays

A video tour around the virtual hospital of University of Auckland, you can see an example of how the emergency room is equipped with items such as a huge black information board on the wall above the patient bed(figure 16b). The information on this black board is controlled by the users, typically an instructor and student. They use Heads Up Displays(HUDs) in order to adjust the information on the black board (figure 16a). These HUDS can only be seen by the player who has access to it, and it functions as a control panel for that player. A student typical control information regarding medication and IVs, while the instructors have the possibility to adjust information about the patients vital conditions as a response or consequence to the actions made by the students. Such solution using a HUD and information display seem to be a good way for communicating actions and patients information.

(a) HUDs   (b) Information board
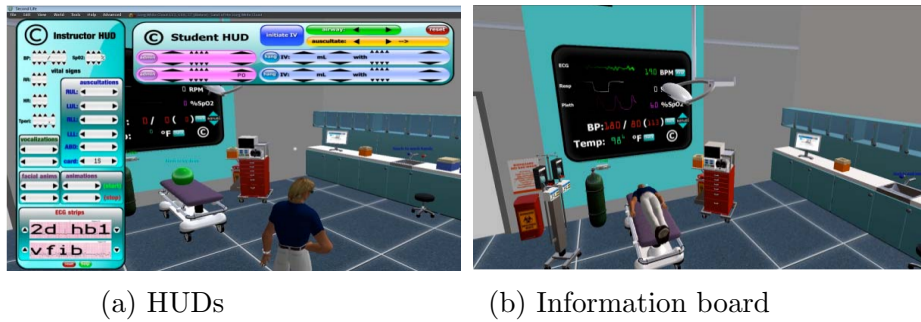
Figure 16: HUDs to control the information board. Pictures from [6]

Lab and medical equipment

As one can see in figure 17, patient equipment, furniture such as patient bed, and other medical equipment are a part of the room. We have seen this in those studies with a virtual hospital as their environment, and it is not unnatural to include such equipment in these environments. It is a part of the scene, and should be integrated in order to make it more realistic. They may, however, not only function as a view, but could as well be interactive objects that can be used by the users. The picture below is another example from the same study conducted at Auckland University.

Figure 17: Equipped nursing simulation room

3D display models

University of Kentucky has been successful in creating an exhibition with

3D display models of cranial nervous system. Such models would benefit
the students learning as they would be able to visualize instead of just read.
Virtual reality makes it possible to create such 3D models which students can
study or even "dive into" to explore them. Such content would be ideal for a
virtual classroom used for anatomy lectures, or even for a public exhibition.
The picture below shows an example from the "Cranial Skywalk".
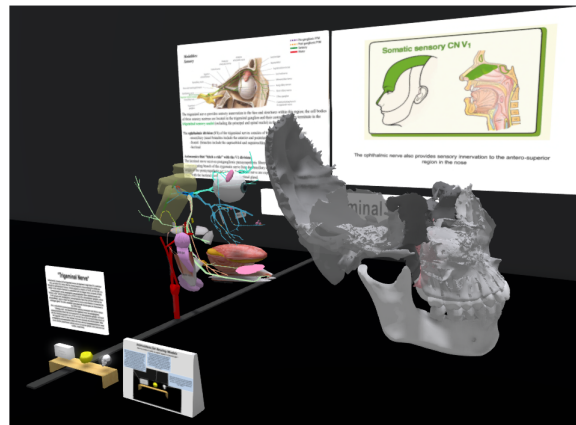
Figure 18: The Cranial Skywalk

Volunteers

Recruiting volunteers is a great way to enhance your virtual environment and
making it more credible and trustworthy. There were an example of using
volunteers at the virtual ability island who assist you in finding relevant
information in your situations. Volunteers can for instance be used to assist
the public visiting a virtual university hospital, guide them to correct places
and answering practical questions. There are many useful possibilities, and
this option is great way to enhance the value of a university hospital and
make it more "alive" and attractive.

Tutorials

It is important to know how to navigate to different locations around in
the environment. In Second Life, the users are both able to walk, run and
fly, but not all(especially first time users) may know this. Know how to do
basic movement with the avatar is highly essential if the user is to do more
and gain any educational value. With a virtual university hospital in mind,
one cannot expect that all of the visitors and new users have the proper
technical knowledge to move around in your facilities and utilize them fully.
The virtual ability island stands out as they have a creative, thoroughly

detailed and enjoyable tutorial made on their island. This tutorial is made
as a path with posters and figures along the way to show you how to do
basic movement. You start with the most basic such as navigating with the
keyboard arrows, and progress to more challenging things along the way.
Some selections of the path are shown in figure 19. This is a highly intuitive
and easy way of learning, and one can any time walk the tutorial path again
if one needs to refresh their memory.

(a) Real Life

(b) Second Life

(c) Real Life

(d) Second Life
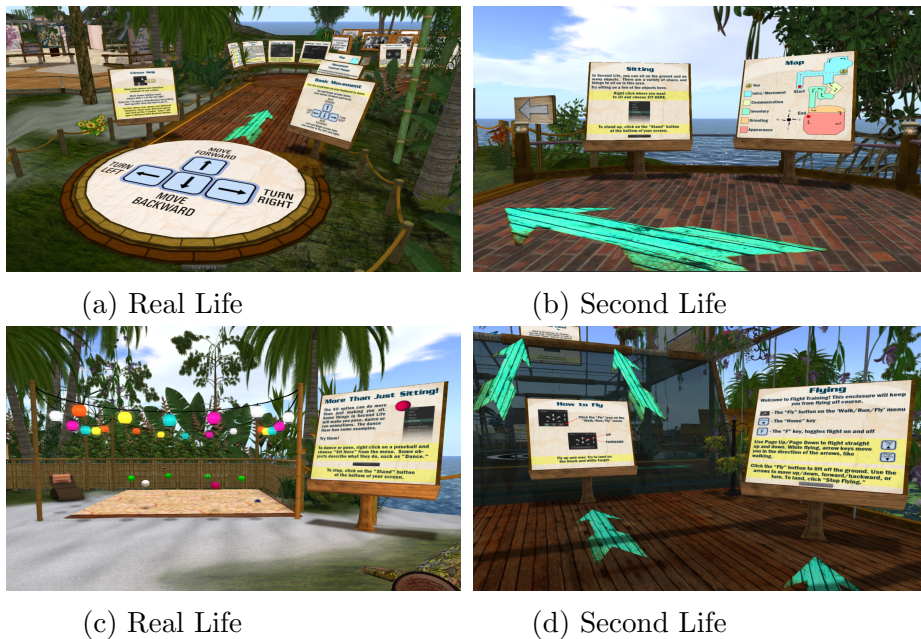
Figure 19: Tutorial: basic movement

3.4.4   Virtual Reality interface

Technology has also made it possible to use different interfaces in the context
of virtual reality. These include Head Mounted displays, motion tracking
and haptic devices. This section presents an overview of the history of head
mounted display and the Oculus Rift which we used in this thesis. Combining
such technology with virtual reality may contribute to new possibilities in the
world of education, and is therefore decided to be included in our exploratory
studies. We have also included short description about motion tracking and
haptic devices in the end to raise awareness about these technologies, but
they are not used in this thesis.

Head Mounted Display

Head Mounted Display(HMD) is an aspiring technology which is about to approach the ordinary consumer market in time of writing. HMD existed since back in 1961 when a company called Philico Corporation made the first head-mounted display called Headsight [9] [45]. The technology has been too expensive for ordinary consumers, making it mostly used and developed by researchers and military. However, with Oculus VR and other big actors such as Sony in front of this development, HMD will become available for ordinary users to purchase and use at home [44] [22]. The potential of this type of interface has been seen within health care education as well as discussed in a newly published story in MedCrunch(April, 2014) [48].

We used Oculus Rift in our thesis, which is a lightweight head gear(figure 16). It has a field of view (FOV) of 90 degree horizontal and 110 degree vertical, and there are different sensors implemented so that it can follow the movement of head and body. This makes it possible to create a high sense of presences in virtual space. A user moving his/her head from left to right will experience that he/she is looking from left to right in the virtual world. From a speech at The Games for Health Conference held in Boston in June 2013, the founder of Oculus VR, Palmer Luckey, said that Rather than controlling something on a screen you can be present in a virtual space and control everything in a natural way. The citation is given in an article from Medical Device and Diagnostic Industry(MD+DI) where they report that research has shown that VR makes it easier to evoke emotions in users. [50]. Another study made at the Bournemouth University where they tested Oculus Rift and immersion through fear obtained results that provided evidence towards the Oculus Rift being the superior display device(compared to a regular computer monitor) for immersing players [11].

(a) Front view   (b) Back view
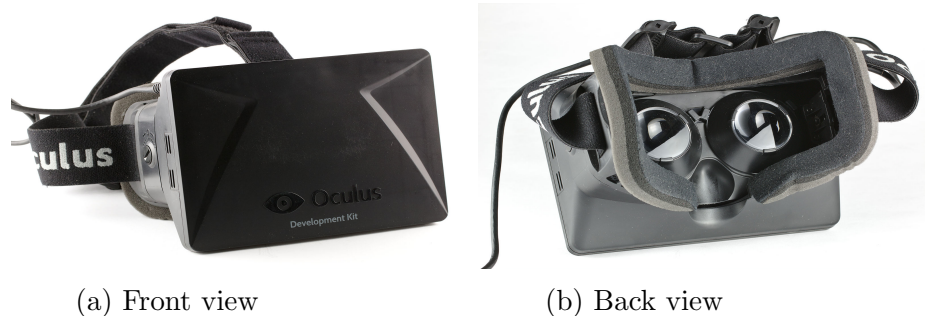
Figure 20: Oculus Rift. Picture taken from wikipedia.org

There are a few issues to consider when using HMD. The first is the size and weight of the device considering that the user will spend some time wearing it.

If it is too large, too heavy or sit too loose, it would be uncomfortable to wear or make the user quickly exhausted. The second is the heat generated when wearing, as to much heat will also make the user feel uncomfortable. The third is about simulator sickness which can be caused such as headache, eye strain, nausea and dizziness. These things are considered in our experiment (when using Oculus Rift) as we will survey any issues experienced.

Motion Tracking
Computer technology which gives the possibility to track movements of both hands, feet and the entire body is on a rise in its development. One example is the Leap Motion(leapmotion.com) which is a tiny tracking device that is connected through a Universal Serial Bus (USB) to a computer. This is a device that is placed in front of the screen in order to track hand and finger movements. Simple hand and finger gestures can be easy configured to match a mouse or keyboard function in order to replace these. It is still not yet sufficient, and more development and support needs to be done before this should be included, but it might be possible in near future. Another type (and maybe more complex) device is Microsoft's Kinect which can be purchased for both their X-box gaming console or a windows pc. The kinect has the possibility of using voice as well.

The combination of using head mounted display and tracking devices together with virtual reality can enhance both presence and immersion, and create great possibilities and innovative ideas within the field of education. These technologies are continuously developed and improved, such that this should be kept in mind when developing a virtual university hospital like St.Olavs.

Haptic devices
An example of using haptic devices was given in sub-section 3.3 from a study where this was used in a simulated learning for Advanced Cardiac Life Support(ACLS). The word haptic has its origin from the greek word haptikos which means being able to grasp or perceive. The haptic phenomenon is a part of our everyday life, and can be found in the vibration of our smart phones or gaming controllers [14]. This is information given to our other senses when we touch and perceive. Haptic devices are therefore mechanical devices that mediate communication between the user and computer by letting the user be able to touch, feel and manipulate 3D objects in a virtual environment [3]. Below is a pictures with examples of haptic devices.

Figure 21: Example haptic devices

4 Project thesis

4.1 Introduction

This master thesis builds upon experiences gained from our previous project thesis with the title "Virtual Operating room for training surgical nurses" that included experiment conducted autumn semester 2013 with nine post graduate nursing students on their last year of study [16]. These participants were introduced to real life scenarios in our virtual operating room where they role played as either patient, relative or nurse. The purpose of this section is to give the reader an overview of the knowledge gained after the evaluation from this previous experiment which is used during further implementation in this thesis. For a more detailed version, the reader is refereed to our paper in appendix A.

4.2 Summary and requirements

The previous project thesis generated some requirements to follow in the next iteration. This included adjustments to participants, role play and interface. The experiment took place 27th of November 2013 were nine post graduate surgical nursing students participated and gave their evaluation. Following is a short summarize of the most important and relevant feedback and results that is transformed into requirements which forms the next steps in this thesis.

R1 - Include anesthesia nursing students
Surgical nurses collaborate most often with anesthesia nurses at the operating room. We observed during role play that anesthesia nurses or doctors were frequently mentioned in the dialogue between the surgical nurses and the patients, and that the role play started to halt at this point. It became

very clear that anesthesia nurses should be included as it would have been natural for them to take over some of the interaction in the role plays, as the surgical nurse could not proceed with their tasks without them doing their job. This would have greatly improved the role play as this is more close to real life. The next step would therefore be to invite both surgical and anesthesia nursing students to our nest exploratory study.

R2 - Conduct exploratory study with non-medical participants
This master thesis goes broader as we are looking at a virtual university hospital for both medical and non-medical persons. We therefore included participants who represent this group as well in an exploratory study.

R3 - Use teachers in role playing
Patient, relative, ward and surgical nurse were the four different roles that were played only by the students. It was revealed during the evaluation that this can lead to implications as a fresh student would probably not be able to act adequately enough as patient or relative. With little or no experience from real life, a student would not know how he or she should proceed in an acting, and thus making it challenging enough for their co-students. This would affect the role play and learning in a poor manner. It was decided in cooperation with the teachers that they would play the role both patient and relative during the study with the nursing students.

R4 - Enhance role play with better sound quality
There was a technical challenge using the voice chat in SL. We divided the playing students in two groups and placed them at two different offices. Some echo were therefore experienced when the person next to you talked into the microphone. This was reported disturbing when role playing, and the students were told to ignore it as best as they could. However, we invested more time in order to eliminate such disturbance in order to enhance the quality and potential learning outcome.

R5 - Include 3D Head Mounted Display
As we role played using ordinary screens in the project thesis, a step further would then be to explore the possibilities with the use of 3D Virtual Reality using HMD. We therefore acquired three Oculus Rifts(Section 3.4.4) to be used in both exploratory studies with medical and non-medical participants.

Part III

Study results

5 Project implementation

5.1 Introduction

It is essential to include future potential users in the process when trying to establish some basic design principles to be used in development of a virtual university hospital. One aim in this thesis is therefore to conduct two exploratory studies where the users are roughly separated into two categories: medical professionals and those without any medical background.

This chapter describes the preparation and implementation in advance of and during the two exploratory studies conducted in this thesis. This includes phase 2 to 5 which is described in figure 1, sub-section 2.3. The first study was conducted on March 24 with a group of medical professionals, while the second took place on 8th of May with participants without any medical background.

5.2 Participants

We recruited postgraduate nursing students from the faculty of Nursing at Sør Trøndelag University College(HiST) to our first study. We followed requirement **R1**(sub-section 4.2) were we included both surgical and anaesthesia nursing students on their first year of education. These have in common that they already have a bachelor degree in nursing and at least two years of professional work experience, which make them highly suited to evaluate and give feedback in our project from a medical viewpoint.

The participants recruited to our second study were people with no professional medical background (according to **R2**. These may have been in past situations as either a patient or relative at a hospital, or perhaps with little or no experience at all which they do remember. These are in any case important to include as they will look at this with different eyes and give feedback that represent the other category of users.

5.3   Virtual operating room and role play

A virtual operating room already existed to our disposal at the virtual campus of NTNU before this project. The operating room was developed during the mentioned project thesis(section 4), and has not changed since its last iteration back then. This environment were used during the two exploratory studies discussed in this paper. Requirements and description of the virtual operating room can be found in [17].

Role plays were conducted only during the first study with the nursing students. The same four scenarios used earlier during project thesis were used here as well except from some changes according to requirement **R3** from sub-section 4.2. We divided the roles differently such that the teachers from the faculty of nursing played the role as both patient and relative this time, while the students focused on playing the role as nurses. Anesthesia nurse was included in the scenarios as the third role in addition to the already existing ward and surgical nurse. The students were to play their future role accordingly except from the surgical nursing students who also played the role as a ward nurse. A description of the four scenarios are given below.

Learning Scenario 1

Actors: A woman (patient), surgical nurse, anaesthesia nurse and ward nurse

Plot: A 35-year-old woman is admitted to the gynecological department. She is on her way to a surgery for an abscess that will be operated in spinal anesthesia. She lies on a patient bed transported by a nurse from the ward who delivers her to the surgical nurse.

Learning Scenario 2

Actors: An immigrant woman (patient), husband (relative), surgical nurse, anaesthesia nurse and ward nurse

Plot: An immigrant woman is going to a scheduled hip operation. She will have general anaesthesia during the procedure. Her husband comes with her along with the nurse from the ward. She speaks poor Norwegian, and her husband must therefore be there to translate. She is concerned with keeping her hijab on and wishes to be treated by female personnel only.

Learning Scenario 3

Actors: A young boy (patient), his mother (relative), surgical nurse, anaesthesia nurse and ward nurse
Plot: A five-year-old boy arrives to a sluice with his mother and nurse from the ward. He is going to recto- and gastroscopy.

Learning Scenario 4

Actors: A man (patient), surgical nurse, anaesthesia nurse and ward nurse
Plot: A man in the age of 40 is going to surgery because of a malignant brain tumor. He has been through radiotherapy before when the tumor was too large for surgery when it was discovered. He has two teenage children that he alone is responsible for back home.

5.4   Preparation

First session with the nursing students required most preparation as there were up to five people (including students and teachers) who would play simultaneously. This was in contrast to only having one at a time during the second study with non-medicals. We acquired two rooms for the first session, while only one room was necessary for the second. Figure 22 below displays a list of all equipment used in both studies.

March 24	
Quantity	*Equipment*
5x	Keyboards and mouse
	Computers with power cable and internet connection
	Computer Screens
	Headsets with michrophones
3x	Oculus Rifts
May 8th and 9th	
Quantity	*Equipment*
2x	Keyboards and mouse
	Computers with power cable and internet connection
	Computer Screens
1x	Oculus Rift

Figure 22: List of equipment used in the two exploratory studies

Re-use of the virtual operating room, the avatars and scenarios from the project thesis led to less things to prepare prior to the two exploratory studies. However, some time were spent to prepare the technical set up of computers with appropriate necessary equipment for the first session with the nursing students. Experiences(from project thesis) with bad sound quality when using voice chat in Second Life resulted in requirement R4 (section 4.2) which were this time carefully configured and tested. Quite some time were spent on this in order to obtain an adequate sound quality which means that no echo or noise should be present when using the in voice chat. This would presumably enhance role playing experience. The second study required only two computers with no need of sound and voice chat, which made it easier to prepare.

5.5 Exploratory study with nursing students

Twelve post graduate nursing students participated this day. This group consisted of six future surgical nurses and six future anesthesia nurses which were divided further into two mixed groups containing three of each type. Both groups followed the program given in figure 23 below.

Program
1. Introduction
2. Get familiar with Oculus Rift and navigation
3. Visit and explore anatomical 3D model
4. Role play - Communication & Collaboration
5. Questionnaire & Discussion

Figure 23: Program: post graduate nursing students

We started out with an introduction to the idea of a virtual university hospital, the purpose of this study and the program to follow. All of them got to try on Oculus Rifts and move around in Second Life in order to get used to the 3D feeling and navigation. We gave each of them a quick tutorial while they played around with their avatar. Around half an hour were spent on this as the students began to get hold of both movement and navigation.

We continued with a visit to look at the Cranial Nerve Skywalk, located at the island of University of Kentucky, to look at their 3D display of a cranial nervous system. The purpose of this visit was to give the students an idea

of how one can use a virtual world such as Second Life to create anatomical models in 3D to be explored and used as a supplement in education.
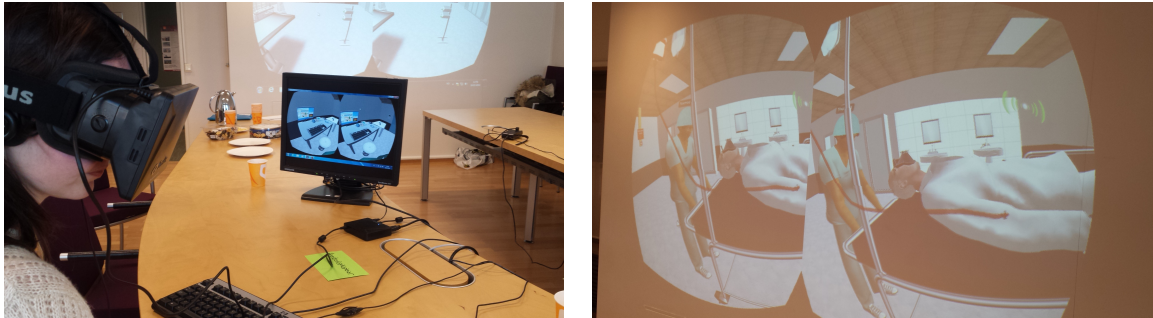
(a) A student with Ocu-
lus rift

(b) Role playing in rift
mode

Figure 24: Nursing students using Oculus Rift

After visiting the Cranial Nerve Skywalk, the students got ready for conducting role plays in the virtual operating room. This was organized such that the teachers and students sat in different rooms playing against each other. The teachers took the role of both patient and relative, while the students played their associated role as anaesthesia and surgical nurse. The students were given a fictive medical surgery programs(see appendix B) with an overview of the different patients, and they were to act their given role as best as possible.

Both group sessions ended with a questionnaire and a discussion where our aim was to obtain their viewpoint on things experienced during the exploratory studies, and other thoughts, ideas and input in the context of a university hospital.

5.6   Exploratory study with non-medical

A virtual university hospital is also to be used by users that have no professional medical background. We therefore recruited twelve people to participate in a guided tour around in the virtual operating room using Oculus Rift. This was carried out by having two computers beside each other which we could give one and one participant in turn their own private tour. They were given the possibility to ask questions while walking around inside the virtual operating room. The intention was to give them an example of how such guided tours could be conducted as we would want their opinion and

point of view. Our goal was to investigate their use and needs of a virtual university hospital. A questionnaire and an interview where conducted at the end of each tour. The full program can be seen below in figure 25.

Program

1. Introduction
2. Get familiar with Oculus Rift and navigation
3. Guided tour around in the virtual operating room
4. Questionnaire & Discussion

Figure 25: Program: non-medical participants

5.7   Summary

This chapter gave an overview of the two exploratory studies conducted during this thesis included equipments used and preparation involved. The reader is referred to this paper [17] for a more closer and detailed description of the virtual operating room and the scenarios used in the previous project thesis.

6   Evaluation

6.1   Introduction

This chapter will go through the evaluation which includes both questionnaire and discussion conducted during the exploratory studies with both non-medical and post graduate nursing students. This chapter is split in three parts were we will start with the evaluation from the study with the nursing students. The second part will contain evaluation from the study with the non-medical group. The last part will do a comparison between the evaluation from the first part with the evaluation from the similar exploratory study done with nursing students during the project thesis.

6.2   Medical perspective

A group of twelve consisting equally of six surgical and anesthesia nursing students participated in this study to give feedback and evaluation from a medical viewpoint. Below is a review of the results from this session.

6.2.1   General

Only one out of twelve were familiar (and had some experience) with Second Life from earlier. The rest were neither experience with SL or other virtual worlds/games, although they all answered either "well" or "fairly well" on the question regarding their computer.

6.2.2   Virtual reality interface

Eleven of them either agreed or strongly agreed that it went quickly to understand the interface of Second Life using Oculus Rift, which was also observed as they needed just a short time before they learned how to move and interact. Eight of them did, however, find it difficult to move their avatar to different directions.

A great majority among the twelve students did either agree or strongly agree that the operating room was looking similar to a real one, and that the scenarios role played were realistic and representative of equivalent real-life situations. The remaining few were neutral. This may be some of the reason

that nine students said they really engaged themselves in the role play, and all twelve found the game experience motivating.

Only five of the students used information based on avatars clothing, behaviour and movements, as it therefore seems to be not so easy to use information from these sources in the virtual world. The students also found it difficult to interpret information from body language and facial expression which eight of them agreed. It was mentioned during our discussion that "It was not that easy to see who talked to who by interpreting the body language and eye contact[from other avatars]". They were asked to select those aspects they thought gave the most information during role play. "Audio"(Lyd) points out as the most selected which can be seen in figure 26 below.

Kroppspråk	0	0%
Lyd	8	44%
Avatarbekledning	4	22%
Avatarens posisjon og orientering i rommet	4	22%
Design av rommet/omgivelsene	2	11%
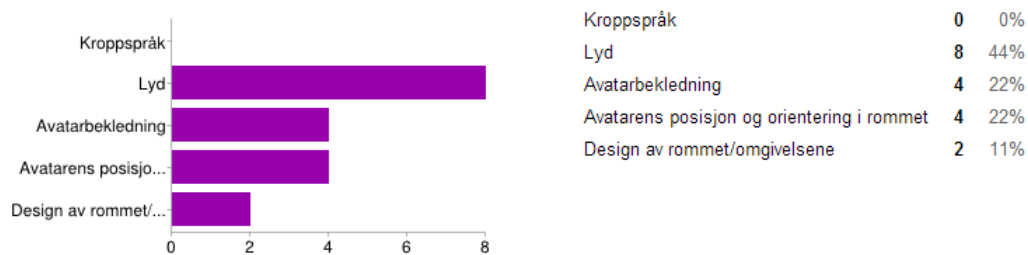
Figure 26: What aspects of the system gave most information during role play?

We investigated further the use of Oculus Rift as we want to look at the potential benefits or drawbacks in using head mounted display(HMD). We asked how much presence and immersion they felt in the virtual environment when using HMD. The result was an average score of 4.2 in a five stage scale ranging from low(1) to high(5). There were also some presence of physical discomfort when using HMD as the average score was 3.5 (on the same scale) on questions regarding how much they felt any physical discomfort when using VR goggles. A following question and the discussion revealed that this caused nausea, dizziness, dry eyes and tension in face or jaw for some people. It was mentioned that some of these reactions appeared only if their avatar was involved in a lot of movement, e.g. when flying around, and thus some resolved them by doing slow movements only if necessary.

The majority found it easy to see and observe others around them in the virtual operating room when using HMD. This may be because of the sensors that allow the users to turn their head in order to observe in other directions in the virtual environment. Most of the students were really excited in trying

on a Oculus Rift, and they were also impressed by the 3D-world which where generated when using this. We asked a question regarding their preferred choice of using HMD or ordinary computer screen where five chose the Oculus Rift, four the computer screen, while the rest answered that both options were equally good.

6.2.3 Virtual learning and training

Role play of four different scenarios were conducted, and the purpose was to give the students some knowledge and experience of handling and collaborate with different types of patients. Six multiple choice questions (using five-level Likert scale) were asked in order to find out how successful this type of virtual training is. A short explanation of the Likert scale and the questions are presented below.

To a great extent *(I stor grad)*
To a some extent *(I noe grad)*
Neutral *(Nøytral)*
To a small extent *(I liten grad)*
Not at all *(Ikke i det hele tatt)*

Q1:

Figure 27: To what extent do you think virtual simulation can provide skills in communication and collaboration with other health professionals?

Q2:

I hvilken grad mener du virtuell simulering kan gi studenter ferdigheter i kommunikasjon og samhandling med pasienter?

I stor grad	6	50%
I noe grad	6	50%
Nøytral	0	0%
I liten grad	0	0%
Ikke i det hele tatt	0	0%
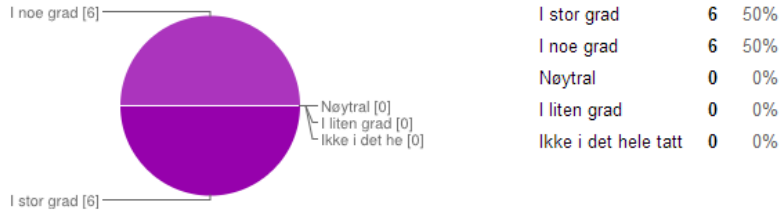
Figure 28: To what extent do you think virtual simulation can provide students skills in communication and interaction with patients?

Q3:

I hvilken grad mener du virtuell simulering kan gi studenter ferdigheter i kommunikasjon og samhandling med pårørende som følger pasienten til operasjon?

I stor grad	6	50%
I noe grad	6	50%
Nøytral	0	0%
I liten grad	0	0%
Ikke i det hele tatt	0	0%
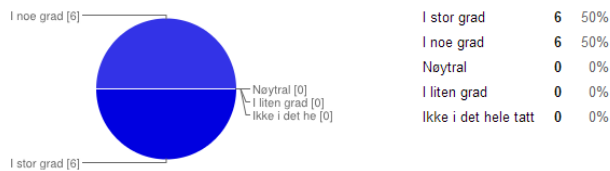
Figure 29: To what extent do you think virtual simulation can provide students skills in communication and interaction with family members accompanying the patient for surgery?

Q4:

I hvilken grad mener du virtuell simulering kan gi innsikt i hvordan man kan berolige en pasient i forkant av en operasjon?

I stor grad	4	33%
I noe grad	4	33%
Nøytral	2	17%
I liten grad	2	17%
Ikke i det hele tatt	0	0%
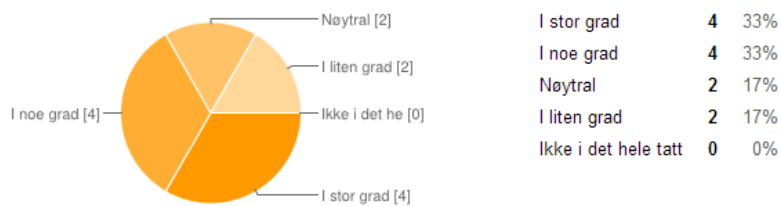
Figure 30: To what extent do you think virtual simulation can provide insights in how to soothe a patient before a surgery?

Q5:

I hvilken grad mener du virtuell simulering kan gi innsikt i hvordan man kan kommunisere med pasienter med annen kulturell bakgrunn?

I stor grad	4	33%
I noe grad	3	25%
Nøytral	3	25%
I liten grad	2	17%
Ikke i det hele tatt	0	0%

Figure 31: To what extent do you think virtual simulation can provide insights in how to communicate with patients with different cultural background?

Q6:

I hvilken grad mener du virtuell simulering kan gi ferdigheter i kommunikasjon med barn i forkant av en operasjon?

I stor grad	3	25%
I noe grad	5	42%
Nøytral	2	17%
I liten grad	2	17%
Ikke i det hele tatt	0	0%

Figure 32: To what extent do you think virtual simulation can provide skills in communicating with children before a surgery?

The three first questions(Q1, Q2 and Q3) show that simulation has the potential to provide enhanced skill in communication and collaboration with other health personnel, patients and their relatives. The students were not nearly as positive on question Q4, Q5 and Q6, however, still quite good to be considered as having some positive value. The three last questions have the majority of the students selecting either "To some extent" or "To a great extent" regarding provided skill in interaction with children, patients with different cultural background, or calming a patient before a surgery.

We asked the students if they felt that "the simulation helped to give a better understanding of the patient, their relatives and situation", which only four agreed on. Five were neutral to this question, while the rest disagreed. This may be based on that the students did not find it easy to interpret either body language, facial expression or clothing of avatars(as is given in the previous sub-section). All of them did agree (half of them even "strongly agree") that

role playing in a virtual university hospital can be a suitable supplement when preparing anaesthesia and surgical nursing students for communication with patients and relatives in a receiving situation at the operating room.

3D-anatomy

Another way of learning is to use HMD and virtual reality to look at 3D models of different parts of the human body. We therefore investigated what the students thought about including visualized 3D anatomy(such as the cranial nervous system) as an assisting supplement to anatomy lectures. We asked the question "To what extent do you think visualized 3D anatomy could be helpful in anatomy lectures"(figure 33) where we gave them an option to rate from 1(Low) to 5(High). The summarized average score was 4.1 which means that they greatly considers this as helpful.
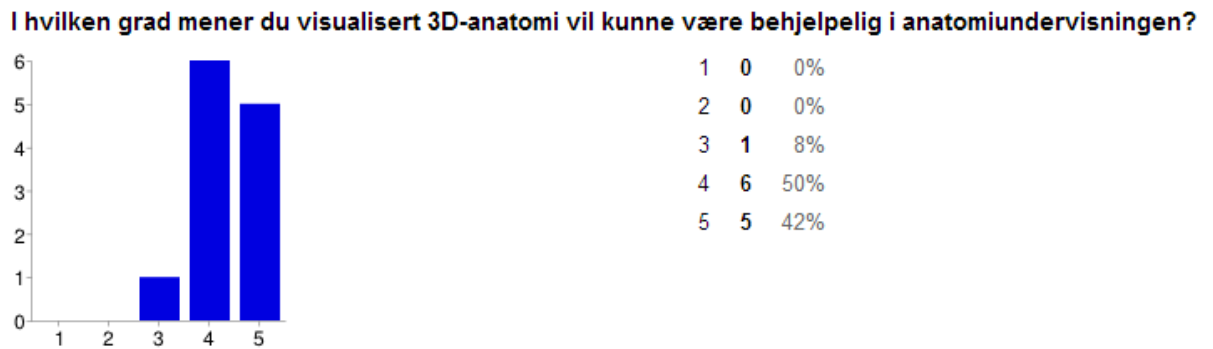
Figure 33: To what extent do you think 3D anatomy would be helpful in anatomy lectures?

6.2.4   Supporting facilities and tools

One of the main aim with this study was to get a medical viewpoint of how a virtual university hospital should be designed. The virtual operating room, role plays and 3D anatomy of a cranial nervous system were introduced in order to give the students some initial ideas. We asked for input through six questions in the questionnaire where five of them were required.

We already established that anatomical 3D models would, from the students opinion, be a great supplement to anatomy lectures. A follow up question was given to find out if 3D anatomy should as well be included in a virtual hospital. Eleven of the students answered positively to this, and it was mentioned during our discussion that 3D anatomical models would be great

to have available as both medical personnel and patients could use this as a information and learning resource.

The next two questions shown in figure 34 and 35 are about what kind of departments, rooms, tools and general resources should be available. The students were told to mark those given alternatives which they would want to have included in a virtual university hospital. The two most selected alternatives in the first question (figure 34) were "Operating Room"(*Operasjonsrom*) and a "patient ward"(*Sengepostavdeling*), while the third most selected was a "waiting room" (*Venterom*). Two of these which the students have already been given an example of inside the virtual operating room used in this study.

Among the proposed alternatives of tools and resources, three sticks out as almost equally selected by nine or ten. These are "Anatomical models in 3D" *(Anatomiske modeller i 3D)*, "Simulated health personnel" (*Simulert helsepersonell*) and general equipment used in hospitals and operating rooms. These three are closely followed up by "patient simulation"(*Simulert helsepersonell*) which was selected by half of the group participants.
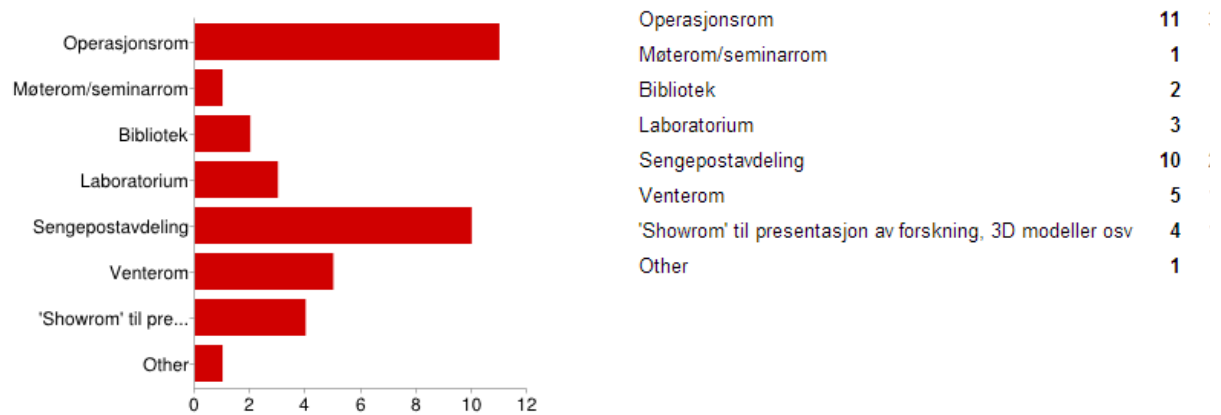
Figure 34: Which departments and other areas do you think should be in a virtual university hospital?

Hvilke verktøy og ressurser burde man ha med et virtuelt universitetsykehus?

Anatomiske modeller i 3D	10
Simulerte pasienter	6
Simulert helsepersonell	9
Informasjonsressurser (Filmer, slider, plakater o.l)	4
Generelt utstyr man bruker på sykehuset (f.eks EKG, Urinmåler, Pulsoksimeteret og BT-apparat o.l)	10
Other	0
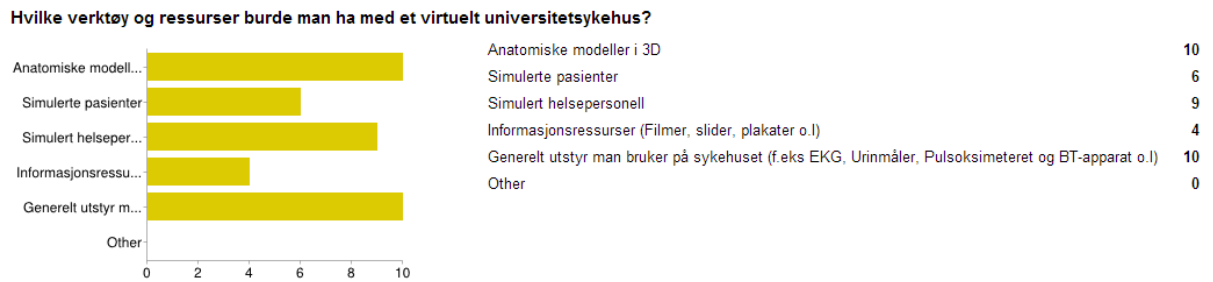
Figure 35: What kind of tools and resources ought to be included in a virtual university hospital?

A virtual university hospital is meant to be used by both medical personnel, patients and a general audience that would benefit from easy available health related information and the virtual concept. We wanted to get some input on how these can utilize such a hospital and gave them two questions which look at both types of users, medical and non-medical (figure 36 and 37).

Hva mener du et virtuelt universitetssykehus kan brukes til av helsepersonell?

Prosedyretrening av helsepersonell	8
Klasseromsundervisning	3
Møter og seminarer	1
Simulert pasientkontakt	8
Anatomiundervisning	12
Formidling av informasjon og forskningsresultater	2
Kontakt mellom helsepersonell og reelle pasienter	2
Rollespill	8
Other	1
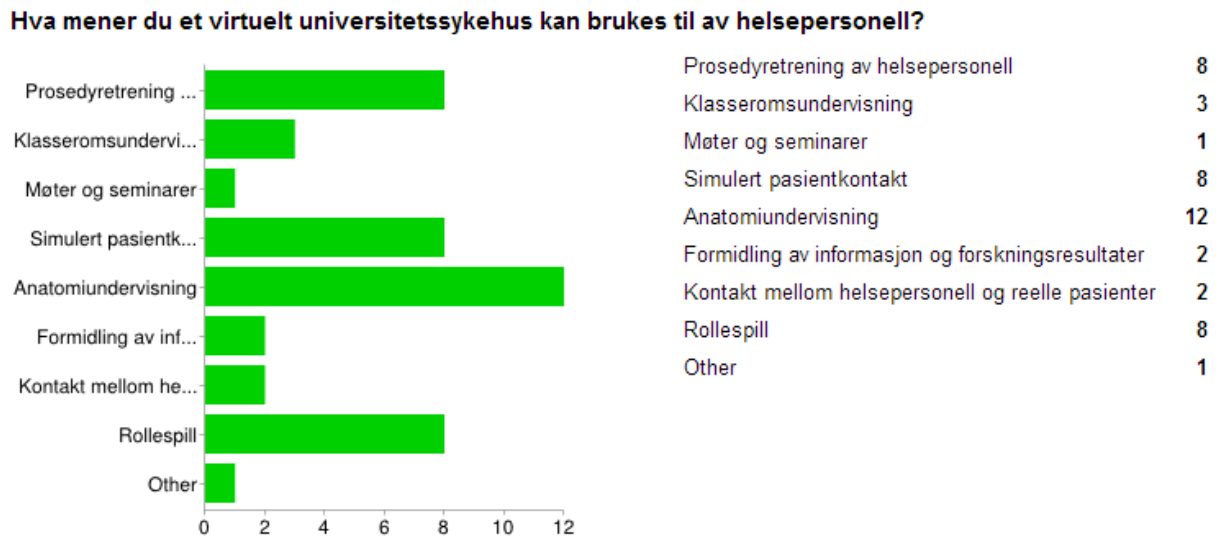
Figure 36: In what way do you think a virtual university can be used by healthcare professionals?

På hvilken måte tror du pasienter/generelt publikum kan nyttiggjøre seg et virtuelt universitetsykehus?

Pasienter kan bli kjent med ulike operasjonsforløp	11
Pasienter kan få kontakt med helsepersonell for å få rådgivning uten å måtte fysisk ta turen til St.Olavs	4
Pasienter/generelt publikum kan lære om de siste forskningsframskritt ved St. Olavs	5
Pasienten kan få lettere tilgang til relevant helseinformasjon	7
Other	0

Figure 37: How do you think patients / general public can benefit from a virtual university hospital?

Amongst the medical personnel, both "procedure training" (*Prosedyretrening*), "simulated patient contact"(*Simulert pasientkontakt*), "anatomy lectures"(*Anatomiundervisning*) and "role play"(*Rollespill*) appears to be the four most appropriate applications. Some of these choices may have been influenced by the role playing conducted earlier as they became more familiar with those concepts.

From figure 37, one can see that eleven of the nursing students thinks that a virtual hospital could provide an opportunity to give patients the chance to be familiar with different patient care which is offered at a real hospital. Some of them also believe it would benefit an audience if it could provide easy access to relevant health information, or even about the latest research. Four of them selected the alternative regarding possibility of "patients who could get professional counselling from medical personnel without having to physically show up at a real hospital".

6.3   Non-medical perspective

We invited twelve ordinary students with no professional medical background to a tour around the virtual operating room using Oculus Rift. The purpose was, as mentioned, to get a better understanding of how a general audience or patients and their relatives can utilize a virtual university hospital. What kind of needs do they have, and opportunities do they see after they had been introduced to the concept and presented the virtual operating room. Following is a review of the evaluation.

6.3.1   General

Twelve students, half of each gender, were invited to participate one at the time in this virtual tour. Four of these had to a little or some extent tried Second Life from before, however, most of them (except two) had earlier experiences with other different games (such as Diablo and Skyrim) which can resemble like a virtual world. They answered either "well" or "very well" concerning their computer competence, while two of them had less knowledge.

Another interesting thing was to know if they had any real hospital experience, either as patient or relative. Seven of them had the experience of being a patient at a hospital, while nine of them had been there as a relative to a patient. It was only one participant who answered that she had not been either of the to roles. It was not much difference between the two genders considering that we had just as many boys as girls who have either been patient or relatives at a hospital. Their stay at a hospital varied from person to person from just a day and till longer than a week.

6.3.2   Virtual reality interface

The participants in this group had no professional medical background, but many of them were students who study to a bachelor or master degree in other areas such as technology and science or humanities and social science. Some of the same questions given to the nursing students were also given to them in order to discover any differences or similarities because of background.

Eight of the participants disagreed that it was difficult to move their avatar in different directions, which is a direct contrast to the answers given by the nursing students. However, both groups (both medical and non-medical) had a high similar score considering the feeling of presence and immersion, which was 4.2 out of 5.

We asked the participants to specify their their experience with the oculus rift. The feeling of presence was really something they appreciated, but many of them felt some sort of cyber sickness in a varying degree just as with the nursing students. This was commented by one of them who said that "it was unnatural to sit when my avatar walked", while other comments pointed out rotation with their head (and virtual view) while walking. The degree and existence of cyber sickness varied a lot from person to person. Some answered that they had to pause and take of the Oculus after 8-10

minutes, while others needed time to get used to the feeling before feeling fine again. We also had one or two who managed just fine with out any signs of illness.

There were not recorded much physical ailments except from one who meant that the Oculus pushed a little against the eyes, however, the person said that this might be because of bad adjustments as she forgot to do this properly. Almost all of them gave the expression that a head mounted display such as oculus rift had potential, but needed to improve somehow such that reaction such as dizziness and nausea were not present. We asked them of their preferred choice between computer screen and HMD where six of them preferred HMD, while three of them could accept both alternatives.

6.3.3   Supporting facilities and tools

The guided tour in the virtual operating room had the same purpose of providing an idea of how these users can utilize this concept. Ten questions were given in the questionnaire in order to establish their needs and thoughts about a virtual university hospital.

We focused first on the virtual tour experience were we asked first to what extent they thought such a virtual tour can be used to prepare patients going to an operation. All of them answered either to some extent or even to a great extent. The two same answers were given to the question if they "thought such 3D virtual operating room had contributed in giving an informative experience". All participants were not that unanimously in their answers regarding how much this type of excursion will contribute to "a patient feeling more safe" considering going to an operation. There were two who answered "neutral" to this, although they had not been in a situation as patient before. One of the participant with a short patient history(less than a day) answered "to a little extent". Nine of them did believe that such a tour would be a good way to give knowledge of what are awaiting a patient at a hospital.

The participants where asked "as an audience, what kind of information would you want to have available through a virtual university hospital?" where ten alternatives were given in addition to an option to input own suggestion. The ten alternatives are listed below.

1. Healthcare

2. Nutrition and training

3. Diseases

4. Activities at a hospital

5. Vaccination

6. Patient care

7. Different patient treatments

8. Medical research and technology

9. Information about support for patients

10. Overview of hospital and its departments

11. *Other - (text input)*

As one can see in the figure 38 below, most of the alternatives suggested were selected. Top four is "information about diseases", "activities at a hospital", "patient care" and an "overview of the hospital and its departments".

1. Helseforebygging	6
2. Kosthold og Trening	6
3. Sykdommer	8
4. Undersøkelser på sykehuset	8
5. Vaksinering	4
6. Pasientforløp	7
7. Behandlingsformer på sykehuset	6
8. Medisinsk forskning og teknologi	5
9. Informasjon om støtteordninger til pasienter	3
10. Oversikt over sykehuset og avdelinger	7
Other	0

Figure 38: As an audience, what kind of information would you want to have available through a virtual university hospital?

We asked a very similar question, but the participants were now to put themselves in the role as a patient or relative. "As a patient or a relative, what kind of information would you want to have available in a virtual university hospital in conjunction with a hospital stay?". Nine alternatives (with some

different than those in the first question) were given. These are listed below
while the resulting chart in shown in figure 39.

1. Healthcare

2. Nutrition and training

3. Diseases

4. Activities at a hospital

5. Vaccination

6. information about patient care with regard to current situation

7. Information about what to expect when arriving at a hospital

8. Information about support for patients

9. Overview of hospital and its departments

10. *Other - (text input)*

1. Helseforebygging	3
2. Kosthold og Trening	3
3. Sykdommer	6
4. Undersøkelser på sykehuset	7
5. Vaksinering	0
6. Informasjon om vanlig behandlingsforløp i aktuell situasjon	9
7. Hva man kan forvente seg når man kommer på sykehuset	12
8. Informasjon til pasienter om støtteordninger	5
9. Oversikt over sykehuset og avdelinger	10
10. Other	0

Figure 39: As a patient or a relative, what kind of information would you
want to have available in a virtual university hospital in conjunction with a
hospital stay?

All of the alternatives 1-5 (which were given in both questions) gained fewer
votes. For instance, healthcare and "nutrition and training" (alt.1,2) went
down from six to three votes, while vaccination(alt.5) seems not to be impor-
tant as it got zero votes. This may be natural since vaccination would not

be of interest when you already are a patient. The three most selected were the added alternatives 6, 7 and 9. These are more relevant to those who are either a patient or relative as it gives information concerning their current situations.

A virtual hospital must include different resources in order to be informative. We therefore asked a question regarding what kind of resources the participants would want to have available virtually. The participants were(as before) given some alternatives they could select, or input new suggestions. As one can see from the figure 40, five types of resources seems to be considered as relevant to include in a virtual university hospital. These are items 2, 3, 4, 5 and 8. No other suggestions were proposed by the participants.

1. A virtual library with health related information

2. Health related simulations which contributes to enhanced public knowledge

3. Visualized different types of patient care

4. Computer controlled avatar who could answer simple questions

5. Online medical professionals which can be asked questions

6. Display of medical research and technology

7. Health related games to play

8. Computer controlled avatars who demonstrates different preventive exercises (e.g. terms of sports injuries and similar)

9. *Other - (text input)*

Hva slags ressurser mener du man burde ha tilgjengelig i et virtuelt universitetsyk
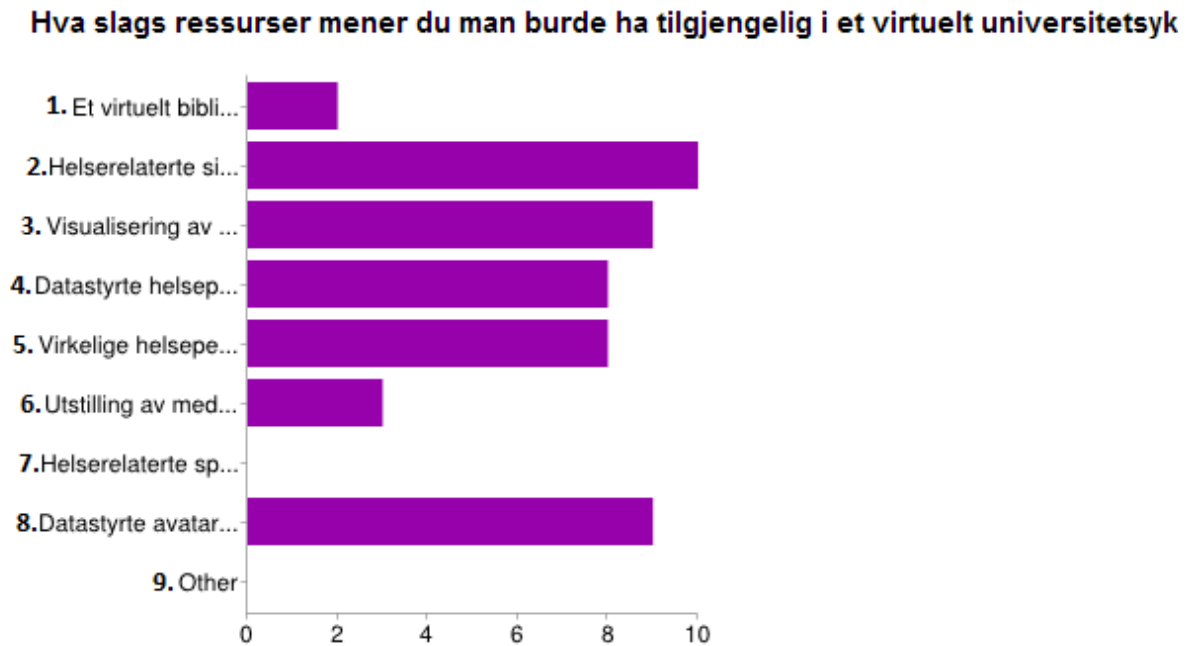
Figure 40: What resources do you think one should have available a virtual university hospital?

There might be things that a real hospital is not capable of which could be considered possible in a virtual hospital. Our participants were asked if there were anything they missed by a real hospital which they may have wanted to include virtually. There were two suggestion that came up. For instance would information about different machines used at a hospital(including how they work). This would be of help to patient (and their relatives) going to a surgery to prepare and be more familiar with equipment used as nurses and doctors often do not always have time to explain. The other suggestion was to have some sort of visualized flow chart which could show the process of different treatments and surgery.

Privacy is an aspect that needs to be safeguarded, and it is an important to include regarding use of a virtual university hospital. Our participants were asked what they think about their activities in a virtual hospital can be recorded and used as patient data for the medical personnel. Some of them thought this would be okay as long as their identity remained anonymous. Others meant that it was acceptable to link data to the user as long as the data was properly and strictly secured where only authorized personnel had access. Some saw the benefits as it was mentioned that this would contribute to knew knowledge and development within health, as well as

give an indication of what the public is interested in knowing. We asked if
it was important for them to be anonymous(if using such a virtual hospital)
in order to get a clear understanding(figure 41). Three of them answered
that it is highly important, while seven of them thought the opposite. It
may be not that important to be anonymous as long as the requirements
given above is followed. The two last selected "other" without specifying
further. We can summarize by saying that privacy is an aspect that must
be considered carefully if a virtual university hospital is to be accessed and
used by the public.

Er det viktig for deg å være anonym hvis noe slikt skal brukes?

Ja, det er viktig	**3**
Nei, det er ikke så viktig	**7**
Other	**2**

Other [2]

Nei, det er i [7]

Ja, det er vi [3]
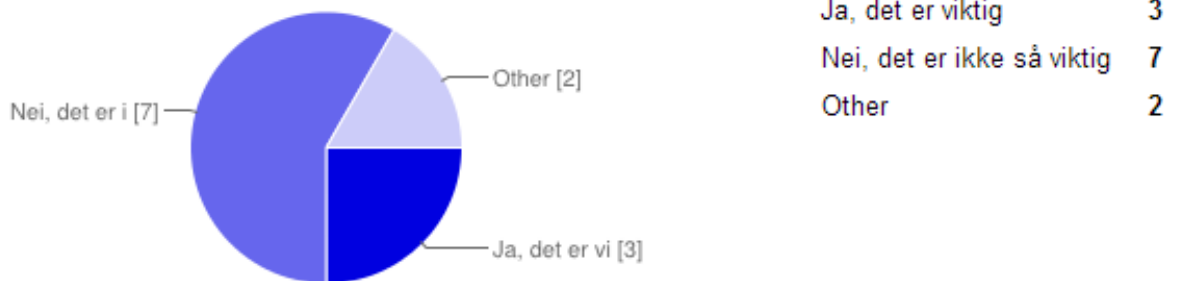
Figure 41: Is it important to be anonymous if you are to use the services of
a virtual university hospital?

6.4   Different settings and interface

Our session with the post graduate nursing students were our second ex-
ploratory study using our own virtual operating room to conduct role plays.
We invited surgical nursing student the first time during the mentioned
project thesis, however, we had this time both anesthesia and surgical nurs-
ing students to play and collaborate together. Other difference in these two
studies are given by the four requirement from sub-section 4.2 which where
implemented during this thesis. We also introduced Oculus Rifts which we
had a hypothesis that would enhance role playing.

The reader should note before continuing:
We will in this section do a comparison on game play and immersion, as well
as the potential learning in nursing. It is important to keep in mind that the
comparison does not give secure facts as this have been tested on different
types of groups with few participants who contributed with their subjective

opinion. This section merely presents data and calculation which reflects subjective aspects.

The study conducted earlier during the previous project thesis included nine post graduate surgical nursing students on their *last year of study*. This study will be referred to as **Before**, and we refer to appendix A for more information. The study conducted during this thesis with twelve post graduate surgical and anesthesia nursing students on their *first year of study*, will be referred to as **Now**. One should note that there is a difference in experiences between the to groups, as the first group where more experienced than the second.

This should be kept in mind when looking through the comparison, and carefully when interpreting this information.

6.4.1   Comparison of game play, immersion and in-game elements

Below is a comparable overview of the results from our two studies. Eight set of questions with a five level likert scale ranging from "strongly agree" to "strongly disagree" were given in both studies. The tables below show the distribution of answers given in those two independent groups. An average score(between 1-5) is calculated below in each table in order to easier compare the two results. The higher the score(closer to 5.0) the more they agree, while an exact score on 3.0 is equivalent to neutral. A score below this is equivalent to disagreeing. A ninth question is included at the end with a different type of input. The "before" column refers to the first study, while "now" column to the second.

[1] It went quickly to understand the interface of Second Life?

Level:	Before	Now
Strongly Agree	11%	17%
Agree	44%	75%
Neutral	44%	8%
Disagree	0%	0%
Strongly disagree	0%	0%
Average score:	**3,66**	**4,1**

[2] I find it difficult to move the avatar to different places?

Level:	Before	Now
Strongly Agree	0%	8%
Agree	0%	58%
Neutral	67%	8%
Disagree	33%	25%
Strongly disagree	0%	0%
Average score:	**2,67**	**3,5**

[3] The virtual operating room gave a good picture of a real one?

Level:	Before	Now
Strongly Agree	11%	8%
Agree	22%	83%
Neutral	56%	8%
Disagree	11%	0%
Strongly disagree	0%	0%
Average score:	**3,33**	**4,0**

[4] The role play was realistic / representative of similar situations in real life?

Level:	Before	Now
Strongly Agree	11%	25%
Agree	33%	50%
Neutral	33%	25%
Disagree	22%	0%
Strongly disagree	0%	0%
Average score:	**3,33**	**4,0**

[5] I became involved in the role play

Level:	Before	Now
Strongly Agree	33%	17%
Agree	56%	58%
Neutral	11%	17%
Disagree	0%	8%
Strongly disagree	0%	0%
Average score:	**4,22**	**3,83**

[6] The gaming experience was fun/motivating

Level:	Before	Now
Strongly Agree	33%	33%
Agree	56%	67%
Neutral	11%	0%
Disagree	0%	0%
Strongly disagree	0%	0%
Average score:	**4,22**	**4,33**

[7] I extracted information based on the avatar clothing, their behaviour and movements

Level:	Before	Now
Strongly Agree	0%	0%
Agree	44%	42%
Neutral	56%	50%
Disagree	0%	0%
Strongly disagree	0%	8%
Average score:	**3,44**	**3,25**

[8] I think it was difficult to interpret information from body language and facial expressions of avatars

Level:	Before	Now
Strongly Agree	33%	58%
Agree	44%	8%
Neutral	11%	25%
Disagree	11%	8%
Strongly disagree	0%	0%
Average score:	**4,0**	**4,17**

[9] What seems to give most information in the role play?

Level:	Before	Now
Body language	0%	0%
Sound	13%	44%
Avatar clothing	31%	22%
Avatar's position	19%	22%
Room and environment design	38%	11%
Winner:	**Design**	**Sound**

Summary

Question 1, 3, 4 and 6 indicates improved aspects since last time. The first question gives us that it is not that difficult to learn the interface of Second Life, even thought using a head mounted display like Oculus Rift. Question

three, however, is fascinating as our second group (with the Oculus) found the virtual operating room more like a real one. The same increase is given in question four which may strongly indicate that using a HMD such as Oculus makes role playing more realistic. The fun and motivation in question six did as well increase in small extent.

Not everything had a positive increase as we can see in question 2, 5, 7 and 8. It seems that it was more difficult to move the avatar around when using a HMD. This may be because of the Oculus which prevents visibility to the keyboard and mouse. The students got less involved in the role plays in our second study. It is not certain of why this is, but it may be because we had a broader focus on both role playing and 3D-models in the second exploratory study, and not only had role playing as in the first study. Question 7 and 8 shows that using information from avatar clothing, their behaviour, body language and facial expression was more difficult when using HMD than 2D screen. A suggestion to this may be because of the different overview given when using a 2D screen than through using Oculus with a smaller field of view. The ninth and last question in this category shows perhaps an interesting change as some of the different sources of information altered in their ratings. Sound has a large increase from earlier, which is natural since this were more carefully configured and tested in the second study. Room and environment design has the greatest decrease which is not completely obvious why this is.

6.4.2   Comparison in potential learning

The same six questions about learning in a simulated environment from the project thesis were used in this thesis as well. The rationale behind this is to be able to get some indications of difference in the quality of learning. The following is a comparable overview from those questions we used.

[1] To what extent do you believe virtual simulation can give students skills in communication and interaction with patients?

Level:	Before	Now
To a large extent	44%	50%
To some extent	56%	50%
Neutral	0%	0%
To a small extent	0%	0%
Not at all	0%	0%
Average score:	**4,44**	**4,50**

[2] To what extent do you believe virtual simulation can give students skills in communication and interaction with family members accompanying the patient for surgery?

Level:	Before	Now
To a large extent	44%	50%
To some extent	44%	50%
Neutral	11%	0%
To a small extent	0%	0%
Not at all	0%	0%
Average score:	**4,33**	**4,50**

[3] To what extent do you believe virtual simulation can provide insights into how to soothe a patient before a surgery?

Level:	Before	Now
To a large extent	22%	33%
To some extent	67%	33%
Neutral	11%	17%
To a small extent	0%	17%
Not at all	0%	0%
Average score:	**4,11**	**3,83**

[4] To what extent do you believe virtual simulation can provide insights into how to communicate with patients with different cultural background?

Level:	Before	Now
To a large extent	22%	33%
To some extent	56%	25%
Neutral	22%	25%
To a small extent	0%	17%
Not at all	0%	0%
Average score:	**4,0**	**3,75**

[5] To what extent do you believe virtual simulation can provide skills in communicating with children before a surgery?

Level:	Before	Now
To a large extent	22%	25%
To some extent	56%	42%
Neutral	22%	17%
To a small extent	0%	17%
Not at all	0%	0%
Average score:	**4,0**	**3,75**

[6] To what extent do you believe virtual simulation can provide skills in communication and collaboration with other health professionals?

Level:	Before	Now
To a large extent	11%	42%
To some extent	89%	50%
Neutral	0%	8%
To a small extent	0%	0%
Not at all	0%	0%
Average score:	**4,11**	**4,33**

Summary

All of the calculated average scores shows that the students in both exploratory studies found the role plays of the given scenarios applicable. The average score does, however, not seem to be influenced by using Oculus Rift as there are both decreasing and increasing scores. It would be natural to think that they all would increase or decrease when adding an element such as 3D-VR to a role play. Instead, an increase is given in question 1,2 and 6 which asks about skills in communication, interaction and collaboration with patients, their relatives and other health personnel. A decreasing score is found in 3, 4 and 5 which includes soothing a patient, communicate with children and patients from different culture.

7   Discussion

7.1   Introduction

A virtual university hospital should be available for everybody. We started this thesis with dividing the users into two main categories: medical professionals and those without any professional medical background. The first category can for instance be divided further into occupations such as physicians, nurses, chiropractors, paramedics, students and similar occupations which has a hospital as its place of work. The second category is large, as this basically includes every one else. This can be any type of patients with e.g. diseases, physical disabilities or mental illnesses. It can be their relatives as well, or even quite healthy persons such as athletes, sports people or researchers who may be interested in other things such as nutrition, training or the latest health research. These are all potential users of a virtual university hospital which have different interests and needs for information within the fields of medicine and health.

We will in the following discuss the research questions given in sub-section 2.2, in the light of related work and our evaluation of the two exploratory studies with medical and non-medical users.

7.2   Educational activities in virtual university hospital

7.2.1   Training of medical professionals

The nursing students gave their answers in sub-section 6.2.4 regarding their application of a virtual university hospital as medical professionals. The top most selected activities were:

- Procedure training

- Simulated patient contact

- Role play

There are examples of these three activities in the related work sub-section 3.3. For instance, Imperial College London, USF Health, the discipline of surgery at university of Sydney and the medical faculty at the university of Auckland are all examples of actors which have successfully implemented

simulated patients and suited environment to use in role play and practice. E.g. practicing on patient counseling, solving virtual patient cases in collaboration with others and emergency training. We did also in our previous exploratory study last year demonstrate that such educational simulation in a virtual operating room can be implemented with limited resources, and yet be practically useful in education of health personnel(appendix A).

Another popular selected application for medical professionals was "anatomy lectures". The students visited the "Cranial Skywalk" at the island of University of Kentucky in Second Life which includes models of cranial nerves. The nursing students gave a strong impression during our discussion that this would be a fun and motivating way to learn anatomy, and they also showed a great deal of excitement when flying around with their avatar and observed the models. Quotes such as "It was really interesting!" and "The anatomy was really cool" together with positive results in the questionnaire strongly points out that this is something that is longed for among them. Related work section includes an example of "hearth murmur sim" which another way of implementing an interactive educational facility with both sound and tasks included. The human body is complex, and virtual 3D models may be the future of educating on this subject.

There were some other selected areas as well such as conducting "classroom lectures" and "meetings and seminars". There were not much examples in the study of related work about these two areas of application towards medical students. However, one study were found where the teacher conducted a pilot postgraduate medical education program at the Boston University School of Medicine, using Second Life. Some benefits of using VEs to conduct lectures were mentioned. For instance the possibility to be geographically distant from each other and to use the text-based chat to ask questions and be active during lectures. There were also some limitations, but this mostly regarded technical parts such as internet connection and processing and graphics power [47]. Virtual classroom lectures and meetings were not preferred by our participating nursing students, so that this should be included secondly after the more popular choices mentioned above.

We believe that a fully real-looking virtual university hospital should be able to meet the needs and desires of our participating nursing students, in order to function as an arena for medical training. This includes more patient contact, giving the students the possibility to practice procedure training as well as role play relevant scenarios and studying models of human body and organs in a risk-free and safe environment. Other usage areas should, however, be explored more and tested on medical professionals to see if it

should be included in a further development. The reason is because of the potentially complex structure that may lead to negative consequences that should be avoided(more on this later).

7.2.2   Educating general public

One of the most important tasks of a university hospital like St.Olavs is to conduct public health education and preventive care. At the time of writing this thesis, debates are taking place regarding how information about vaccination is highly misled which could lead to fatal consequences. These debates had their outbreak after an article published late march(2014) under the section of "Pharma & Healthcare" in Forbes magazine. This article talks about how parents are misled to believe that vaccination of their children is not important and that non-proved alternatives should be considered [49]. Norwegian newspapers have translated this article in order to shed light on this matter, and it gives a great example of how important it is for the public to have access to reliable research and public education.

From sub-section 6.2.4, we can see that seven of twelve of the nursing students think that the public would benefit from having easy access to relevant and important health information. This was the second most selected choice among four alternatives. We see from sub-section 6.3.3 that the group of non-medical persons themselves desire public health information within five areas available in a virtual university hospital:

- Health care

- Nutrition and Training

- Diseases

- Vaccination

- Medical research and technology

An example from related work is the Health Info Island explained in sub-section 3.3.2. This virtual island contains many examples of health related subjects to educate, and our opinion is that they organize these in a clear and systematic manner which makes it easy for the visitors to discover and receive information. A virtual university hospital should make it as one of their main tasks to provide the public with reliable and important health information.

The questionnaire reveals that at least half or more of the participants in the non-medical group would want to include information about the different examinations and treatments that are available at a hospital, as well as being able to get an overview of the hospital. Some of those who selected these alternatives explained that it would become very relevant if they find themselves in a situation where such knowledge will be important and come in handy. An example from the related work section is Imperial College London which to a little extent gives visitors an idea of what kind of facilities and services exists. Organizing their virtual hospitals into departments(e.g. "Polyclinic" and "Long term care") included with some related information, gave a small impression of what kinds of subjects and activities they might be involved with.

Ordinary non-medical users have the need for some level of privacy. The majority of our participants answered that "this is not that important". However interviews and questionnaire reveals that some sort of security when recording and storing data in addition to strictly access control are important to them if they are to trust in their use of a virtual hospital. Three of them did, however, select that privacy is important, and a virtual university hospital must therefore be constructed with proper policies and security in order to maintain the users privacy.

There generally seem to be to little research and studies on how a virtual hospital can be used and benefit for the public users. We therefore have to mostly use our own research results when forming requirements for a virtual university hospital in the perspective of non-medical users. Our evaluation from the exploratory study with this group in sub-section 6.3.3 gives two lists of rated alternatives which points out what this group of users potentially would desire(as a patient/relative or audience) to have available in a virtual hospital. All of the alternatives are applicable, but the ones mentioned above are those that are more desired than the rest. It would therefore be natural to start with these when one shall begin designing and implementing a virtual university hospital for a group of users with no medical background.

7.3   Content, facilities and technological solutions for a virtual university hospital

We are in this sub-section considering those elements that should be included in order to meet the needs of both medical and non-medical users, and to facilitate an effective arena for medical training and public education.

7.3.1 Virtual places: appearance

A realistic looking virtual university hospital will be of great benefit for both medical and non-medical users. The related work gives examples of medical students that uses realistic looking facilities (and even detailed replication of real life) in order to role play or conduct clinical medical training with simulated patients. The more realistic appearance, the more valuable is the training conducted, as it was mentioned in our exploratory study with the nursing students that they would get the chance to be familiar with places and equipment before entering the same facilities in real life. It may not be necessary to re-create the entire hospital, as a hospital like St.Olav's would be too large and would create complications regarding structure(more on this later). But the facilities used should be displayed as they are in real life in order to enhance the student's learning.

All our non-medical participants who were given a virtual tour around our virtual operating room pointed out that the virtual university hospital should be more or less re-creation of a real hospital. They mentioned especially if we are to offer virtual tours. One of our participants said that it should be much familiar to the situation he is going to. Another one said that it would not be the same to have something that does not look similar if the purpose is to calm down a patient before his or her visit. It should resemble a realistic place more than a simple game. There was also mentioned that the level of detail may not always be so high, for instance in non-hospital related matters such as conveying public health information. Some of our non-medical participants expressed that the virtual university hospital should not only be realistic, but actually look like a virtual copy of a real hospital, in this case St.Olavs Hospital.

Both related work and our own exploratory studies points in the direction of a realistic looking virtual university hospital. It seems to be of more value if its appearance resembles more or less a real hospital.

7.3.2 Virtual places: structure

A university hospital may typically be large and consist of complex structures which may be confusing to understand, especially by non-medical users. A virtual copy of university hospital like St.Olavs would bring the same complex structure inside the virtual world. As mentioned in sub-section 3.4.2, most of the places visited in Second Life were similar as they were large in space and in some extent cumbersome to explore. Our experience is that we often

became confused over our location, as well as which direction we were heading towards in order to find our destination. A virtual university hospital has the potential to expand over large areas and include buildings with several floors and rooms, and we therefore need to cope with the challenges this causes. Solutions are required if a stay or use of a virtual hospital is to be effective and satisfying for the users. Maybe even more important if the users are to navigate inside buildings and rooms, as it is too easy to get lost and confused when exploring with your avatar inside buildings with no possibilities for orientation.

We have mentioned by now that it is recommended to start with only the few areas selected by our medical and non-medical participants, and eventually build further upon this. This would contribute to making the structure less complex and confusing in the beginning. Although, a virtual university hospital is likely to be complex if it is to expand and include other areas. The important thing is therefore to implement a suitable infrastructure in order to cope with this. Many adequate solutions were experienced from our study such as using road signs, teleports, guiding lines on the floor or a map customized for the place and situation. A virtual university hospital should make sure of having proper support for giving the users an overview of the environment both outside and inside buildings and facilities. We also recommend to include a proper starting area where the user can acquire overview. This would help them to continue their path from the very beginning, and give them a much more pleasing experience.

7.3.3   Virtual places: roles, functionality and content

This sub-section is divided into three parts which considers both medical and non-medical perspective, in addition to a general perspective.

For medical professionals
Different departments filled with associated interactive hospital equipment seem to be important for our nursing students. Operating room and patient ward were the top most selected areas they would like to include in a virtual hospital. This might perhaps be as expected as these are areas that both surgical and anesthesia nurses are very familiar, and especially the first which is a place where they reside the most during their work. However, there were other examples of places among the related work such as receptions, emergency rooms and lecture areas that should as well be included as these may be more suited for other medical occupations.

We have been explained that nurses "use their hands" a lot when doing their job so that having interactive artifacts available in the virtual hospital would make a huge difference if they were to practice their occupation in the virtual world. General hospital equipment and tools were therefore highly desired among our participating nursing students. This does for instance include artifacts like electronics used in operating rooms and other useful items such as blankets, surgery gloves, x-rays and similar artifacts which they use daily in their work. A benefit mentioned was the great advantage of being able to learn how to use different equipment at an operating room. It was told that many students are unsure of themselves and their own expertise when they enter an operating room for the first time such that this would probably contribute to enhance their assertiveness.

The role play conducted during our exploratory study with the nursing students gave a taste of how one can practice communication and collaboration with both patients and health personnel. We have also seen that there are related examples of this in related work. Our nursing students selected both simulated patients and medical personnel as two desired resources to include in a virtual hospital. This would be natural since patients are the main focus of a hospital and medical personnel. A simulated patient avatar can be played by a student or teacher, but using computerized simulated avatars (known as NPCs) is also something to consider. The benefits mentioned of having a NPC which acts as either patient or other health personnel would give the opportunity for the nurses(or other medical professional) to practice their skill without being dependent on others. An NPC which plays the role of a patient would in many cases also be more realistic in contrast if a student were to play this role, as the students may perhaps not know how to act as a specific patient. Therefore, including NPCs to simulate patients or other medical personnel would be things to include in the virtual university hospital.

We were mostly alone when visiting the places in the related work section. It was very rare to meet someone else, and you got the feeling of being alone all the time. A common denominator for these places is that one gets quickly tired of just walking around with no other form of interaction than reading and watching. Artifacts, tasks, games and simulated non-player characters to interact with would, in our opinion, greatly enhance the feeling of being at a hospital and create much more value, motivation and fun for the users. Another possible solution would be to use volunteers and hired personnel to be present and of assist. This would make the virtual universe appear even more alive, and most likely more attractive to users.

From sub-section 6.2.4, one can see that anatomical models in 3D were one of the top most desired alternatives among the resources to be included, and the students gave the impression that this would be longed for as a supplement in anatomy lectures. The Cranial Nerve skywalk is an example from the related work. But this has the possibility to be taken much further. A great inspiration is given by the movie "Jakten pånyresteinen" from 1996 where a little kid shrinks himself so that he can travel into the body of his grandfather in order to kill a kidney-stone which his grandfather is suffering from(plot description taken from imdb.com). The idea of "diving" into 3D models of virtual organs or the entire human body to study them and follow processes is an exiting thought that will be possible to do using virtual reality. Adding other virtual reality interface technologies (discussed later) would increase the feeling of presence and thus make this subject even more exiting to investigate further. 3D models are therefore a type of content that should as well be included.

For the public
Sub-section 6.3.3 gives four popular types of resources among the non-medical users that would contribute to public health education. Health related simulations in order to enhance knowledge among them were highly desired. The most selected alternative was to include health personnel simulated by NPC. These could for instance run demonstrations of different preventive physical exercises, or function as an oracle which can answer simple questions asked by users. Such non-player characters have(as mentioned earlier) the possibility to be available and active at any time and provide service to the public. An example of such NPC is given from Allied Health and Science College in section 3.4.3.

There was, however, a great interest in the possibility to meet and communicate with real medical personnel in a virtual hospital. This would be a more appropriate choice for some as they would probably feel that the information given is more reliable and easier to understand than an answer given from a NPC. This could be an effective and simple way for getting information as one does not have to physically meet in order to ask questions and get consultation. A potential positive consequence could be a lowered threshold for contacting health professionals in matters that one would normally let pass because it is often costly and time consuming to seek consultation. An interesting addition to hired health professional would be to use volunteers to take care of appropriated tasks. This was mentioned in the related work section about Health Info Island which uses volunteers to do suitable assistance for the visitors.

Another type of popular activity desired by the group of non-medicals were the possibility to view visualized representation of different patient treatments. This would be useful for both patients and their relatives as it was said from some of the participants that health personnel sometimes did not have the time to properly explain while treating a patient. This kind of resources could therefore be helpful in preparing both patients and relatives before a real hospital visit, making them more informed on what is going to take place.

We can not expect new users to know how to control their avatar and move around the virtual world in a fluently manner. It is therefore important to give all users the same base of knowledge of how to manage this. As mentioned in sub-section 3.4.3, three different ways of movement such as walk, run and fly are possible in a VW such as Second Life. Some of these may not be known or be intuitive to the users, and especially not for first time users. A virtual university hospital must resolve this somehow. We used about half an hour in order to teach everyone of our medical participants how to do this. We had three skilled people standing behind each group and instructed them as they sat in front of a computer logged onto an avatar in Second Life. This worked well, but this is not feasible in any other settings than if you have people geographically gathered at the same location, and with enough instructors. However, using adequate solutions such as the "tutorial path" at the virtual ability island would be a second best thing. A proper tutorial implemented is essential in order to give all users the possibility to fully utilize a virtual university hospital, and should therefore be included.

7.3.4 Virtual Reality interface

New advances and development of computer and VR supported technologies creates more possibilities when using virtual reality within the field of education. We have already mentioned Head mounted display such as Oculus Rift in related work, and we have after the exploratory study with the nursing students gained some experiences ourselves.

We have conducted two independent exploratory studies among post graduate nursing students. There was one important difference in the matter of virtual reality. We used the Oculus Rift as interface this time in comparison to ordinary desktop screen interface the first time. A comparison with and without the use of HMD was therefore conducted and presented in sub-section 6.4.1.

Our impression from comparing the two evaluations is that Oculus Rift provides greater realism in both the appearance of the place, and therefore also the conducted role plays. They seem to have more fun as well while role playing as the comparison indicates. The outcome of role playing was in a small extent greater with Oculus Rift on three possible learning achievements, however, there was also a very small decrease in the last three achievements. Our thought is that the Oculus Rift did not alter the outcome that much so that the educational value was equal using both interfaces. Although the comparison shows a very small decrease using Oculus, considering the use of body language,facial expression, behavior and avatar clothing during role play. We believe that this may be because of the low resolution and the early stage of such technology as the Oculus still is just a development kit.

Our non-medical participants felt the same presence and immersion using the Oculus, but experienced more reactions while using it than the nursing students. This may be because of more movement as our non-medical participants went along on a virtual tour. There were typically three outcomes of the non-medicalparticipants 1)They felt ill right away, but it eventually disappeared as they got used to it, 2)It went fine in the beginning, but some illness appeared after some minutes of use or 3)They experienced no illness at all. Generally, the Oculus was well received by both our medical and non-medical participants, but it was a drawback that most of them experienced some type of reaction such as dizziness, dry eyes and nausea. We do although believe that, given an ideal situation where "cyber sickness" such as these is eliminated in addition to improvements in graphics and quality, this would be highly applicable in use for further research. Imagine doing a travel into the human body using 3D virtual HMD, or moving around a real looking hospital where everything is in its proper proportions. At the time of writing, Oculus VR is soon launching their second version with many improvements, and should therefore be used to conduct further research.

We mentioned other virtual reality interfaces such as **motion tracking** and **haptic devices** in our preliminary study as well. We did not use any of these in our exploratory studies, but these technologies together with head mounted display such as Oculus Rift seems to be on the rise in the time of writing. As more research and development is being conducted, and with the gaming industry (such as Sony and Microsoft with their consoles) heading in the same direction, these may in near future be both satisfying and standard products used with virtual reality. We therefore include this in our discussion to rise awareness about these technologies in order to consider these as well when developing a virtual university hospital for the future.

8   Conclusion

A virtual university hospital should ideally be for everyone to use. We have looked at related work, and combined our experiences from our visits together with the input from both medical and non-medical group of participants in order to get both perspectives. The discussion brings together results from both sections, and highlights the most important findings to consider in own development of a virtual hospital.

We have in this thesis tried to find out *What educational activities should be supported in a virtual university hospital, and how.* We also specified further into two sub-questions:

1. *What educational activities, for both medical students and general public, should be supported in a virtual university hospital?*

2. *What are the content, facilities and technological solutions for supporting these activities in a virtual university hospital?*

Below are those educational activities that initially should be supported by a virtual university hospital. These activities are displayed in two tables, one for medical students and the other for the general public. Supportive content, facilities and technological solutions are given based on what we have learned from this study. It is necessary, during the development, to have a close cooperation with persons with the correct domain knowledge in order to select the most appropriate choices of content.

Educational activities for medical students:

Activity	Content, facilities and technological solutions
Patient simulation	Operating room, Patient ward, emergency area, NPCs, volunteers, Heads Up Displays, interactive hospital equipment, VR interface
Procedure training	Operating room, Patient ward, emergency area, information using videos and posters, interactive hospital equipment, VR interface
Anatomy lectures	Classroom, lecture hall 3D models of organs and the human body, posters, videos, VR interface
Role plays	Operating room, Patient ward, emergency area, reception, NPCs, interactive hospital equipment, VR interface

Educational activities for the general public:

Activity	Content, facilities and technological solutions
Public health education	Lecture halls,, exhibitions, posters, videos, NPCs, Volunteers, health professionals, 3D-models
Visualize treatments and examinations	lecture halls, exhibitions, NPCs, posters, videos, visualized flow charts
Virtual tours	Operating room, patient wards, lecture hall, exhibitions, medical professionals, VR interface
Counseling	Operating room, patient wards, office, medical professionals

Navigation, movement and interaction are three fundamental elements that need to be in order if a virtual university hospital is to be useful and effective as an arena for medical training and health education. The table below gives therefore two supportive activities which concerns those elements.

Support activities:

Activity	Content, facilities and technological solutions
Navigation	Road signs, Teleports, Maps, Entrance point
Tutorial	NPCs, posters, videos, "Tutorial learning path"

St.Olavs Hospital in Trondheim consist of very large areas, several departments and activities which together makes a complex structure. A virtual university hospital should more or less resemble the real hospital in order to support many of the mentioned activities, and will therefore probably lead to the same complex structure. It is recommended to start with implementing only the most relevant areas of applications mentioned in this thesis, and expand with more eventually as more research and studies are conducted. A complex structure will be inevitable, and must therefore be coped with by having a solid infrastructure to make it as simple as possible for the users.

A virtual tutorial should be located (preferably) close to the entrance point. One can not expect users to be skilled in navigating and moving around in the virtual world. Including an intuitive tutorial customized to the virtual hospital would benefit the users greatly, and probably enhance their effectiveness and positive experience of their visit. An example of how to make such a tutorial is given in this thesis.

This thesis includes examples of the listed activities and items, and they can be used as inspiration when finding ways of orient the users and teach them the basics. This is highly important, especially when the area becomes large and complex. We would emphasize the usefulness of having a entrance

point/starting area with the proper information to guide the visitors.

Virtual Reality interface
We have tested the Oculus Rift, and experienced a more fun and motivating way of learning. Many of our users, both medical and non-medical, were positive to the use of head mounted display such as Oculus Rift. Eleven (of 24, including both groups of medical and non-medical) participants selected this alternative instead of desktop as desired interface when entering a virtual reality. The drawback was the presence of reactions such as dizziness, nausea or dry eyes, and is probably the reason that the other half did not solely preferred this choice.

Virtual reality interface such as Oculus Rift enhanced immersion and presence, as well as the contributed to more fun and motivation when during the activities conducted in this thesis. We therefore conclude that this will contribute to the educational activities mentioned above. The recommendation is however, to have both alternatives(HMD and desktop) available as interface to the virtual university hospital.

9   Limitations and future work

9.1   Limitations

Limitations exists in any research projects due to various factors. The identified factors in this thesis are

- Compared to the the amount of research on virtual worlds for medical training, the literature on public health education is rather limited.

- Because of the scope of a master thesis, it was not possible to include additional groups of medical and non-medical participants in irder to perform more extensive studies.

- The lack of other hospital related occupations (e.g. physicians, paramedics and medicine students) makes us not able to obtain their point of view of a virtual university hospital and educational activities.

- Not all related work in Second Life are available to the public, thereby not possible to gain first hand experience of some of the environments.

- This study is based mostly on evaluation of Second Life, which excludes the properties of other platforms.

- It is not possible to obtain objective measures of learning outcome in our exploratory study. We had in addition different groups of people who participated last autumn and this spring.

Despite these limitations, we believe these findings are sufficiently generalized to be used by other medical and non-medical users as well. The activities given are also transferable to other virtual platforms as they in fact are utilizing the general properties of virtual worlds and virtual reality, and not linked to only one platform.

9.2   Future Work

Future work should include more studies on other areas of a hospital, and including users within other types of hospital related occupations as well (such as physicians, chiropractor, paramedic and similar) in order to expand the usage of virtual university hospital.

Both head mounted display, motion tracking and haptic devices should be included in future research considering the virtual hospital as an arena for medical training and health education. All of these technologies seem to be the future of virtual reality interfaces, and within close reach. Future work should investigate how these solutions can contribute to support even more possible use of a virtual university hospital.

We are living in a time where social medias such as Facebook, Twitter, My Space and Instagram is a central part of peoples everyday lives. Together with constantly improved mobile technology, people are connected every time of day. A suggestion is therefore to investigate how a virtual university hospital can be integrated with social media and mobile technology, in order to contribute even more to education and distribution of information.

A Virtual Operating Room for Collaborative Training of Surgical Nurses

Nils Fredrik Kleven, Ekaterina Prasolova-Frland, Mikhail Fominykh, Arne Hansen, Guri Rasmussen, Lisa Millgrd Sagberg, and Frank Lindseth: "Virtual Operating Room for Collaborative Training of Surgical Nurses," in the 20th International Conference on Collaboration and Technology (CRIWG), Santiago, Chile, September 710, 2014, Springer, in press.

The paper follows on the next page.

Virtual Operating Room for Collaborative Training of Surgical Nurses

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Abstract. In this paper, we present the first results of a study on exploring how to support collaborative learning of surgical nursing students in a 3D virtual world. A Virtual Operating room, resembling the one at St. Olav's University Hospital in Trondheim, Norway was created in Second Life to accommodate an educational role-play. In this role-play, the operating nursing students could practice communication with patients and cooperation in the team while preparing patients for surgery. At the first stage of the evaluation, the virtual simulation has been tested among nine postgraduate nursing students. The participants gave their evaluation and opinions in the form of questionnaires and discussion after the role-plays. Following the analysis of the data, we present a summary of the most important results in this paper. This study provides a number of suggestions for improving the learning process when role-playing in a virtual environment. We demonstrate that an educational simulation can be implemented with limited resources, and yet be practically useful in education of health personnel. Further research with medical and nursing students is highly applicable and feasible, and should include a larger group of participants. In the next stage of our work, the evaluation of the Virtual Operating room has been conducted with nurses, who are on an earlier stage of their study program, as well as anesthesia nurses and non-medics.

Keywords: 3D collaborative virtual environments, medical training, collaborative learning, virtual operating room, educational role-play

1   Introduction

At the core of educational activities of health professionals at all levels is the patient. The ultimate goal of basic research is the treatment offered to patients. Traditionally,

the bulk of the student contact with the patient has been through placement mainly in hospitals. However, there is a major challenge to this – the availability of time for contacting patients. One aspect is the increase in number of students. This is in part ameliorated by increasing the number of patients. The other aspect is not so easily remedied, the fact that patients spend less and less time in hospitals. As the hospitals improve their effectiveness, e.g. by increasing the number of day patients, there is dramatically less time for the contact between students and patients. Consequently, students get less time on the task. Thus, there is a need for solutions that give the students more time on tasks or make the time with the patients more effective.

In addition, in today's hospitals, a patient is treated not by a single practitioner, but by a team of specialists, with complex collaborative procedures and practices within the team. That means that a student needs to practice not only on patient interaction, but also on complex interactions within a team of professionals, such as when preparing a patient for surgery.

One has to look for alternatives to facilitate practice and explorative learning experiences to meet these challenges. Addressing the knowledge needs requires that students are provided with flexible online educational solutions which must be embedded in a holistic system. Therefore, the idea of an online virtual university hospital has emerged, to be a venue for learning, research, and development. The idea is to make a virtual mirror of St. Olav's University Hospital (St. Olav) as it is one of the most modern university hospitals in the world. It has a state of the art technological platform and modern clinical buildings with a unique feature: the faculty of Medicine at the Norwegian University of Science and Technology (NTNU) has integrated its teaching and research facilities within the hospital. In addition, NTNU and St. Olav have developed 'Kunnskapsportalen', a portal for distributing knowledge and information to patients and the general public, as well as to students, staff, and researchers.

In this paper, we present a pilot study within the Virtual Hospital project. The goal of this study is exploring educational role-playing in a 3D virtual environment as a method for training communication, cooperation within a team, and other practical skills of surgical nurses. The study was conducted at the NTNU, involving several other organizations. The major learning objective of the training simulation developed is to obtain in-depth knowledge of communication and interaction with patients and their families. In particular, we focused on the procedures of receiving and delivering patients on their way to complicated operations, something that requires coordination between ward and surgical nurses. The teachers from the Faculty of Nursing at the Sør-Trøndelag University College (HiST) have contributed to providing learning goals and designing scenarios for the study. Another group of subject experts from the Department of Neurosurgery at St. Olav was involved to provide requirements and feedback for the design of the virtual environment.

2   Background

As identified in recent relevant studies in the field, "as available teaching time in anatomy and surgery are expected to continue to decline, the adoption of unique in-

structional methods such as virtual learning may serve not only to attract more technologically inclined candidates but also improve the efficacy of the relatively fewer opportunities that will remain" [1]. This motivates the exploration of different modes for virtual learning, i.e. flexible low-cost 3D virtual simulations, 3D virtual environments, and associated infrastructure accessible over the Internet. Recent studies in the field indicate that this technology can "[...] effectively replicate clinical PBL scenarios", with the potential "to considerably augment, if not eventually, revolutionize medical education" [1].

Many studies report the potential of three-dimensional virtual worlds (3D VWs) for educational activities [2]. This technology can benefit educational process due to low cost and high safety, three-dimensional representation of learners and objects, and interaction in simulated contexts with a sense of presence [3,4]. Possibilities for synchronous communication and interaction allow using 3D VWs by various collaborative learning approaches [5], as well we facilitate situated learning [6] and project-based learning [7] approaches. Nowadays, 3D VWs can be used in combination with other VR technologies, such as motion tracking and head-mounted displays, to increase the sense of immersion and, therefore, improve the experience, making it more believable and transferable to the real life.

There have been several cases where 3D VWs have been used in the health care domain, including both desktop-based VWs and other VR applications. Examples include training facilities for nurses [8,9] and doctors (e.g., in palliative care units [10]), health information centers, and 3D visualizations of internal organs. Such training is, on several occasions, reported to provide a cost-efficient and user-friendly alternative to real-life role plays and training programs [10]. As demonstrated in several studies, "virtual worlds offer the potential of a new medical education pedagogy to enhance learning outcomes beyond that provided by more traditional online or face-to-face postgraduate professional development activities" [11].

Desktop-based environments have been augmented with VR elements for treatment of various neurological and psychiatric disorders such as autism, phobias, and post-traumatic stress syndrome, the latter especially in military settings. For example, Virtual Afghanistan/Iraq system has undergone successful clinical trials in using exposure therapy for treatment of combat-related post-traumatic stress syndrome among veterans [12]. VR is being increasingly used for developing educational medical visualizations, for example, to be used in anatomy classes [13].

Several leading world universities and hospitals, especially in the US, UK, Australia, and New Zealand have adopted 3D virtual simulation as a part of their educational programs. Examples include virtual hospitals/medical faculties at University of South Florida, Imperial College of London, and Auckland University Hospital. Such environments typically include an array of different facilities, such as emergency room, intensive care unit, nursing simulation, and general information for the public. Other examples include Maternity Ward at Nottingham University and Emergency Preparedness Training at University of Illinois in Second Life (SL). Our own Virtual Hospital initiative is inspired by these projects but seeks to achieve a more holistic and coherent approach to the development of a virtual hospital.

3 Learning Objectives and Collaborative Scenarios

In this project, we focused on communication with patients. Surgical nurses often have to inform, prepare, and even calm both the patient and their relatives before a complicated operation. These elements can be practiced through role-playing different scenarios in the virtual environment in SL.

The learning objectives below are based on the teaching plan for postgraduate surgical nurses at the Faculty of Nursing at HiST and have been used to develop the scenarios for the simulation. The major learning objective is to obtain in-depth knowledge of how to communicate and interact with patients, and their families, in particular when receiving or delivering patients who are on their way to a complicated operation. The major learning goal is split into several sub-goals:

- Learning objective L1: Reassuring a patient in advance of an important and complex operation
- Learning objective L2: Dealing with relatives
- Learning objective L3: Communicating / dealing with patients with immigrant background, especially women
- Learning objective L4: Reassuring / dealing with children in advance of an operation
- Learning objective L5: Dealing with a seriously ill and potentially dying patient
- Learning objective L6: Performing basic medical tasks prior to the operation (e.g., moving the operating table and disinfection)

In order to address the learning objectives given above, four typical scenarios have been developed, including a variety of medical cases and a variety of patient and relatives groups, as well as both males and females, children and patients with immigrant background:

- Learning scenario 1
  - Actors: A woman (patient), surgical nurse, and ward nurse
  - Plot: A 35-year-old woman is admitted to the gynecological department. She is on her way to a surgery for an abscess that will be operated in spinal anesthesia. She lies on a patient bed transported by a nurse from the ward who delivers her to the surgical nurse.
- Learning scenario 2
  - Actors: An immigrant woman (patient), husband (relative), surgical nurse, and ward nurse
  - Plot: An immigrant woman is going to a scheduled hip operation. She will have general anesthesia during the procedure. Her husband comes with her along with the nurse from the ward. She speaks poor Norwegian, and her husband must therefore be there to translate. She is concerned with keeping her hijab on and wishes to be treated by female personnel only.
- Learning scenario 3
  - Actors: A young boy (patient), his mother (relative), surgical nurse, and ward nurse

- Plot: A five-year-old boy arrives to the sluice with his mother and nurse from the ward. He is going to recto- and gastroscopy.
- Learning scenario 4
  - Actors: A man (patient), surgical nurse and ward nurse
  - Plot: A man in the age of 40 is going to surgery due to a malignant brain tumor. He has two teenage children that he alone is responsible for back home.

4 Requirements, Design, and Implementation

4.1 Requirements for the Virtual Operating Room and Avatars

The requirements for the virtual operation room were acquired from the Department of Neurosurgery at St. Olav, including photographs and textual description. However, no formal set of requirements was made, therefore, we employed Scrum methodology for the development. We divided the requirements into two parts: the virtual environment and the avatars.

The requirements to the virtual environment describe three rooms, their size, structure and artifacts to fill them (such as equipment and furniture). According to the final requirements, it consists of a hallway leading to three rooms, described below:

- *Waiting room* is an ordinary waiting room that you find within all ordinary hospital clinics, consisting of a reception desk, sitting chairs for patients and relatives, and a table with magazines and papers.
- *Sluice* in this context is a room that health personnel use for the delivery of patients on their way to an operation.
- *Operating room* is a place where the surgeries are conducted. The room is usually equipped with operation lamps, different medical equipment, and an operating table for the patient.

The avatars are divided into three types: patients, relatives, and nurses. The avatars for the relatives had to match the description in the scenarios, e.g. a 'mother' or a 'person with immigrant background'. The patient and the nurse avatars had more details, and they should have been dressed in accordance with the standards adopted at the Norwegian hospitals.

4.2 Design and Implementation

The process of designing and implementing the virtual environment for conducting role-plays was conducted in two iterations with feedback sessions in between. The first one was based on the initial requirements received from St. Olav's hospital. The second iteration was based on the feedback from the Faculty of Nursing teachers which generated new requirements and suggestions for improvements to be implemented. We were, however, not able to implement all the requirements (e.g., certain artifacts/equipment) from the initial set, and there were refinements that could have been done in more details (e.g., images and instruments). The goal of this process was

to create a virtual environment (Fig. 1, right) that is realistic enough to give a feeling of being in a real operating room at the Department of Neurosurgery at St. Olav's hospital (Fig. 1, left). Since the environment was meant for conducting role-play with the focus on communication (not on interaction with virtual artifacts), the operating room was not evaluated (e.g., considering the functionality of the medical equipment).
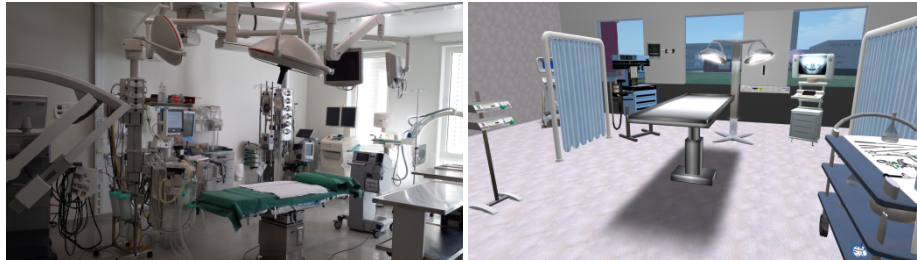

Fig. 1. Real life and Second Life operating room

We designed and implemented the building, its rooms, and some details from scratch, but most of the more complex artifacts, such as the operating table, anesthesia machine, and other similar equipment were purchased at the SL marketplace. The negative side of purchasing items created by others is that some minor conflicting details may follow. For instance, the patient bed on wheel was supposed to be used to animate the transportation of patients from the ward or sluice to the operating room. We purchased the only bed with that function available at that time on the SL market-place. However, it was an 'emergency bed', with an integrated animation of blood infusion into the patient. This last detail would not be correct in the situations given in the scenarios, and the students were instructed to ignore such details.

Nine avatars were required according to scenarios. Customization of the avatar appearance to fit some of the more detailed role descriptions was a time-consuming task. We created 11 avatars, including two spare ones. The resultant nursing avatars had pale green or white clothing where the former is used for the surgical nurses and the latter for the ward nurses (Fig. 2). SL does not have default avatars matching the description of some of the patients and relatives, such as a young boy and a Muslim person. Therefore, we purchased 'skins' and related accessories (e.g., a hijab and jewelry) at the SL marketplace. All patient avatars were required to wear a plain patient gown with a front opening. We purchased a plain white open shirt for the adult patients and a gown with a back opening for the child.

Fig. 2. Nursing avatars

5　　Study Settings and Results

5.1　　Role-playing Settings

After completing the virtual environment and a set of avatars, we recruited nine post-graduate nursing students from the Faculty of Nursing at HiST, who were on their last year to become surgical nurses. These students already had a bachelor degree in nursing and at least two years of professional experience in addition. In other words, they were well experienced and should already have acquired skills given by the learning objectives (section 3). Therefore, as we could not expect them to learn much from the role-playing, we used their knowledge and experience to evaluate the teaching method and the environment developed. Instead of assessing the learning improvement, we rather asked them to evaluate the simulation and provide feedback on how well it might be suited in the nursing education at an earlier stage.

Low computer competence and little experience with 3D VWs were expected for such a group. In order to address this, a tutorial on the gameplay, such as camera controls and avatar navigation, and a one-hour practice session were conducted before the role-playing session. In order to accommodate role-playing with four players, four fully equipped computers were set up in two different offices at our university (Fig. 3). The third location with a computer, a large screen, and speakers was prepared for the teachers and those students not playing to observe the role-play.

In the beginning of the role-playing session, the students chose one of the roles from each scenario and received "role-play cards" describing their characters. The cards contained information about name, role description, and a description of the situation. In all scenarios, the students were told to improvise their role as best as they could using their knowledge and earlier experience. The teachers and other students were observing the role-play and discussing questions that have been emerging during the play. After completing a scenario, its players joined this group to have a discussion before going to the next scenario.

Fig. 3. Surgical nursing student participates in the role-play (photo by Anne Midling)

5.2 Data Collection

The data in this study was collected from several sources. The role-play in SL was recorded as a screen capture (with sound), while the subsequent discussions were recorded with written notes and sound capture. In addition, a questionnaire consisting of 28 questions was given the students after the role-playing session. It included multiple-choice questions using a five-level Likert scale, 'check-box' questions allowing to select multiple answers from a list of options and open questions.

The questionnaire was divided into four main topics. The first one covered the competences of the participants in use of computers and their previous experience with SL or similar VWs. The second topic included questions about the use of SL during the role-play, including the process of getting used to the navigation, realism of the environment, and game experience. The third topic contained more subject-specific questions on believability of the simulation and its suitability for providing knowledge and skills described in the learning objectives. The fourth topic contained open questions where the students were asked to input proposals for changes and improvements, describe what learning outcomes a student may gain from the simulation, and suggest other areas within medicine they thought could benefit from it.

The group discussion was conducted to supplement the questionnaire and let the participants express ideas immediately after the role-playing. We used five questions to engage the students in a discussion. However, several other questions appeared too. The major topics were the general impression, possible educational value, level of engagement, alternative solutions, and application domains within medicine.

5.3 General Issues

The teachers reported after the role-playing session that not all the students were prepared for the settings. We observed some hesitations every time we asked who wants to go next in playing a scenario. Some of the nurses said that they did not feel that comfortable role-playing in the VW when they knew the other students and the teachers watched the play on a large screen. "One should like to role play, or else the role

will become limited", a student mentioned in the questionnaire. One student asked if it was possible to identify the person behind an avatar. Even though role playing while being remotely observed by others made some of them uncomfortable, they all tried to play at least once and they came through all the scenarios. It was also observed that the role-playing became smoother for each new scenario as they started to get hold of the navigation in SL and more immersed into acting. This trend was also reflected in the open questions of the questionnaire were one student answered: "The role plays got better eventually. Got more comfortable after some practice".

5.4   Previous Experience and Technical Issues

The questionnaire reveals that none of the students had any previous experience with SL or other VWs and/or games. Only three out of nine also describe themselves as having good or better computer competence. This is likely to be the reason to why some of the participants were not so steady when moving around and interacting with objects in the virtual world. Six of them answered "neutral" on the question regarding the difficulty in moving the avatar to different places. This may be interpreted that it has been easy to move the avatar as we did not observe any issues there, but challenges came when they were to move the avatar while interacting with objects, for instance, operating the rolling patient bed.

Half of the participants agreed that it went quickly to learn the interface of SL, while the other half answered neutral to this question. We observed that fewer questions were asked as we proceeded, and the participants even started to inform and teach one another of how to manage different SL controls. The students experienced some echo inside the game while playing. This was most likely due to having two computers with microphones located in the same room with a distance not greater than three meters from each other.

Even though the students got one hour of training before conducting the role play, the avatar and camera movement inside the game were still challenging. The majority of the students expressed (both during the role play and during the discussion afterwards) that it were difficult to focus both on role-playing and movement simultaneously. This was also observed, for instance, when one of them lost control over the patient bed, which turned from side to side when trying to reach the operating room. The student tried to get control of the bed in the game while at the same time trying to role-play. It often resulted in laughter from the audience, which appeared interrupting.

5.5   Collaboration

We observed that when the immersion and acting part became better, the collaboration between the participants in SL improved as well. The reason was probably that while the students became more confident in playing 'difficult' patients or relatives, the students playing the nurses had to work harder to get things in order. For example in Scenario 2, the Muslim woman refused to take off her hijab, and the two nurses had to talk their way around to get the patient and her husband understand the rules. Another example is from Scenario 3, where the 'boy' resisted a while before positioning

his avatar on the bed. His mother, the ward, and the surgical nurse together tried to convince the anxious boy in cooperating and to calm him down.

At some point in every scenario, the role playing started to halt because of a missing part. It was explained that surgical nurses collaborate most often with anesthesia nurses at the operating room. We observed during the role play that anesthesia nurses/doctors were frequently mentioned in the dialogue between the surgical nurses and the patients. The students and teachers mentioned during the discussion that it would have been natural for an anesthesia nurse to take over some of the interaction, as the surgical nurse could not proceed with their tasks without them doing their job. Therefore, it was concluded that anesthesia nurses should be included in future role-plays. This is implemented at the subsequent evaluation as mentioned in the Future work.

5.6 Evaluation of the Environment and the Play

Even though role-playing is not currently used as a tool in their study program, all students except one reported that they felt engaged in the virtual role-plays and the same people found the experience fun and motivating.

The majority of the students were neutral to the question about how realistic or representative the virtual environment in SL was in comparison to St. Olav. Seven students answered that it was difficult to read and interpreted information from the body language and facial expression from the avatars. The ability to read nonverbal cues or signs such as these is an important aspect of being a nurse [14]. The avatar appearance was easier to interpret, as four of them agreed.

We asked the students about what elements they thought gave the most and least information in the simulation. The most informative elements included room design/environment, avatar clothing and their positioning, while the least informative elements were sound and body language. Six of the students agreed that the simulation in general gave them enough information so that they were able to understand the patients, relatives, and their situation. The rest were neutral on this question.

5.7 Value of Using Virtual Simulation

Evaluating the educational value of the simulation, the participants used what they learnt at the college as well as their professional experience. We gave them nine questions asking how well they thought the simulation would contribute to enhancing skills in collaboration and communication with relatives, other health personnel, and different types of patients.

The positive choices on the Likert scale were more frequent. Therefore, we assume that using a simulated environment may be a positive supplement to the education of practical nursing skills. Eight out of nine students answered positively to the question if the use of role-play in a VW can be a supplement to help the surgical nurse students in communicating with patients and relatives.

We listed six other medical areas that might be suitable for practicing inside a VW and asked the students to choose the areas they believed to be most relevant. Four most popular areas selected by seven or more students were collaboration in teams in

an operation room or emergency department, procedural training, anatomical visualization, and diagnostic training. Other popular areas included education of patients and relatives to improve understanding of the treatment procedures and disseminating health-related information to the public in general.

6 Discussion

6.1 Environment Design

The fact that only three of nine students agreed that the virtual environment were realistic and representative to an operating room in real life could be partly attributed to the fact that not all of them have been to the real Neurosurgery operating room that was replicated in this study. From the questions regarding "potential for improvements", some of them suggested that we should have "more equipment to interact with". One student mentioned during the discussion that "more items to interact with needs to be included if surgical nurses are to treat and communicate with a patient". This was explained by that the surgical nurses often communicate their actions to their patients in order to inform the patient and to keep the patient's thoughts occupied. The lack of interactive items may be an explanation to why most of the students did not find the virtual environment realistic. Such an item could for instance be a blanket to put over the patient, or other items such as suited clothes for the relatives to put on if they were to follow the patient and the nurse to the operating room. However, tasks such as changing avatar clothing during the role-play would require additional training, and therefore, these details were skipped.

The replies to the question on what aspects gave most information show, however, that six of the students did use information given from the "surroundings" which is also reflected in the recordings of the role plays. For example, when one of the surgical nurses tells the patient's husband to step away from the instrument table when he gets too close, as these instruments are sterile and prepared for surgery (Fig. 4). Another example is the nurse asking the same person not to be in the way, but stand beside the "machine with the screen" located at a distance from the operating table.

Fig. 4. Role-playing, Scenario 2

Another factor contributing to inhibiting the feeling of realism amongst the students might be the lack of experience working with VWs. All nine students answered in the survey that they had no earlier experience with either SL or other VWs. This lack of experience might have made it difficult to feel immersed inside a VW.

6.2 Using the Technology

There are at least three aspects to look at when considering simulation in a VW as a suitable tool in the education of nurses. The first being how much time and effort it takes for both the students and the teachers to gain enough technical knowledge before it becomes useful to practice inside a VW. Our students had no experience with SL or VWs in general, and they got only one hour of training before they were set to role-play the scenarios. The evaluation reveals that is was challenging for the students to focus on their actual task when they simultaneously had to interact with a few set of objects (such as rolling the patient bed and using the operating table). Observing the role play and the recordings afterwards also reveals several disruptions caused by object handling in game. For instance, some students did lose control over the rolling bed, or those playing patients often misclicked and sat down at other objects rather than lying down at the operating table as supposed to. This often led to some laughter amongst the students, and the need for some help before continuing role-playing.

Even though the study was exploring communication with patients, the role play became to a certain extent challenging considering the number of objects the participants had to handle. One hour with tutorial would not have been enough if the students were to interact more and still conduct role-playing fluently. The students from our discussion remarked themselves that 'it does take a while to learn', however, another uttered that 'a day more with role-playing, and they would be skilled'. A third one said that 'it was difficult to role-play when you had to concentrate about the technical part such as navigation, interaction and camera movement. They all agreed on that a larger quantity of training would have been necessary in order to forget the technical aspect completely and focus on their actual task during the role-play.

6.3 Learning and Improving Skills

The second aspect to consider is whether the simulation supports learning and improvement of practical skills. We did not measure this directly during the evaluation, as our participants were postgraduate students on their last year and had both sufficient knowledge of the procedures and work experience. However, we engaged them as evaluators contributing their subjective opinions of how well this type of simulation would benefit nurse students at an earlier stage.

The survey contained nine questions regarding how well the simulation would improve various practical skills of early-stage nursing students. The feedback was positive overall, but we divided it to three types. The most positive feedback was received in two questions on communication and interaction with the patient and with the other medical personnel.

In five other questions, the feedback was also positive, but with one or two neutral answers. Such moderately positive feedback was given to the educational value of the simulation in calming down the patient, communicating and interacting with the patient from a different culture, the child patient, the relatives of the patient, and relatives of the child patient.

Two answers to the remaining two questions were also positive, but had more neutral and some negative answers. These questions were evaluating the usefulness of the simulation for training communication and interaction with the patient who needs an interpreter and the patient who is visibly under stress.

During the discussion, several aspects were appreciated and many suggestions were made by the participants. The students reported that it would be much more appreciated if they could get some feedback during the role-plays from either a teacher or a more experienced nurse. This could for instance be through an avatar standing in the corner and contributing with inputs, functioning as an expert guide. Another suggestion made was to let teachers play the patients, as they often have more experience and they would be more suitable to play them, as it was done e.g., in [11]. We also observed that it was easier for participants to put themselves into the role of a young boy than of the Muslim woman and her husband. However, the results from the two questions regarding their opinion of how well such simulation would improve the skills in communication and interaction were the same for the two patient types.

The students gave several suggestions for improving the scenarios. They agreed that more strict guidelines for the role-plays would be helpful, as the scenarios were quite open only providing the students with some background information before they were asked to improvise. One of the student mentioned "the scenarios would have been too difficult if you do not have any real experience, one would not know how to proceed". This is important feedback when it comes to using the simulation with students at earlier stages in their studies and later.

The last suggestion was to integrate different scenarios in a single story with game elements. In such a game, completing one scenario would allow a team of participants to advance to the next level, i.e. to the next scenario.

6.4 Motivation, Engagement, and Fun

The third aspect concerns whether the role-playing activity was motivating, engaging, and fun. This is important if simulation is to be accepted by the students as a part of their educational program. As mentioned earlier, laughter was frequently recorded during role-play, especially when the participants made small mistakes, such as crashing the rolling bed with the patient or making their avatar sit at odd places. This was indeed a new experience to them, but we observed that many were eager to immerse themselves in the role-play when they started to be more comfortable with it. Eight out of nine answered either "agree" or "strongly agree" to the two questions "if the game experience was fun/motivating" and "did you feel immersed in the role-play?". The fun factor is, however, not enough to make the students want to use the simulation in their study program, as they need to have a stronger reason and motivation.

An important point was raised when discussing changes needed in order to increase the educational value for the surgical nurse students. Surgical nursing is a practical profession and the procedure needed to prepare a patient for surgery is relatively complex. Many of the students stated that it would be natural to do more practical things in the virtual operating room, such as washing hands, covering patients with blankets, position the operating table, disinfect, prepare instruments and similar tasks and routines, which is an important part of their job when dealing with a patient. As one of the students puts it, "use our hands more". Most of our discussion centered on how we can improve the virtual operating room to make empathy and interaction to feel more like in real life. Therefore, it appears that some of the motivation amongst the students also lies in the possibility to practice on medical procedures as a surgical nurse and working on associated tasks in the VW to gain early experience.

7   Conclusion and Future Work

This study gave valuable information that can be used as guidelines for further development of virtual operating facilities and, on the longer term, of a Virtual Hospital. There is also a need for further exploration of the different ways to support collaborative team training and practical medical training with innovative technologies. The role-playing facilities in a virtual operating room have the potentials to provide the students with a safe, realistic, and accessible environment for practicing their nursing tasks. In order to achieve this goal, the virtual operating room should be equipped with interactive objects related to the tasks and routines of a surgical nurse. This could be simple tasks, such as putting a blanket over the patient or preparing instruments before surgery. Surgical nurses use their hands a lot, and the students should be able to do this within the VW in order to immerse themselves properly into the role. It also follows that interactivity in general, such as navigation, object manipulation and interaction with co-players should be improved and made more intuitive.

Another implication of the study is the need for guidelines and methods for scenario development, including definition of roles. For example, a student might not have experience with certain types of patients and certain medical conditions. Therefore, he/she would not be able to give the correct feedback to co-players. This would require formalized guidelines for how to play this type of patient, and probably some more information and preparation for the student in advance of the role play. A related aspect is interaction between different actors in the nursing team. An efficient learning experience requires receiving cues and other sorts of feedback frequently during the role play. Our participating students got these cues mostly from the dialogue with each other as nurses and patients, though they participated in a reflection round afterwards. The students mostly agreed agreed that this should be improved for the role play to have an educational value. Types of feedback suggested were an avatar guide/game leader played by an experienced person who can join them and give inputs along the way. Another suggested solution was to let a more experienced nurse or teacher play the patient, as well as to implement tasks to be done where you either fail and stay put or complete to advance to the next level with a new set of tasks.

The major limitation of the study is that for practical reasons we were able to recruit only nine postgraduate students at their last year of studies. The small number of participants does not give statistically significant data, but, at the same time, they provide some useful indications for further development of the system. For example, all but one of the participants have been positive towards the use of role-play in a VW as a supplement to surgical nurse training in communicating with patients and relatives. Therefore, despite the limitations of this study, the results provide a motivation for further development of the Virtual University Hospital a basis for further elaboration of design principles for a collaborative virtual training environment.

The ongoing second stage of evaluation is based on our experience and feedback from this study. Both anesthesia and surgical nursing students at their first year were recruited to role play together in the Virtual Operating room at this stage. We attempted to make the gaming experience more intuitive and engaging and enhance the feeling of immersion by using head mounted displays (Oculus Rift). The teachers acted as patients, providing correct feedback and giving the students the possibility to focus on their roles as anesthesia or surgical nurses, teamwork and interaction with the patients. We have also conducted an evaluation among non-medics, as the operating room could potentially be used for informing general public and preparing patients for a surgery. Apart from evaluating their experience in the operating room, both user groups, medics and non-medics, have been asked to suggest services and features to be included in the Virtual University Hospital.

We are currently working on analyzing the motivation, degree of immersion, and learning experience amongst the participants at the second evaluation stage, comparing the findings with the results from the study presented in this paper and outlining requirements for the Virtual University hospital as an arena for health education.

Future evaluations will include a larger group of students, but also different scenarios and groups of patients and medical professionals. One example is language and cultural awareness training for nurses from other countries (e.g., Philippines and Easter and Southern Europe) recruited to work in Norway. We will continue developing the Virtual University Hospital, both conceptually and technologically. In the longer run, such an environment will be enhanced with other features and facilities for collaborative work and learning, such as library of medical resources, anatomical visualizations, meeting facilities, patient information facilities and so on, normally present in a real university hospital.

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B   Surgery program

Below is the surgery program used during role play with the psot graduate nursing students. The surgery program is in Norwegian.

Operasjonsprogram mandag 24/03-2014 Med tilleggsopplysninger for Arne/Knut/Guri++

Tid	Post	Navn	F-år	Diagnose	Operasjon	Andre opplysninger	Opr	ASA	Anest
		Operasjonsstue 1							
		Solborg Iversen f. 1979		Residiverende Bartholinitt	Drenering av abscess	Ingen fødsler. Tidligere 2 spontan-aborter i 10 og 14 uke. Røyker Allergi Stiv i ryggen		1	Spinal
		Operasjonsstue 2							
		Mahmbi Ghane f. 1949		Coxarthrose Hofteleddsartrose	Totalprotese høyre hofte	Svært engstelig Snakker kun noe norsk Ønsker å ha med mannen inn som tolk. Høyt blodtrykk Lett overvektig		2	N
		Operasjonsstue 3							
		Crisstoffer Moe f. 2009		Kontroll	Gastro og rectoskopi	Gjentatte episoder med diffuse magesmerter OBS løs tann i overmunn Vært på sykehus mange ganger, er engstelig Mor er med. Har astma		2	N
		Operasjonsstue 4							
		Borgar Evensen f. 1969		Tumor cerebri	Tumor ekstirpasjon	Har Bechterew Preoperativ stålebehandling Eneforsøger for to tenåringsbarn Er overdrevent optimistisk		2	N

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