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Sepsis Training in Virtual Reality

A Study on Enhanced Learning

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ABSTRACT

Sepsis is a health condition where the bloodstream is bacterial infected, it affects annually 18 million people around the world. Especially does the illness affect individuals with weaker immune systems. Treating sepsis presents some challenges as it requires rapidly detection and correct treatment. Virtual Reality (VR), which is defined as three-dimensional computer science, presents potential solutions as it can provide efficiency and proficiency. Still, this avenue has not yet attracted much attention and this master's thesis is among pioneering efforts in the field presenting VR solution to sepsis. More precisely, will VR be used to increase competency in detecting and handling patient with sepsis so that health personnel can be better prepared. The technology will add to existing training opportunities for health care students and professionals with a solution that is cheaper, more fun, and easy to integrate into ongoing activities. Thereby, the targeted market for VR include both educational and health institutions that address patients who can get a blood infection.

The key to succeed with implementation of this new form of educational tool is include health personnel early in the production process of the application. Sudarsana et al. (2019) remarked that the target group "has a vital role in the development of educational technology" (p. 3) as it in the end was the one going to use it. The health personnel's perception is not only important knowing for the development of this VR solution, but also for future usage of this technology. By taking the perception of these users into consideration, developers will be able to make customized product adequate to the reality, affecting positively the learning outcomes and motivation of its users. Therefore, this study was conducted to address end-user's thoughts about VR as an educational learning tool on sepsis. We collected perspectives of 44 volunteers from health care services through a quantitative design survey.

To address the target groups thoughts on sepsis training and learning in VR, two questions can be asked: whether they accept it to the certain degree that they will use it, and whether they think it can enhance todays learning with being more efficient and proficient.

This master's thesis is based on the Technology Acceptance Model, containing several elements that together contribute to address attitude towards educational tool. Perceived usefulness and perceived ease of use are the two main elements affecting participants relation to sepsis learning and training in VR. High results were found on intention to use as 65.90 % of the participants wished for VR to get adopted to supply and maintenance health personnel's knowledge on sepsis. A corresponding percentage reveled that the health personnel would predict to use VR to refresh knowledge on sepsis given access. Meaning that the target group overall accept the tool as an add to the conventional classroom.

The survey participants experienced the solution for sepsis training suitable as they thought it could give a reflection of being present in a situation with sepsis. Also, they thought they would be more concentrated in a fun and deep learning case in VR than by the conventional classroom learning. The participants predicted to be able to transfer accumulated knowledge from a virtual case to a real-world case. The technological tools given characteristics are expected to enhance todays learning.

Keywords: VR; Education; Learning; Training; Sepsis; Enhanced Learning; Efficiency; Proficiency

CONTENT

1. INTRODUCTION

1.1 Potential for Improvements

Every year, an immense sum of money is appropriated for education and a substantial amount of it is set for the education of health professionals. This is particularly true in Norway where large funds are devoted to finance present tuition, alongside with research initiatives on developing future aids to improve teaching and working methods. Naturally, the educational goal is to deliver high quality. However, despite the large sums spent by governments on health education, the expected quality of execution for health professionals in educational institutions and health care services does not seem to be reached. Number of studies have manifested the lack of knowledge from health personnel (Nguyen et al., 2009; Tromp et al., 2009). Furthermore, the Norsk Sykepleierforbund (2019) expressed the following statement to the national health and hospital plan 2019-2023:

> «Spesialisthelsetjenesten bruker i dag ikke nok ressurser på utdanning av helsepersonell til å dekke kompetansebehovet. Kvaliteten i praksisstudiene er for dårlig og kapasiteten er ikke tilstrekkelig. Sykepleiere utgjør den største profesjonen i spesialisthelsetjenesten. Likevel satses for det lite på utdanning, fagutvikling og forskning innenfor sykepleie.» (p. 1)

Education is important as it sharpens advanced expertise of the health personnel, and sufficient resources must be provided to the relevant institutions to provide such educational opportunities. Lack of expertise on health personnel can therefore arise due to limited resources, which could be solved by tightening some of the budget items. Nevertheless, as Menon Economics (2017) mentioned, looking on the amount resources used is not always the most relevant, but instead improving how we can better use them. In order to improve the training quality of health professionals, resources will thereby need to be used more efficiently as the public sector is given a restricted budget for education purposes. Such efficiency can be achieved by developing tools that can deliver high quality education to a lower price. There are several ways to make a better use of given resources from the governments. For example, one could suggest to make a better use of resources by maximizing participants on healthcare courses while maintaining course quality. On another hand, one could instead suggest to use the resources more efficient by giving a course with the same content on shorter periods. Thereby, if we asked a group how we could do so, we would get several answers. However, if we asked same individuals whether technology could make a difference for the teaching methods and learning outcome, we would most likely have a more unambiguous response. As the emergence of technologies made us change the way we operate into a more proficient and capable manner. It has such revolutionized everyday life that the potential of new technologies to resolve various issues is widely welcomed by societies. Indeed, Menon Economics (2017) claimed that investments in new technology could help us reducing long term cost and that it could be a resource for productivity growth.

Over the last decade, technology has developed rapidly in our everyday life. Not only has it increasingly become part in our personal life, but also at school and throughout our work careers. Kron, Gjerde, Sen, and Fetters (2010) declared that 80 % of their survey respondents found new media technology valuable for their education. The medical students' point of view is assumed to be a result of their perceived usefulness, as almost 90 % of the students "thought that real life is migrating online in many aspects" (Kron et al., 2010, p. 5). The same statement has been claimed about the technological tool VR, that has developed a world corresponding to the real one. Not only does the virtual world give a reflection of how things are, it also gives us the opportunity to get immersed in an artificial dimension close to reality and to interact in it. Many studies have shown that technological tools can provide a more efficient and proficient learning outcome, as we later show statistically have these results also been clarified about the virtual world. By achieving these terms, VR gives the possibility for maximized utility, with lower cost and higher learning outcomes. Maximized utility would naturally be good for the society as it reaches the highest form for value creation. VR users, in this thesis represented by health personnel, could be better prepared for daily work tasks. The enhanced learning will make them more confident on their duties and have a positive effect on value-added during education. This would as one could expect, cause a win-win situation – benefitting both the state investing resources and the society benefiting from the services. Some would think it sounds like an utopia, but is it? As illustrated above, countless amount of scientists have shown in their studies how technology could give a better learning outcome in educational institutions. In this thesis, we will address several of these applications of technology and supply the existing literature with our own findings on VR and sepsis. Training to treat sepsis using VR is a novel idea, few pioneering efforts on the field has been done. However, is sepsis education getting introduced for new technology as the incidents of the illness increases and the health personnel's competence on sepsis shows room improvement.

1.2 Research Question

As technology continues to improve, we observe that classrooms are showing interest for technology as an addition to the traditional educational tools (Larsen, Oestergaard, Ottesen, & Soerensen, 2012; Rehman et al., 2013). Scientists have long emphasized that the use of VR would be beneficial for education. As computer science has established itself towards this area over the last decade, it has been easier to address the significant differences from the traditional one. Several studies (Larsen et al., 2012; Nguyen et al., 2009; Sankaran et al., 2019; Seymour et al., 2002) have shown that use of technology can improve today's training of health personnel as it can reduce the time needed to complete tasks and give superior skill training. Whether these statements only can be applied to the certain study groups or if we can generalize it to health personnel in general, is a question for deeper reflection. In the following background section, we will review studies that has been done on this field and use this prior knowledge towards this study. This paper will contribute to the field of study by answering the following research question (RQ):

RQ: What are VR's potential users' thoughts about computer simulations as an educational learning tool? And which elements should be considered to determine the users' perception?

The prime question is divided into two research questions:

RQ 1: Is VR accepted as an educational tool to a certain degree that health personnel will use it to learn and train on sepsis?

RQ 2: Could VR enhance todays learning along with being an alternative for Norwegian Health Care for more efficient and proficient education program?

As the innovative learning platform distinguish itself from the traditional, we find it necessary to look closer on how practitioners find the potential new education tool. Do they find the usefulness high enough to accept it as an educational application and further on, a system usability processing the intention to use? In order to address how the tool overall is perceived, we need to look at both research questions, as the two affect each other. By investigating the first question, we will get an impression of health personnel's acceptance. By investigating the second question, we will get an overview on whether the innovative system can be characterized as a more efficient and proficient application than the conventional learning tools. Ultimately, the answers to these research questions will be to a certain degree illustrating the value of VR characteristics for the participants and whether they think the tool can be a good alternative for educating health personnel.

1.2.1 Delimitation

As we present the research question quite broadly, we find it necessary to make some delimitations for this thesis. Firstly, we have chosen to focus on the public health sector, as the public system is built up of similarities. The health personnel have taken the same education and been through courses with similar content. Secondly, we distinct the medical procedural training in VR from the traditional one – as the two kinds of training are viewed as distinctive educational processes. As we later will present, do the traditional training sessions take place in a classroom, where actors are used to be patients, health personnel and medical equipment. VR does on the other hand have all the mentioned elements implemented in a medical application. As demonstrated, the foundation of this paper will be based on education through the innovative platform of VR. The medical procedural training in this article will remain its focus on sepsis as we have gotten to know that there is improvement to be done in the school career.

The first section has introduced the papers base on educational learning and training through VR and clarified that the focus will be on the phenomena of sepsis. The second section will provide an overview of the technological tool's development and will define implementation possibilities for VR. Third section will examine the framework used to answer the presented research questions, introducing the *Technology Acceptance Model*. It will also reveal results from prior studies results and introduce other important concepts, such as clinical background and situated learning, into this study. The fourth section will present the research methodology, and results will be illustrated in the following section. These results will be presented through factors and multiple regression analyses. In the sixth section these results will be interpreted, and discussion will be entertained on whether the results measurements can be considered valuable and reliable, and whether they can be generalized to health personnel. Finally, the document will provide a conclusion of this master’s thesis, summarizing its findings.

2. BACKGROUND

2.1 The Innovative Computer Simulation

2.1.1 What is VR

VR is computer science that makes it possible to enter a world similar to the real one. By using well-qualified tools, one can not only be immersed into a simulated reality, but also perform in it. The Dictionary (n.d.) has described VR as:

> “a realistic and immersive simulation of a three-dimensional environment, created using interactive software and hardware, and experienced or controlled by movement of the body.”

VR is a well-known technological tool that has been in development since the 1950’s (Mandal, 2013). VR as we know it today has been through decades of evaluation and is by many contemplated to be a revolutionary tool in future technology. Especially within the last years, significant technological advancements have put VR on its golden age, providing various services and investment opportunities. For instance, in the end of 2018 Walmart supercenter used more than 17 000 Oculus Go to train their employees (Incao, 2018). In addition, a half year later, Facebook launched Oculus Quest – that after two weeks was sold for 5 million dollars (Matney, 2019). These revealing numbers, among others, show the interest of the world community for this type tools and its functionality.

The hardware for VR has been for a long time in a continuous development phase of improvement and been considered as an open market as no major players have concurred the market and established a monopoly yet. The machine known for being the first VR tool, Sensorama, assisted individuals to get immersed by stimulating its senses when seated in a box, as illustrated in the Picture 1. Even though the machine was a technological breakthrough, it was considered being too complex. The inventor, Morton Heilig, pitched his inventory as a possible showroom display for Ford and others, but had a hard time finding investors. Due to this, the “Sensorama stalled in the prototype stage” (Turi, 2014, para. 6). A decade later, a new invention form of VR, the Head Mounted Display, entered the market. This tool made it possible for the user to move its head as the tool would identify its position and adjust the virtual sight accordingly (Mandal, 2013). As the technology matured, it became possible not only to be immersed into the simulated reality, but also to perform actions through interactivity, as demonstrated in *Picture 2*.

Picture 1. Sensorama Simulator. Reprinted from *The sights and scents of the Sensorama Simulator*, by J. Turi, 2014.	*Picture 2*. Reality Check. Reprinted by ESA, September 2017.

As the cost of equipment has lowered and its quality has increased – the usefulness of the hardware has strengthened considerably. This has made it possible for VR to progress further and offer more and more an artificial reality that is closer to the reality as we know it. For several years the technology of VR allowed one to enter and perform in a virtual world through using headset and controllers. At the end of 2019, the equipment entered a new level by facilitating interaction without controllers, instead using hand movements that are tracked and used as controllers. The phase we find the innovative computer simulation today can be seen as the beginning of the implementation of VR. The tool differs from the traditional education as it allows its users to be present in a setting even more similar to the real one – and by this letting its users become more familiar with constraints that could be otherwise difficult to translate to students using traditional educational tools. As we now have an impression of what VR is, we will below get an idea its usage and the potential benefits of it in health education.

2.1.2 Multiple Tool

The list of possible usages of VR is broad and new applications are constantly found. Indeed, VR is often considered as an entertainment tool, but can as well be a tool for educational learning. VR can be used as a part of a rehabilitating program, highlighting indeed that VR is therefore not only a tool for amusement, but can also be used for to resolve issues and improve life quality. Along with supporting the rehabilitation, VR also contribute to the education of various fields of professionals. VIAR360 (2019) demonstrated that the technology can be used in educating future firefighters, pilots, surgeons, military, and even astronauts, among others. A common characteristic for several of these different fields is that they involve dangerous and complex situations that can be hard, or even impossible, to re-create using traditional educational tools, living out students without opportunities to actually experience these situations before encountering them in real life. We will look closer to this in the next subsection, as this plays a major part of the motivation for use of VR in the training of future health professional to treat sepsis.

2.1.3 Motivations of Use

As highlighted above, VR gives the opportunity to various professionals to practice executing on important tasks under conditions which we would not be able to re-create before actually happening. Indeed, Ribaupierre et al. (2014) addressed four problems to the traditional education system, one according to safety, one to ethics, and others to time and cost. All these four drivers can play a significant role for extending the use of VR in different educational fields. Medical surgeries can be a good example to emphasize the importance of this technology during the training of future health practitioners. Still today, medical students generally do not have any pre-experience of surgery before physically entering an operation room. Using computer simulation and VR during their training, they can instead be put into realistic situations, experimenting close-to-reality conditions of medical operations and go through the procedure without actually having to do it already on living patients. These exercises can be repeated numerous times until every step is done accordingly to the procedure. The use of VR in training sessions can thereby prevent dangerous situations whom the student normally would not be prepared to. In addition, it prevents any form of harm for patients as there is no risk for the patient’s life in this kind of procedural training. Yet, there are still some distinguishable differences between the virtual world and the actual one, but the

VR continuously improves and progressively education through computer simulations will make situations more and more similar to the ones in reality.

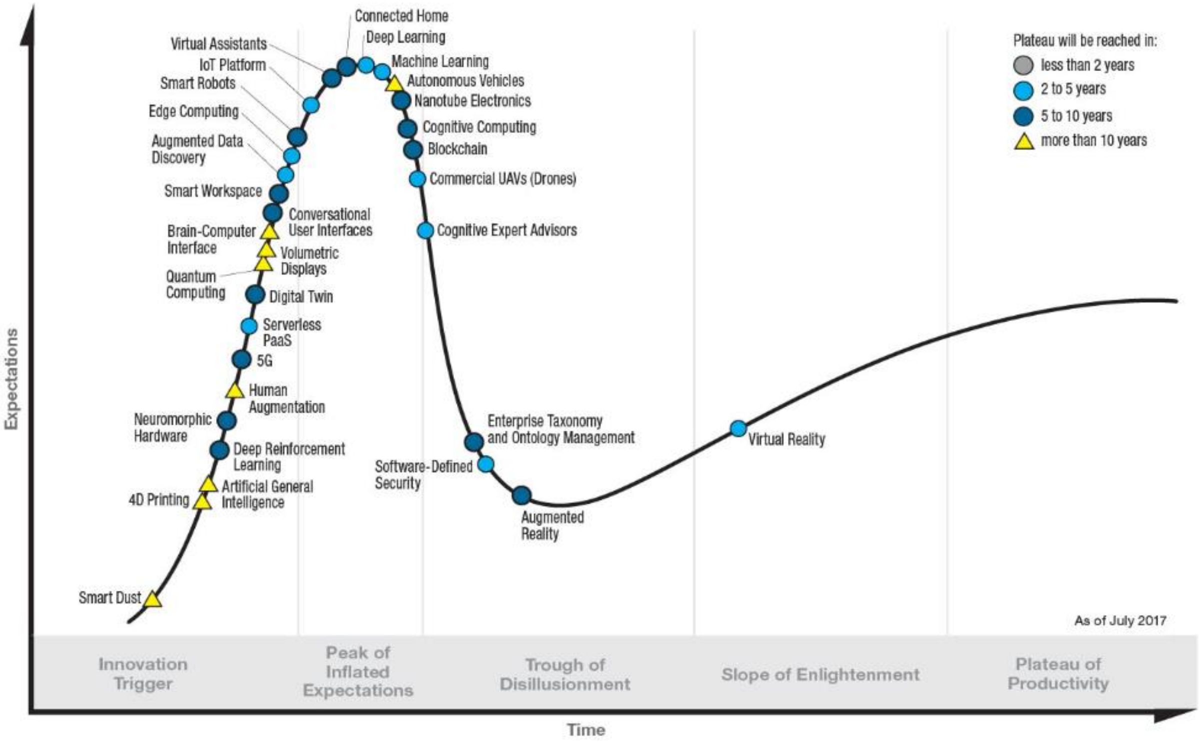

Figure 1. Gartner Hype Cycle for Emerging Technologies, 2017. Reprinted from *Enterprises should explain the business potential of blockchain, artificial intelligence and augmented reality,* by K. Panetta, July 2017. Copyright 2017 by Gartner.

A common way to address technology development is through the Gartner's Hype Cycle, illustrated in Figure 1. As seen in the figure above, the two first phases accumulate expectations until reaching the peak of technological expectations, and then over time the anticipation continuously drop. The cycle can be used to determine whether or not a technological tool will reach mass adoption. For the year of 2017 VR, as a technological tool, was presumed to be in the phase of *Slope of Enlightenment* (Figure 1). Any tool entering the Slope of Enlightenment possess a low percentage of adoption, but leave its phase with significantly 30 % (Linden & Fenn, 2003). As the technological tool goes through the 4th phase, system characteristics and system adaption improve and increases, respectively. Being in this phase is a good sign for developers and investors of VR applications as it is not built on a short time hype. We presume the technological tool to be in the same phase for year 2020, but with higher expectations and to be in a phase closer to *Plateau of Productivity*.

2.2 Implementation

If VR is as ideal as it seems like, why have we not yet implemented and used it as an asset to the conventional education system? Over the last decades, one of the limitations to investments in VR has been to the price of the technological tool. The tool has had a high price, whereas only few interested parties have had a budget to accept such investments. Educational institutes were especially not appealed by the investment due to their limited budget. Other limitations relucting the development and implementation of the virtual world have been the lack of design and quality of the developed tools. As Mandal claimed (2013, p. 308) "The big challenges in the field of VR are developing better tracking systems, finding more natural ways to allow users to interact within a virtual environment". Some challenges due to quality could for instance cause delays for user interactivity and possess difficulties identifying objects in the virtual world. In the context of training future health professionals, users could for example have a hard time interpret facial expressions. Limitations due to VR's price and quality naturally and subsequently generated a low intention to invest and implement in the technological tool.

2.2.1 Status quo

The above mentioned limitations are today smaller problems, as the cost of the technology has lowered and the design and quality have been improved. The last years has been claimed to be the time where "Virtual Realty gets real". Mandal's statement from 2013 on the obstacles to further develop VR is likely to still be relevant today, however these challenges seem to be solved to an extensive degree. First in 2016 was VR official haptic interfaces characteristics published, allowing user movements in the virtual world. The technology of 2019 allowed interaction without handsets, meaning that the user could get immersed and interact by only using VR goggles. Current questions raised on the implementation of the tool is whether it now, with its good characteristics, can deliver high quality experience to the user, and by so providing a better learning outcome. Huang et al. (2010) study revealed that system features as immersion and interaction could strengthen the user problem-solving capability. As we will later review, several studies have shown that health personnel could do tasks more efficient and proficient after training in VR. Improvements have been detected in the execution of their tasks both in- and outside the virtual world. Imagination has been an important feature for this as it has been defined as users' capability to address and solve issues (Huang et al., 2010). Nevertheless, several medical fields have yet encountered VR and in order to get knowledge on whether VR can be used for sepsis training, investments and research will need to be done.

2.2.2 Investment on Simulation Training

The Norwegian government recently shared their national health- and hospital plan for 2020-2023, and for the next three years they have decided to integrate training resources, such as simulation tools to enhance learning. The decision was reasoned by the following (Helse- og omsorgsdepartementet, 2019-2020, p. 24):

> «Hvert år får om lag 12 000 mennesker hjerneslag i Norge. Rask behandling er avgjørende for det helsemessige resultatet for personer som rammes. Stavanger universitetssjukehus har arbeidet systematisk med simuleringstrening og har redusert mediantiden fra pasienter kommer inn på sykehus til de får trombolyse fra 27 til 13 minutter. Ingen andre sykehus i verden har rapportert om raskere behandlingstid»

The government has decided to invest and improve the training at professional schools. As they believe simulation trainings could provide a better outcome for the students and health care personnel. However, VR is not the only option for simulation training, and there are possible substitutes for the technological tool. Mannequins are another tool for simulation training, as it also comes with different human capabilities that allows a user to do realistic trainings. By using a mannequin, the user stays in the actual world and perform on a human look alike doll. The most expensive simulation mannequin cost around 750 000 kroners (Wennerød, 2017), while the VR tool has an average price on 5 000 kroners. Despite the wide price range, can the two mentioned tools substitute each other. Liaw, Chan, Chen, Hooi, & Siau (2014, pp. 1-7) presented no superiority of one simulation method over the other, but concluded in their studies on the two methods that:

> "Both simulations have demonstrated to be effective refresher learning strategies for improving nursing students' clinical performance. Given the greater resource requirements of mannequin-based simulation, the virtual patient simulation provides a more promising alternative learning strategy to mitigate the decay of clinical performance over time. … Given the flexibility, practicality, and scalability of the virtual patient simulation, it appears to provide a more promising learning strategy over time than the mannequin-based simulation"

Despite the mannequin's realistic size, the simulation tool does seem to have limited instruments, while the virtual world gives the opportunity to improve and change the applications characteristics. Indeed, the mannequin requires an actual hospital room, whereas the VR only needs a certain free space, but not limited to a medical room for the user for its movements to practice on medical procedures. Today's training on sepsis also require a certain free space, but a significantly bigger free space than the technological tool. It is important to mention that they could use mannequin in today's training, but that the training case without a hospital room would be similar to the sepsis courses with human actors. We have described this in more detail in subsection 3.2.

2.2.3 Considerations

Several considerations will be needed before adapting technological tools into educating future professionals. What will it cost, how will it be implemented, and what does it require in short and long term? The costs due to implementation will be related to the equipment purchase, its installation, and the technical instructions and support for VR. Not only will it require an economical cost, but also will the implementation require work time from professors, as they will need to gain and maintain competence on using the new technology in order to take it in use. Nevertheless, the implementation of the new technology will generally be a one-time cost, that over time can provide benefits for the society by saving costs and making health personnel prepared for early sepsis detection. The saved cost does not necessarily come from the costs due to education, but from the costs due to sepsis treatment. An early detection of blood infection will require less care and support than an infection on a severe stage, meaning that the cost of treatment will be lower (Castellucci, 2019). The saved costs lead to free capital, which can be invested in health personnel by giving them access to appropriate sepsis training, or it can be used to facilitate better rehabilitation for sepsis patients.

In this section, we saw that conditions facilitate implementation of VR. An important factor to take into consideration before a potential development of this technology would be to question the potential user and its perception on new technology. As Sudarsana et al. (2019, p. 3) explained “Educational technology that has been considered as a hardware and software, it has one more coverage that needs to be understood namely brainware or users. This user has a vital role in the development of educational technology». Studies in the next section have shown overall good user perception on VR. However, only a few of these studied whether the technological tool could be an appropriate solution for sepsis training. In the following part of the thesis we will present the paper’s theoretical framework, before we later address health personnel’s perception on sepsis training in VR.

3. THEORETICAL FRAMEWORK

To answer the presented research questions, this article will base its theoretical framework on the Technology Acceptance Model (TAM) – which was implemented by Fred Davis in the early 1980's (F. D. Davis, 1985). The implementation of the framework stemmed from the lack of perception on employer's technology acceptance, and more concrete their use of it. By knowing the independent variables, such as perceived usefulness or perceived ease of use, the developers of TAM had a vision they could affect the technological potential users' attitude (Holden & Karsh, 2010). Since its first publication, the model has gotten a lot of attention and has according to Marangunić and Granić (2015), been the foremost model for investigating user acceptance, or more precisely behavior, towards the implementation of new technology. Holden and Karsh (2010) confirmed its utility and showed through their article *The Technology Acceptance Model: Its past and its future in health care* that a numerous of studies have used TAM in order to address acceptance of new media technology in health care services. In the next subsection we will show which elements the TAM consists of, along with presenting complementary literature that will help us answering our research questions.

3.1 Technology Acceptance Model

The Technology Acceptance Model consist of three main elements: *Design Features*, *User Motivation* and *Actual System Use* (Davis, 1985). The first element refers to the system characteristics, whereas the second refers to the user perspective, and the third to the user's usage of technology. The model contains causal relationships where the *Actual System Use* is affected by *User Motivation* whom is affected by the *Design Features*. Across this causal relation we have therefore *Actual System Use* as the dependent variable, and the others as independent variables – influencing the dependent one. The *Design Features* possess system characteristics, such as immersion and interaction, leading to different response. The response is grouped into cognitive response, affective response and behavioral response. The two first mentioned responses, cognitive and affective response, defines the *User Motivation*. The cognitive response is divided into two variables: *Perceived Usefulness* and *Perceived Ease of Use*. The two variables define the user perspective on system, whether it is useful and whether it is easy to use. Subsequently these triggers the *Attitude Toward using*, which is defined as one's desire to use the technological tool. And whom again will affect the *Actual*

System Use. The main elements of the TAM are plotted in Figure 2, and in the following part of this subsection we will further describe each one of them.

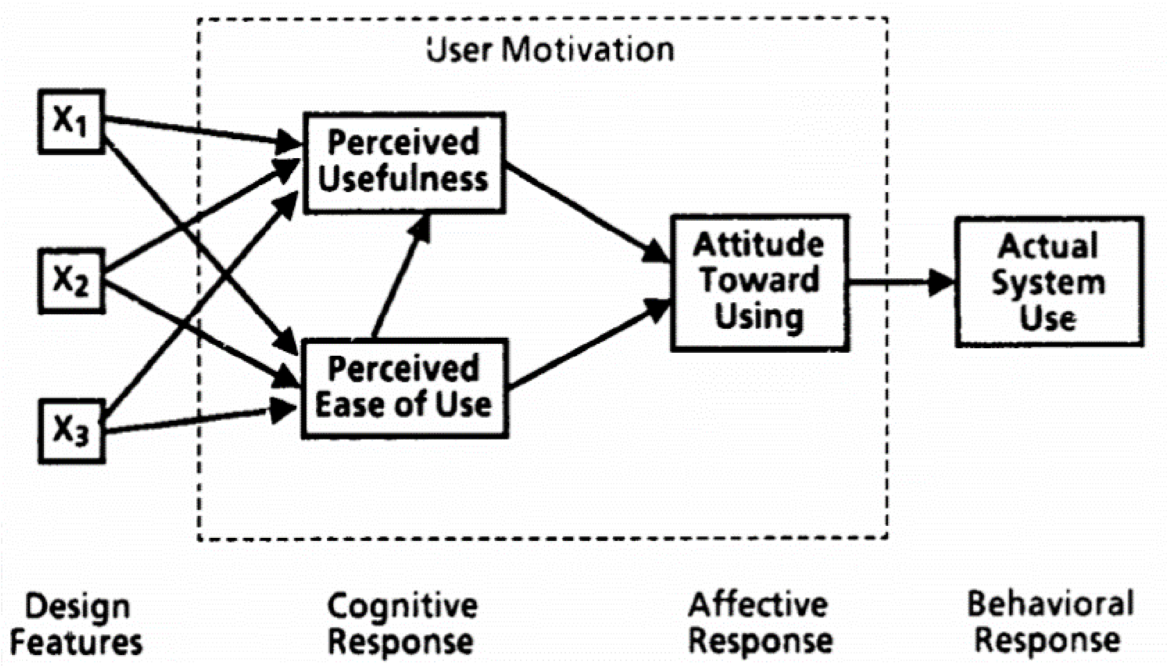

Figure 2. Technology Acceptance Model. Reprinted from *A technology Acceptance Model for Empirically Testing New End-user Information Systems: Theory and Results*, by F. D. Davis, 1985, p. 24. Copyright 1985 by Massachusetts Institute of Technology.

3.1.1 Design Features

In Figure 2 the *Design Features* are represented as X_1, X_2 and X_3. As we see in the figure, these features directly affect *Perceived Usefulness* and *Perceived Ease of Use*, while indirectly affecting *Attitude Toward using* and *Actual System Use*. The Design Features reflects the characteristics of the technological system (Marangunić & Granić, 2015), whom plays an essential role on the users' perception of the technological tool. Burdea and Coiffet (2003) associate VR with three characteristics: interaction, immersion and imagination (Is). As these fits well for the exploration of VR usage in medical education, several studies have been done with the given features (Huang, Liaw, & Lai, 2016). The three Is are akin as they determine each other. As the VR tool makes it possible for a user to react and its virtual world to respond, interaction has taken place. The tool stimulates it users' senses and could, especially for a high-end user, make its user immersed into the virtual world (Huang et al., 2016). Together with these characteristics, Burdea and Coiffet (2003) payed attention to the human imagination as it makes a crucial foundation for the users' ability to address and solve issues in the simulated reality.

3.1.2 User Motivation

Davis proposed model defines *Perceived Usefulness* (PU) as "the degree to which an individual believes that using a particular system would enhance his or her job performance", whereas *Perceived Ease of Use* (PEU) is defined as "the degree to which an individual believes that using a particular system would be free of physical and mental effort" (Davis, 1985, p. 26). PU and PEU are directly affected by the system design characteristics. In addition, PEU is also affecting PU as a useful tool will be easy to use. Together PU and PEU, along with the design features presented above, affect the *Attitude Toward Using*. Meaning that, if the user finds the virtual system useful for his future work, along with easy going, he will more likely have a positive attitude toward using the VR as an educational tool. The attitude will be a result of the perceived utility, which will be reasonable to consider strong when system is perceived to be useful and easy to use. Particularly will this be the case when the first-mentioned attribute, usefulness, is deemed. Several studies on technological systems showed that PU had particularly a significant effect on the *Behavioral Intention To Use* (Chow, Herold, Choo, & Chan, 2012; Venkatesh & Davis, 2000; Verhagen, Feldberg, van den Hooff, Meents, & Merikivi, 2012). Lok et al. (2006) further explained that if a user believed that a technological tool was useful, or would bring benefits such as improving skills of that person, the individual would be likely to continue using it.

3.1.3 Attitude Toward Using

The *Attitude Toward Using* is a result of the PU and the PEU, and will play a significant role for the *actual system use*. Attitude toward using is also known as *Behavioral Intention To Use*, we will in the rest of the paper call this element for BI. Davis refers to BI as the "individual's subjective probability that he or she will perform a specified behavior" (Davis, 1985, p. 16). As mentioned in the previous subsection, PU determine primarily whether an individual has the intention to use a technological tool or not. If the potential user finds the innovative technological system beneficial, he will be more likely to try or to continue using it. Ribaupierre et al. (2014) revealed that 98 % of the medical trainees endorsed modern technology to take part in the education for health. Further, the study showed that the system capacity to generate enjoyment, engagement and motivation was crucial as it would define the educational benefit. The student's immense percent towards the use of technology in health education showed that the motivation for using the technological tool was there. This meant that the attitude toward using for the respective group was positively directed.

3.1.4 Actual System Use

Whether or not individuals are using a technology is the outcome of their motivation, whom again is affected by the technological characteristics (Davis, 1985). *Actual System Use* can be a measurement of the systems customization, that is implemented through the components of usefulness and ease of use. If the technology has caught the users' interest by having the qualities of being easy to use and convenient for future work, then it will be more likely to use it. This was showed in a study on use of Personal Digital Assistants in healthcare professionals where PEU and PU were reported to be 23 and 45 %, respectively – leading to an actual usage of 62 % (Liang, Xue, & Byrd, 2003). The high percentage of actual use gave an intimation that the system was well customized. Given the same or higher percentage of user motivation after the first time testing, the technological tool would have high chances for being used on a later occasion.

3.2 Medical Procedural Training on Sepsis

The previously mentioned article *The Technology Acceptance Model: Its past and its future in health care* reveals that a numerous of studies in health care have used TAM to address potential users' point of view in the introduction of new technologies (Holden & Karsh, 2010). In the context of this thesis, as we aimed to focus more on the phenomena of sepsis, we found comparable studies on sepsis using TAM to address health personnel's acceptance of VR. We will in the following subsection define the diseases of sepsis, before presenting the potential of VR into improving its detection and diagnostic. Thereafter, we will introduce comparable studies. In the end of this section, we will review complementary literature that will, along with the presented framework, give a better understanding of the users' attitude towards the technology.

3.2.1 Clinical Background

Sepsis is a medical condition that has gotten a lot of attention due to its high mortality rate. The medical dictionary (n.d.) defines the illness as "a bacterial infection in the bloodstream or body tissues". Sepsis' death rate is high, ranging from 40 to 60 % on severe stages of sepsis (C. P Davis, 2019). The global incidents of sepsis are estimated to have an annually number of 18 million (Slade, Tamber & Vincent, reviewed in Tromp et al., 2009). Sepsis can happen to anyone at any stage of life. As Davis (2019) declared, individuals with an impaired immune system will be more vulnerable for blood poisoning. Impaired immune system refers to individuals suffering from bacterial infections, and particularly lung and kidney infections are two endangered conditions that can trigger the illness. In addition to bacterial origins, the illness can also originate from fungal infections. The apprehension of having infections in the bloodstream is that it affects body organs, which over time can lead to organ dysfunction. This severe stage of sepsis is, as previously mentioned, critical due to it is high mortality and therefore is it crucial for an early detection as possible.

Sepsis require rapidly treatment at every stage of the illness (Tromp et al., 2009). If the symptoms do not get recognized promptly, it can lead to a septic shock which lead to death if not given intensive care. As Kesavadas, Sankaran, and Lavalle (2019, p. 6) explained, "patients become highly dependent on intensive care and continuous medical support". Detection can be difficult. As the National Health Service in Great Britain (2019, para. 4) claimed "symptoms can be vague. They can be like symptoms of other conditions, including flu or a chest infection". Also, Ranhoff (2014) noted this, and supplied with saying that there could be difference on symptoms, making it even harder to detect the illness - especially on elderly people who could have vague and undetermined symptoms. Meaning that not necessarily do younger and elderly patients have same symptoms for blood infection. Furthermore, as we will present below, sepsis symptoms will vary as there are three different stages on blood infection: sepsis, severe sepsis and septic shock. Tromp et al. (2009) tested knowledge of doctors in training on sepsis, and the results were significantly low as only 30 % of them could identify the illness correctly. Thereafter, all the participants were given an educational program, before their knowledge was tested again, where 48 % could now correctly identify sepsis, showing that the grade doctors ability to diagnose sepsis went from about 1/3 to 1/2. In a context where early detection of a medical condition that poses lethal risks for 40 to 60 % of its victims, a detection rate of circa 50 % can thereby be viewed as still unsatisfying.

Detecting the right symptoms has been such a challenge that there have been discussions over the last decades on the signs and symptoms of sepsis in order to make a consensus definition. In 2016, the third international consensus definition on sepsis got published (Singer et al., 2016). The third definition is the latest version and is still assumed to be the current definition on several symptoms of sepsis. Despite the clarifications on sepsis symptoms, the consensus clarifies the following: “There are, as yet, no simple and unambiguous clinical criteria or biological, imaging, or laboratory features that uniquely identify a septic patient” (p. 807). Meaning that there is agreement on key signs and symptoms of the illness, but yet not a solid base for the detection for blood infection. Sepsis symptoms will vary as there are three different stages on blood infection: sepsis, severe sepsis and septic shock. Because this article aims to focus on training on identifying blood infection on an early stage, we will focus on the first stage. In order to address whether someone is suffering from sepsis, three symptoms are particularly investigated; altered mental status, fast respiratory rate and low blood pressure. These are illustrated in Figure 3, and sepsis can be set criteria to two or more of these critical statements.

Figure 3. How can you measure qSofa? Reprinted from *Three criteria*, by qSofa. Copyright 2016 by University of Pittsburgh, CRISMA Center, and/or University of Pittsburgh Department of Critical Care Medicine.

The table below, Table 1, shows the three mentioned statements with their critical measurements (Singer et al., 2016). In order to diagnose a patient with blood infection, two of the three conditions need to be critical measured so that sepsis can be diagnosed. We can see that the first statement will be critical if ones’ mental status suddenly change, and Glasgow Coma Scale is used in order to address this. Glasgow Coma Scale is a score system where the given scores can be used to identify whether the patients' consciousness is in change. Eye opening response, verbal response and motor response are the three behaviors being measured (Sternbach, 2000). The three behaviors are listed in Table 2 with their respective score. For example, if we use Glasgow Coma Scale to evaluate patient's eye opening response, we can see from Table 2 that a spontaneously response will fulfill a maximum score on 4. Further, will the low ranged response, "No response", give a score on 1. The highest score is 15, reflecting a healthy person's responses. Patients with lower scores are somehow affected by an illness. By using this score system, health personnel can confirm or deny one of sepsis common statements – altered mental status. The altered mental status can be the fastest statement (Table 1) to detect when being in contact with patients suffering blood infection.

Another way to examine whether a patient is suffering from sepsis is by assessing breathing of a patient and verify if the respiratory rate would be more than 20 breaths per minute (Tabel 1). Two statements being already mentioned, if both results are critical measurements, sepsis can be the illness causing the affliction. Besides addressing patient's mental status and respiratory rate, the health personnel can also measure the blood pressure in order to see if someone's statement is critical. In case of infection, blood pressure will be estimated low when having rate of lower than 90 beats per minute.

Table 1. Statements of Sepsis

Statement	Critical measurements
Altered mental status	A statement that acutely have taken place | Glasgow Coma Scale < 15
Fast respiratory rate	≥ 20 bpm
Low blood pressure	≤ 90 bpm

Table 2. Glasgow Coma Scale

Behavior	Response	Score
Eye opening response	Spontaneously	4
	To Speech	3
	To pain	2
	No response	1
Verbal response	Oriented to time, place, and person	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sounds	2
	No response	1
Motor response	Obeys command	6
	Moves to localized pain	5
	Flexion withdrawal from pain	4
	Abnormal flexion	3
	Abnormal extension	2
	No response	1
TOTAL		/ 15

Besides measuring the three statements will it be important to address whether the patient have other possible sepsis symptoms as high or low body temperature, unusual skin color like facial flushing or skin discoloration, or whether the patient are shivering due to infection (C. P. Davis, 2019). It is important that the health personnel feel confident addressing sepsis symptoms, so that they detect the illness as fast as possible. As we will demonstrate it in the next section, VR can contribute strengthening health personnel's confidence.

3.2.2 Increased Efficiency and Proficiency

As we pointed out in the section 1.1.3 about motivations of use, VR can be a good solution for the problems that we find in the traditional education. Two major problems mentioned were time and cost (Ribaupierre et al., 2014), and innovative computer simulation gives us the opportunity to reduce both of these. A study on Robotic Surgical System, a similar tool to VR, was conducted to see if the simulation could provide cost effectiveness. The results were uttermost significant as the price using the technological tool had a price five times lower than the current surgical training (Rehman et al., 2013). Another study on Virtual Realities effectiveness showed that by using the tool, one could reduce the operation time in laparoscopy by 1/5 up until 1/2 (Larsen et al., 2012). Similar findings were identified in the article *VR Training Improves Operating Room Performance,* where the ones who had been trained through VR were 29 % faster than the ones who had not (Seymour et al., 2002). Further the results revealed a statistical significance between the amount of errors and the educational process – where the ones who trained with VR had remarkably fewer errors than the group who trained the conventional way. Differences were also detected as the ones who did not train through VR had a nine times higher lack of progress than the ones who did.

Based on the prior studies, it is clear that education through VR could have promising effects with regards to the efficiency of future medical professionals. But what about the outcome? Are the trainees as well-trained through the technology tool as the ones who do it the traditional way? One of the articles that revealed efficiency according to time also demonstrated higher proficiency when using VR. This means that not only could the equipment lead to lower operation time, but also to superior skill training (Larsen et al., 2012). Lok et al. (2006, p. 193) pointed out that in the virtual world “A medical student could practice 40 or 50 times in a row … with no real added cost to the medical school”. This shows that the tool can help to reduce educational obstacles that we are facing today – both when it comes to the economical part and to the trainees learning contribution. As briefed, better learning outcome can arise with usage of technology, Ježek et al. claimed following (2015, p. 3679):

> “A level of educational benefits usually rises with costs - from a simple book to seminar, or a physical training using physical models, mannequins or actors to real situations, which necessarily bring about the largest benefits.”

To date health personnel’s sepsis training has taken place on courses. The courses are mainly given to health personnel during their education. Refresher courses on sepsis have been given to health personnel, but these are still rare. Currently they use actors during training sessions, which remains helpful as they are in contact with a patient, but that there are several shortcomings. They do not have for example access to any equipment, but rely on one person pretending to be the medical tool, telling them the results of what they intend to measure. Courses can cause problems due to several causes, for example sick trainers, actors, or simply ineffectively. However, VR can be available at most times and facilitate training on real life situations, giving the same or even better learning outcome as the courses give on sepsis. Recent study attempting to compare traditional and technological tools in learning the ABCDE (Airways, Breathing, Circulation, Disability and Exposure) approach showed similar learning outcome for self-training (Berg & Steinsbekk, 2020). Their conclusions were based on the measured performance of medical and healthcare students’ toward executing adequately the ABCDE approach. Despite the equivalent outcome between the learning platforms, the students still favored VR tools as results presented superior appreciation level over the traditional tools. Nearly 82.60 % of the participants that trained using VR claimed that they liked the practice, finding it suitable for learning and practicing the ABCDE approach, whereas only 36.00 % of the participants that trained with the traditional tools claimed similar statement.

Overall, the technology tool seems to be a solution for several of the disadvantages the conventional medical training contains. Leading to lowering cost, minimizing time and simultaneously honing skills. Less time can lead to more practice time, and along with better skills this can lead to increased knowledge around the identifying of sepsis – which can save many lives along with saving big costs at the public hospitals. Sepsis discovered in an early stage has an average price on $22 000 per case, and cost more than 3 times more if identified on a more severe stage of the illness (Castellucci, 2019). Sepsis cost are high due to the high level of care and support needed. It would be less expensive if the blood infection get identified on an early stage. But more importantly, the patient potential long-term effects can be minimized. We find it then convenient to take a closer look on sepsis education through VR, if learning and training through the simulation could provide effectiveness - and more so, if it could result in an earlier identification of the illness of sepsis.

3.2.3. Sepsis and VR

As the technology has continued to improve, health system has been opening more up for medical education through VR. Even though education on identifying and treating the blood infection in a virtual word has been up for discussion, sepsis learning and training in VR can still seem to be a new phenomenon as there have not been done many scientific studies on the two together. The lack can be a result of two variables. Firstly, the skepticism regarding the innovative learning platform, as VR is still in the phase of adoption (Panetta, 2017). Secondly, the high costs as it has been a barrier for the adopting process of the simulated reality. However, when we look through publicized scientific articles on sepsis and simulate-based training, we can see user acceptance, and even more so, suggestions for this innovative platform to take part in the medical school training (Nguyen et al., 2009; Sankaran et al., 2019). We will in the following section look closer to these articles, before in the next section describing how enhanced learning can be linked up against education in an immersive and interactive world.

A 2019 study on sepsis prevention and interactive education tools showed that medical students found the innovative study system ideal due to its high system usability (Sankaran et al., 2019). One of the dominant variables were the systems ease of use. The students thought the VR program was easy to use to train on sepsis, despite their lack of VR experience. Even though most of the participants ended up being neutral to the need of technical support on VR, the majority agreed that most people would learn to use the VR program very quickly. This was shown, as the student overall had a high-performance percentage in the sepsis scenario. The solid progressed competency was also reflected in a medical training study on sepsis, as the average student from four different medical schools had an impressively higher score after simulated-based teaching (Nguyen et al., 2009). Also, this group had a successful learning experience as the students felt far more confident managing sepsis. Participants with low experience were generating good scores on sepsis knowledge and gained better benefits than the ones with more clinical experience. In addition, knowledge gained from using the technology by the students appears to be retained by the students. This was demonstrated by a survey taken two weeks after the course that still showed significant numbers – from a pre-test score of 57.5 % to gaining a remarkable percentage of 85.6 % four hours after the use of the technology tool, to then getting a score of 80.9 % two weeks later. The results from the two studies are therefore showing both high amount of perceived ease of use and perceived usefulness, which conceivable will result in acceptance of VR as an educational tool when it comes to learning and training on sepsis.

3.3 Complementary Literature

The revealing results from all the previous articles have overall given a positive perception on the use of VR in medical education and indicated that the technology acceptance on the virtual world might be there. This paperwork is conducted to continue the research on TAM and VR, in order to get more clarity whether the good results can be generalized to a larger population of health personnel. The positive perception on the VR from the prior studies is a result of several attributes. Mei and Sheng claimed that "knowledge must be presented in authentic settings and relevant situations to be properly understood" (Mei & Sheng, 2011, p. 299). VR facilitates this as one can be situated in a context equivalent the real one. By situating the learner in an authentic sepsis case, it can generate knowledge from listening, watching, and more importantly by doing. The motivation for system use will raise when one feels better off using the system, which most often will be the case when a user feels its skills are being honed. In the following section, we will in the further address authenticity, motivation and situated learning as they all contribute to explain the elements in TAM.

3.3.1 Authenticity

The better the system features are, the more authentic and realistic will the system feel. Lok et al. (2006) compared students undergoing training experiences with real and virtual patient in order to look at the differences between the two training scenarios. The scenarios were based on the same script, meaning that the patients possessed the same symptoms. There was shown differences in the degree of scenario authenticity due to characteristics of eye contact, recognized speech and audio quality. The scenario that scored the lowest was the one with the synthesized speech as its characteristics did not deliver the same quality as the scenario in the real speech. Despite the deficiencies, educational goals were met as there was no reported difference in scenario effort. The students considered the training in VR as an authentic experience, even though there were technological improvements to be done. One of the students from the survey pointed out that the patients had a life-like size body, in fact this produced a more authentic setting as it was reflecting a real-world sized person. As Mandal (2013) identified, a full-scale world would strengthen the sense of immersion, whom again would lead to a more present state and which in turn can be linked up to system authenticity. In other words: the system design characteristics determines the virtual worlds degree of authenticity. Meaning that the better design, the more authentic will the student find the tool. The design will affect the learning outcome as the student will be more present and more likely to have a more positive perception of the system.

The participants of Lok et al. (2006) study on VR in medical education perceived the system as authentic, and the majority said further that they would use the virtual training room to improve their clinical skills. The accumulated knowledge in the learning environment can be applied in a real-life situation, meaning that a user can directly benefit from its experiences in the virtual world to its future patients. VR capability to process the three features of immersion, interactivity and imagination, is determent as it will define how well the virtual world reflects the real one. Even though the last-mentioned study was perceived as authentic, it could have achieved an even higher perception if the synthesized speech was even more similar the real one. The authors described this as a real speech would have a better flexibility of conversation, that could have facilitated a higher level of interactivity. Good user interactivity strengthens the immersed sensation, and the state of being immersed in a virtual world "create a strong sense of presence, which in turn motivates and thereby causes the learner to cognitively process the learning material more deeply" (Huang, Rauch, & Liaw, 2010, p. 1173).

3.3.2 Learning Motivation

The father of our theoretical framework, Davis (1985), showed that user motivation was incorporated in cognitive and affective response, meaning that PU, PEU and BI stimulates the users' motivation for system use. The motivation for the use of a system is important as it have been addressed by many scientists as an utmost factor for effective learning (Huang et al., 2010). The studies done on VR showed that the motivation for system use raised as the system provided a realistic environment. According to a study on VR, all the three system features – immersion, interactivity and imagination, are attributers to enhancing the student's problem-solving capability, and increase motivation on system use (Huang et al., 2010). Interactivity has substantial effect on enhanced learning, while immersion generates motivation. Health personnel's motivation is important in order to achieve high-level health care. As a study claimed (Joolaee & Bohrani, reviewed in Hassankhani, Aghdam, Rahmani, & Mohammadpoorfard, 2015, p. 98) "a lack of motivation among nurses will not only burn them out, but may also have destructive effects on the health of society and result in a waste of time and money." The health personnel's motivation is crucial in order to have a well-functioning health care system, therefore motivation needs to be taking into account throughout school and work career. By creating a fun and deep learning case in VR, this can be easier to achieve than by learning in the conventional classroom.

VR does not only give the user the opportunity to be present in the virtual world, it also facilitates the opportunity to review interaction and immerse on previous embodiments through video recording. As Yoo, Yoo & Lee (2010) revealed, students can by reviewing video recordings of own performance, enhance their learning process by increasing their self-awareness. The gained self-awareness in the mentioned study led to improved competency and increased learning motivation. Also, students' performance on communication skills was improved after being self-evaluated, and performance retested. Motivation can be affected by several variables. A study on nursing student's learning motivation showed a significant relation to self-efficacy (Hassankhani, Aghdam, Rahmani, & Mohammadpoorfard, 2015) and suggested a self-efficacy promotion would strengthen learning motivation. With self-efficacy the study refers to student's own perception on nursing performance such as care due to rehabilitation and support, disease prevention and interaction between nurse and patient. The relation between motivation and self-efficacy tells us that if a nurse were to be confident on different performances, its motivation would be considered high. By referring to the quote presented in last subsection, we can declare that a motivated nurse would in general benefit the society and saving it for resources such as time and money, but more importantly lives.

3.3.3 Situated Learning

A study indicated increased motivation through learning in a realistic setting, as the students thought the system improved their knowledge. The given results also revealed that perceived usefulness was a significant contributor for a student to choose situated learning (Mei & Sheng, 2011). Situated learning describe the learning progress in VR well, as one is learning and training in an environment that reflects a real one. The goal with situated learning is to make a student ready to perform in a similar context, and therefore it can be said that the importance of the learning is the “ability to apply knowledge of procedures learned in one context to new contexts” (Mestre, 2002, p. 3). As presented earlier, an article from 2002 showed that knowledge from virtual training could be transferred to real-life operating rooms (Seymour et al., 2002). The study looked on results from both virtual trained and non-Virtual-Reality-trained performance in operating rooms, in order to see if the outcome could show if the system really improved skills. The validation was clear, as there were significantly differences.

Underlining the fact that the last-mentioned results are from the early 2000s, we can assume that the virtual features have improved, and therefore suggest VR to be an even better platform for situated learning today. As technology advance, the virtual world is becoming more comparable to the real one, making it easier to transfer knowledge and more importantly to enhance traditional clinical education. Even though it is clear that learning and training in VR will generate better results given improved characteristics, it is not known how good quality it can possess, and to which extent degree it can facilitate the appropriate training needed. In the following section, we will describe our methodology, before presenting our collected data on perspectives from target groups on sepsis learning and training in VR.

4. METHODOLOGY

This study aims to explore learning and training about the illness sepsis using VR. More precisely, the study explores whether VR could be considered as an accepted technological tool for medical training on blood infection. It also explores whether the tool can be considered as an alternative for more efficient and proficient education program. The study uses several elements to explain how the different characteristics of VR technological tools affect the target groups perspective, which for this study is the health personnel within the municipality of Tromsø. In the first part of this section, the study design and detailed methodology according to research questions will be presented. While the second part, supplement with more detailed survey characteristics.

4.1 Selection of Research Design, Subjects and Data Collection Techniques

4.1.1 Research Design

The research questions open for both a qualitative and quantitative design. For this master's thesis, we have decided to adopt a quantitative approach in our research design. This is because we assumed that it will be easier to get a higher and better participation from respondents to the study. The method has already been used on similar studies (Chow et al., 2012; Huang et al., 2016; Verhagen et al., 2012), and therefore appears to be suitable for investigating variations and relations between elements of TAM.

The quantitative analysis was conducted through a survey. The survey was web-based and designed through Google Forms. At first was given to all participants an introduction video to provide insight on what VR is, presenting its usage and potential medical procedures that can be simulated. Thereafter, the participants received and filled the online survey. The method was appropriated to our research design as we wanted to address user's overall intention to accept and use new technology. By asking our survey questions, we could get an insight on which elements, such as design features and perceived usefulness, affect the intention to use VR during training procedures for treating sepsis. Overall, most of the 19 questions were defined and answers were listed as multiple choices for the participants. Only the last question of the questionnaire remained open for additional comments, so that we capture any additional information from the standardized questions.

The method for data collection is cost-efficient, as it collects large collections of data on relatively short time (Jacobsen, 2015). The web-based survey allowed respondents to choose where and when they want to fill in the questionnaire. The method can be timesaving for both participants and for researchers, in comparison to organize sit-in video presentations and responding by hand to surveys. When respondents have filled in the survey and pushed "send", Google Forms compiles all submitted data. Forms are saved online and data are also compiled in a spreadsheet that can be downloaded to do further analyzing with external software. By using this method we can avoid human errors, which can strengthen the study reliability.

4.1.2 Experimental Procedure

As mentioned, the survey contains two parts – one on watching an introduction video to VR, and one on filling the questionnaire. Estimated time for completing the two parts was three minutes, one for watching the video and two for reading and answering the questionnaire. The estimated time was evaluated by testing the survey prior to the experiment.

The experimental research was conducted in March 2020. At the beginning of the month, an e-mail was sent out to the 7 different health care institutions we for this survey found relevant. The 7 selected health care institutions are emergency room, intensive care unit, medical department, emergency department, surgical department, other hospital department and nursing home. These health care institutions were selected by affiliation to sepsis. These 7 amounted a number of 23 departments. Each department were contacted through e-mails, inviting them to take part in the research. University electronic mail system was used as we suggested a difference in the professionalism perception of participants toward the survey if the mail address contains "uit" or "gmail". Also, in order to catch the attention to the e-mail, we established the object as "Sepsis + Virtual Reality". By doing so the target group know the e-mail's content and its importance. The e-mail contained a few lines, including encouragements for department responsible to help forwarding our initiative to their employees. The e-mail also informed readers that the request was based on a master's thesis written at the UiT, and that the overall goal is to develop and implement a VR solution to improve sepsis learning. We also highlighted to the participants about the estimated time of 3 minutes required to go through the process and attached the link to our online questionnaire.

Researchers name and telephone number was listed at the bottom of the e-mail, along with the UiT’s logo. This was done to make the e-mail more trustworthy and to not be confused with spam e-mails carrying risks of viruses.

For the dissemination of the survey, we expected leaders of the different departments to forward the e-mail to their employees. Thereby, participants for this master’s thesis choose to voluntarily participate to the survey. The importance of participants contribution was also highlighted in the e-mail and in the survey. Within the questionnaire, we first emphasized the following:

> “This survey is conducted to get an insight in health personnel's acceptance on VR as a medical educational tool for learning and training. The survey is a part of a master’s thesis, that builds on the need for increased competency in detecting and handling patients with sepsis (infection in the blood). A VR solution for this purpose will most likely be developed and implemented in educational institutions and health care services. It will add to existing training opportunities for health care students and professionals with a solution that is cheaper, more fun, and easy to integrate into ongoing activities.”

We consider important to let participants know that their contribution could be important for future design and programming of sepsis learning and training using VR. This information could eventually have had a positive effect on the number of participants filling out the form and their commitment to the questionnaire, as they would consider sepsis education important. Also, anonymizing the questionnaire could have positively influenced the participants on the accuracy of their inputs (Jacobsen, 2015).

The data collection did not have a specific timeframe, however we expected that all potential volunteers would have filled the survey before the end of March 2020. In the e-mail we added also a request for confirmation of receivability. This helped to plan sending out a reminder. A reminder was useful as we also anticipated that our e-mail may still have ended with the spam e-mails, or diluted within the mass of e-mails received daily by these departments. The e-mail with the questionnaire was first sent out in the end of the winter holiday in Norway, the 5th of March. Already after two business days 30 participants had volunteered and participated to the questionnaire. Seven of the departments sent a confirmation upon receiving the e-mail and told us that the survey was forwarded to their employees. The eight department sending confirmation responded that the survey was relevant for the field, but that a Norwegian version would have got more responses. Due to this, the questionnaire was translated to Norwegian and sent within the same day to the department that requested it.

On the 16th of March 2020, each department managers were called to get a more personal interaction and to follow-up on the participation of colleagues within their departments. We have been able to reach most of the department managers. Our initiative was launched nearly at the same time as the global pandemic and therefore managers had been busy for the last five days been busy, planning and preparing response activities due to the Coronavirus Disease 2019. Still, six of the department managers responded that they were interested to participate and that they wanted us to contact when routines at the institutions would be back to normal, estimated to be in the middle of May (8 weeks later). The mentioned departments were excluded from the study as the delivery of this master's thesis was in the end of May. Furthermore, other departments responded us that the e-mail had most likely been overlooked and requested us to send a new e-mail. After the calls with the department managers, a reminding e-mail was sent out 11 days after the first. This time, the survey was sent out both in English and in Norwegian. Additional answers were received, and we reached a satisfying number of 44 participants for this survey, taking into consideration the stressing conditions fueled by the SARS-CoV-2.

4.1.3 Participants

As previously introduced, sepsis can happen to anyone. However, it is more likely to happen to the ones with impaired immune system. Therefore, we decided to include participants from health care institutions and nursing homes to investigate their intention for VR usage on sepsis treatment learning and training. Participants were particularly recruited for this survey among the health personnel. Seven health care institutions were contacted for the purpose of this research. The 7 institutions belong to the public sector, more specifically to the municipality of Tromsø in Northern Norway. Six of the health care institutions were located at the Universitetssykehuset Nord-Norge (UNN), 5 chosen departments and one open department, labeled “other hospital department”.

All hospital departments at UNN were studied before selected. Choice of targeted departments was based on the relations to sepsis patients, this to assure a certain professional competence. By having participants with appropriate competence, we ensure high quality response in data collection. Despite the selection, will some departments have a closer relation to sepsis than others. For example, it be will natural to expect high competence on sepsis in emergency departments, while a lower competence can be expected from participants employed in nursing homes. However, is sepsis as well important for health personnel working at nursing home as for health personnel working at the hospital. It is important to highlight that answers from respondents with low sepsis competence and little insight in VR might affect survey results, and by so not give a realistic approach. Based on this, characteristics on the participants were also collected, and we address these in the paragraph below.

For this study we sought both males and females. In addition, as VR is a technical learning system, we found it also relevant to take in consideration different ages, as there might be differences. Both gender and age groups were answered through multiple-choice questions. The survey also investigated four other questions to put characteristic to the survey’s participants. The participants were asked to choose their associated health care institution, and also on the amount of time since they first learned about sepsis and their confidence level on detecting it. The very last question asked them to define their relation to VR, not being necessarily limited to practice for healthcare. As we looked for these different characteristics, we attempted to see correlation effects and possibly detect clusters divided by some or all variables presented in this paragraph. The selection strategy was based on cluster sampling, that was chosen when the research decided to study health care institutions within the municipality of Tromsø. Twenty-three health care departments were included and our sample size had a number of 44 participants.

4.2 Survey

In this second part of the methodology, we will give detailed information of the survey's characteristics and configuration. Presentation, structure and measures are the main factors in this part.

4.2.1 Grounded Presentation

The survey contains, as already presented, an introduction text. The last part of the introduction text was written as follow: "Attached is a video on an already developed patient room. This is provided to give an insight of how the virtual world is built up and its different functionalities." The video contained the well-known ABCDE approach. The picture below gives an impression of a patient room in VR that was presented to the participants.

Following the introduction text, a video was used to show participants how could a medical virtual world potentially look like and the different possibilities it contains. The video presented an already developed medical procedure practiced in VR, the ABCDE approach. It contains similar simulated measurements that there would be for learning and training on sepsis. Matter of fact is the ABCDE approach used for emergency occurs on already hospitalized patients. In many occasions this ABCDE approach will be used for assessing patients affected by sepsis.

As mentioned above, the detection of sepsis can be diagnosed from altered mental status, and/or fast respiratory rate and/or low blood pressure. The introduction video demonstrated to the participants that the VR tools can simulate the measurement of respiratory rate and blood pressure. Along with this, the video mentions that the application allows participants to evaluate whether the patient status changes over time and also allows participants to analyze patient disability. Eye-, verbal- and motor responses are modules addressed for declaration of altered mental status. The introduction video also shows to the participants that the patient looks in different directions and/or close its eyes, meaning that the patient eye response may vary. The video also shows that the VR user can move patients' body, such as opening its mouth. The video shows it is possible to create a multiple-choice questions tablet in the virtual world, meaning that it is possible to make a score system like Glasgow Coma Scale.

The video show how one could interact in the virtual world, and how the setting looks in the real world. By showing both inside and outside of the virtual goggles, we gave survey participants a wider understanding of immersion and interaction in the virtual world. The video showed interaction between patient and health personnel - a group of three students measured patients' respiratory rate. In the end of the video did the patient screen show three different measurements, blood pressure, circulation and patient body temperature. These, along with body exposure are important elements for sepsis diagnostics. The video finally reveals to the participants toward the end of the simulated training that the users will be provided feedback on their performance. This feedback can be given in the conventional classroom, however, can the functionality in VR show the users if the procedure was done in the right order and the amount of time used. It can also track and monitor previous scores of users, providing a fun and deep learning platform.

4.2.2 Structure

The survey was carried out in 19 questions, where 13 of them referred to a five-pointed Likert scale (where 1 refers to strongly disagree, 3 neutral and 5 strongly agree). The Likert scale questions were asked to get an insight on participants perspective on the innovative tool intersected with sepsis. By using a five-pointed Likert scale we could easily address a participant's thoughts and compare it with his or other participants answers. The other 6 questions included 5 multiple-choice questions and one open question option to give any further comments. The 5 multiple-choice questions were used to get information on participants demographic and relation to sepsis and VR. Finally, by providing standardized questions, respondents might have utterly thoughts and therefore we included an open question so that we can take into consideration additional useful information from the respondents.

The survey contained a structured questionnaire as we want to see if the answers differ from one to another. The multiple-choice questions were especially designed to differentiate between participants different characteristics. This was described with details in the subsection above on participants. Human characteristics are most likely to affect the way we interpret. We cannot guarantee that all respondents interpreted the questions the same in this survey, however we reduced the scenario probability by using simple and direct language. We assumed that question structure and language use are important for survey outcome. Potential misinterpretations from the respondents were also prevented by testing the survey prior to distribution it, as presented later in this subsection.

4.2.3 Measures

This study was based on the model presented below, in Figure 4. Figure 4 reflects our theoretical framework which consists of design features and motivation elements (Davis, 1985). Interaction, immersion and imagination are the main elements that we address in this study as design features. Besides the three is perceived self-efficacy and authenticity effecting the figure elements. The rest of the model is identical to TAM, as presented in

Figure 2. We have decided to label “attitude toward using” for “behavioral intention to use”. Figure 4 was constructed in order to answer the thesis research questions.

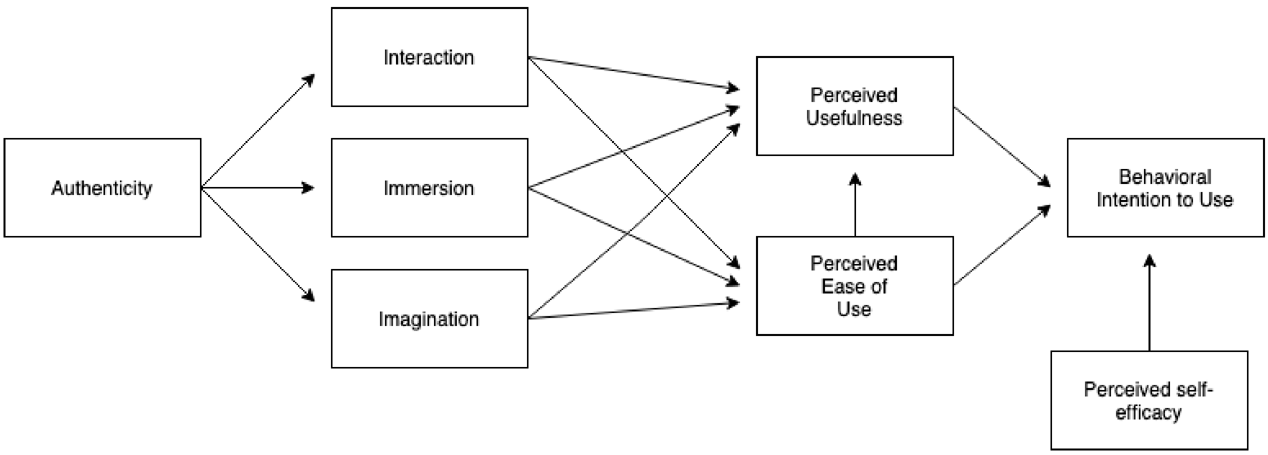

Figure 4. Model presenting the theoretical framework on the survey sent in March 2020 on the potential role of VR in educating for sepsis treatment.

All survey questions are based on Figure 4, especially the thirteen Likert-scale questions. The questions target to address the dimensions to TAM on learning and training on sepsis in VR. As previously mentioned, have we based our research design on previous work, the dimensions of measurements for the main elements are presented in Table 3. The first listed element, PU, does as explained in the theoretical background, refer to user’s thoughts about technological tools usefulness. The statements to address this element were “I think VR could help me getting confident diagnosing sepsis”, and “I think I would be more aware of own performance by watching it”, where the last statement informed that VR facilitates video recording. The second listed element, PEU, refers to user’s thought about technological tools ease of use. Two statements were used to address this, “I think VR is easy to use” and “I think it would be easy for me to become skillful when learning and training on sepsis through VR”. The element at the bottom of Table 3, BI, can give an indication whether the user have intentions to take the technology in use, we used the following statements “Given that I had access to refresh the knowledge on sepsis in VR, I would predict to use it”, and “I wish simulation training in VR get adopted to supply and maintenance health personnel’s knowledge on sepsis”. Already, by getting answers on these questions, we could have good insight in the participants thoughts, however, did we supply with other elements to get a deeper insight. The full version of the questionnaire can be found in Appendices, labeled Appendix II.

Table 3. Dimensions of Measurements

Dimensions	References
PU	Mei and Sheng (2011)
PEU	Davis (1985), Liang, Xue and Byrd (2003)
Interaction	Huang, Rauch and Liaw (2010)
Immersion	Huang, Rauch and Liaw (2010)
Imagination	Burdea and Coffiet (2003)
BI	Yusoff and Ahmad (2011), Davis (1985), Huang, Rauch and Liaw (2010)

4.2.4 Pre-Test

The questionnaire was pre-tested in order to get an insight on the survey's overall design. To assure good quality and accuracy, questions were tested before it was sent out to its final participants. The test was evaluated by six external respondents: three nurses, one VR programmer and designer, and two respondents who throughout this master's thesis has been involved in its progression. The six different respondent's characteristics varied across age groups, gender and competence. By using external respondents, we got an indication on the surveys design – whether the five-pointed Likert scale is convenient for this study, and whether the surveys length and completing time was considered as reasonable. Further on, expertise on sepsis and VR helped to design a better survey for this kind of study. As they possess knowledge of high standard, their aspects helped improving the given questions.

The feedback from the pre-test was taken in consideration, before the questionnaire was again tested and evaluated by two professors at the UiT. The respondents and expert's expertise helped to improve survey instrument. By strengthening the questions, survey possessed a higher reliability and validity so we could offer our final participants a quality-based survey. Google Forms was self-tested before envoy to make sure no technological difficulties related to the completion of the form and to the analyzes of results in Excel and SPSS. After several evaluations, reformulations and testing, the survey was sent out to its final potential participants on the 5th of March.

4.3 Analytical technique

The data was, as previously mentioned collected through Google Forms and compiled in a spreadsheet. Google Forms gives the opportunity to download excel sheet with data collection to analyze it with other programs. This surveys' collected data was coded and analyzed in the Statistical Software Package for Social Science (SPSS) version 26. In the software SPSS we produced descriptive analyses, factor analyses and a multiple regression analysis.

4.3.1 Descriptive Statics

In SPSS, descriptive statistics gave us the number of answers, minimum and maximum answer, mean (M) and standard deviation (SD). For our thirteen Likert-scale questions this was suitable analyses as it is based on number ratings. As all questions were required to be answered, we did not present the number of answers, neither did we find it relevant to present the minimum and maximum ratings, however the rating for specific question (M and SD) will be mentioned in the following section as the information can be relevant.

4.3.2 Factor Analysis

The participants were asked 13 Likert-scale questions. All the questions were based upon elements: PU, PEU, imagination, immersion, interaction, authenticity, self-efficacy and BI. Immersion, authenticity, and self-efficacy had 1 question, whereas the other elements had 2 questions. Together all questions helped explaining qualities we needed for this master's thesis to address in order to answer the research questions.

We chose the analytical tool Rotated Component Matrix to find the common denominators for the 13 questions. An SPSS function, suppress small coefficients, was used to set a minimum value of all loadings presented in the matrix. We restricted the factor loadings on .35 as we would consider values below to be insignificant. The table that presented the components (Table 6), i.e. a Rotated Component Matrix, gave an indication on data validity. By evaluating the cross loadings between the items in the table we could address the discriminant validity, and by looking on the loadings in each component we could address convergent validity. Also, a reliability analysis was relevant to conduct so that we could know if the measurements had a consistency. SPSS also facilitated for this analysis.

The information from the factor items are utterly relevant, but as we want to know to which certain degree the different elements affect each other, we need therefore to apply another method for analysis – multi regression analysis.

4.3.3 Regression Analysis

The relations between the elements were analyzed through a multi regression analysis. The analysis was conducted to investigate how the elements together influence participants perspective on usage of VR for learning and training on sepsis. The regression was conducted over five levels. The first level aimed to see the relations between authenticity and immersion, interaction and imagination; the second and the third levels to see the three Is relation to PU and PEU; the fourth level to address PEU's effect on PU; and the fifth level, PU, PEU and self-efficacy impact on BI. The four first levels were conducted to answer RQ1, whereas the last round was to answer RQ2. SPSS regression analysis listed the results in three different data sets, "Model Summary", "ANOVA" and "Coefficients". Together the three data sets gave an indication on model relations by revealing beta coefficient (β), explained variation (R^2), F-value (F) and significance level (P). The first indicator, β, showed the impact an independent variable had on a dependent variable, whereas the second indicator, R^2, showed the variance of the dependent variable explained by independent variable(s). F-value gave an indication whether the results could have occurred randomly, and P whether the relations were significant.

5. RESULTS

In the following part we will present our results. In this chapter are presented the results from our analyses and key points will be discussed in the section 6.

5.1 Presentation of Interviewees

As mentioned in the methodology, the five first questions in the interview guide provided information about the survey respondents. Three of these questions aimed to describe the demographic characteristics of the respondents. Overall, 59.10 % of the respondents were female and 40.90 % were male. Their ages also covered a wide range where half of the participants were between 31 and 40 years, while the rest of the participants were within the groups of 21-30 years (11.40 %), 41-50 years (18.20 %) and over 50 (20.50 %). The participants represented the seven different health care institutions, where a majority of health personnel from the intensive care unit. The three first questions are presented in Figure 5, 6 and 7. Additional statistics on the pool of respondents are detailed in the Appendices, labeled Appendix I.

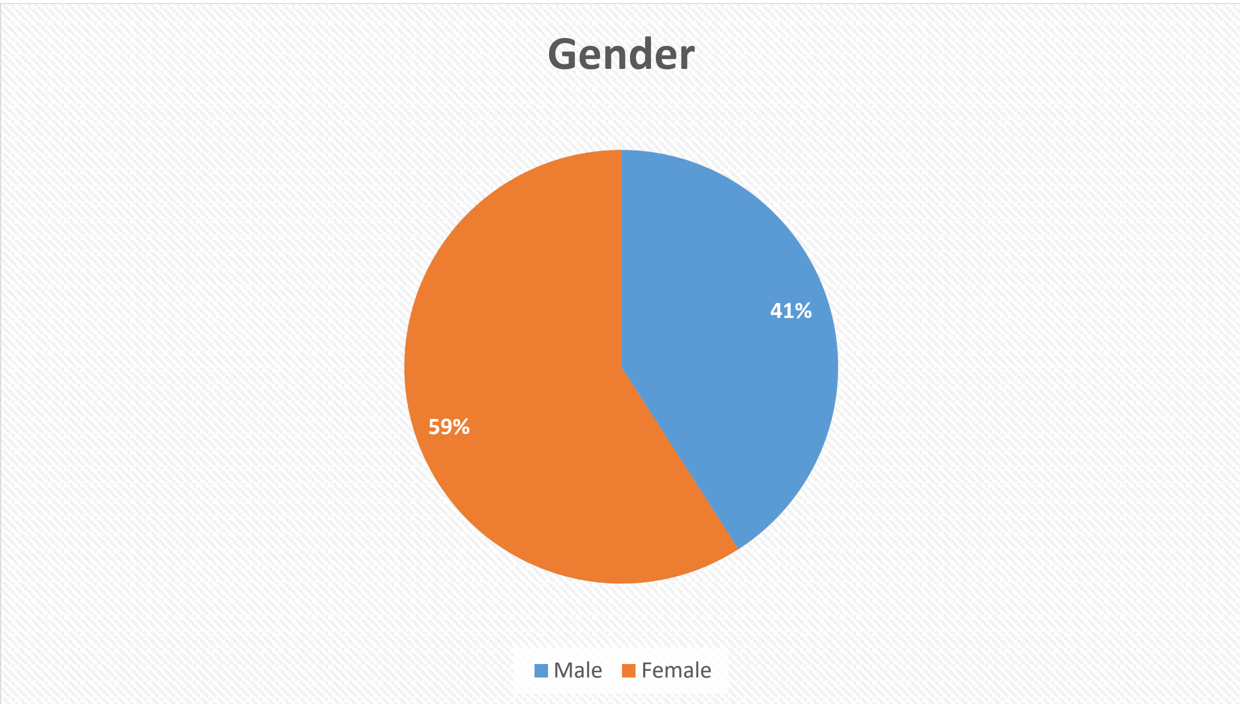

Figure 5: Pie chart presenting the gender ratio of respondents to the survey sent in March 2020 on the potential role of VR in educating for sepsis treatment.

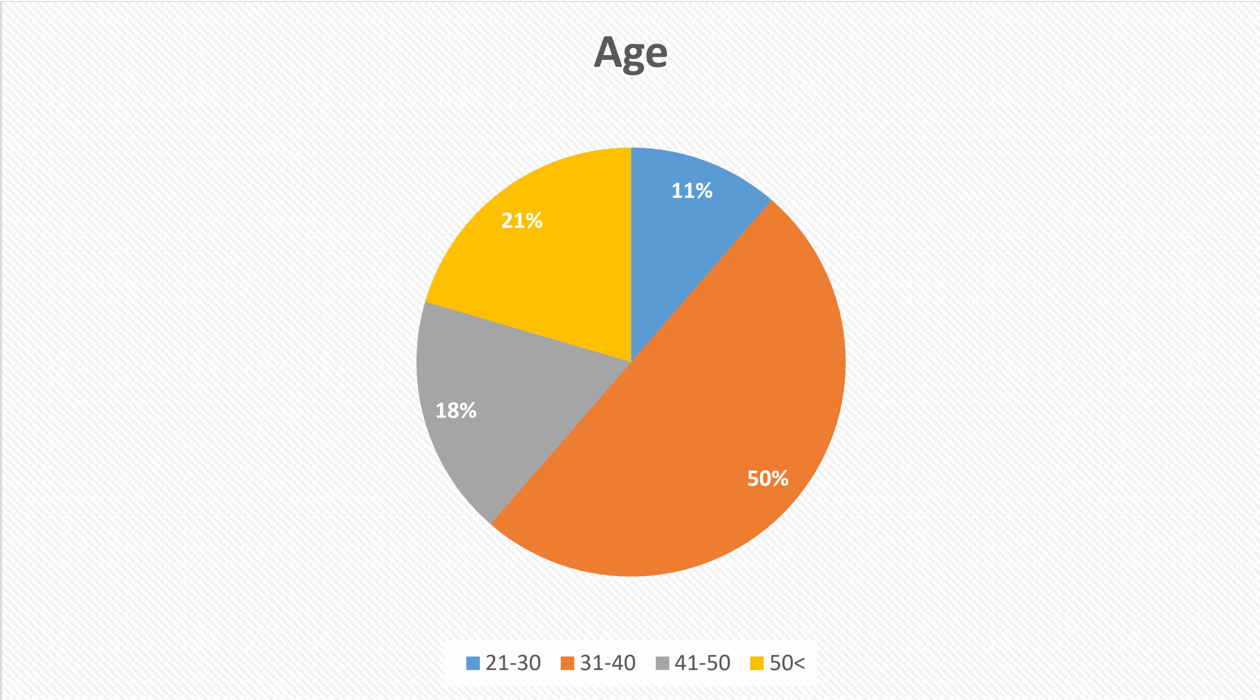

Figure 6: Pie chart presenting the age groups of respondents to the survey sent in March 2020 on the potential role of VR in educating for sepsis treatment.

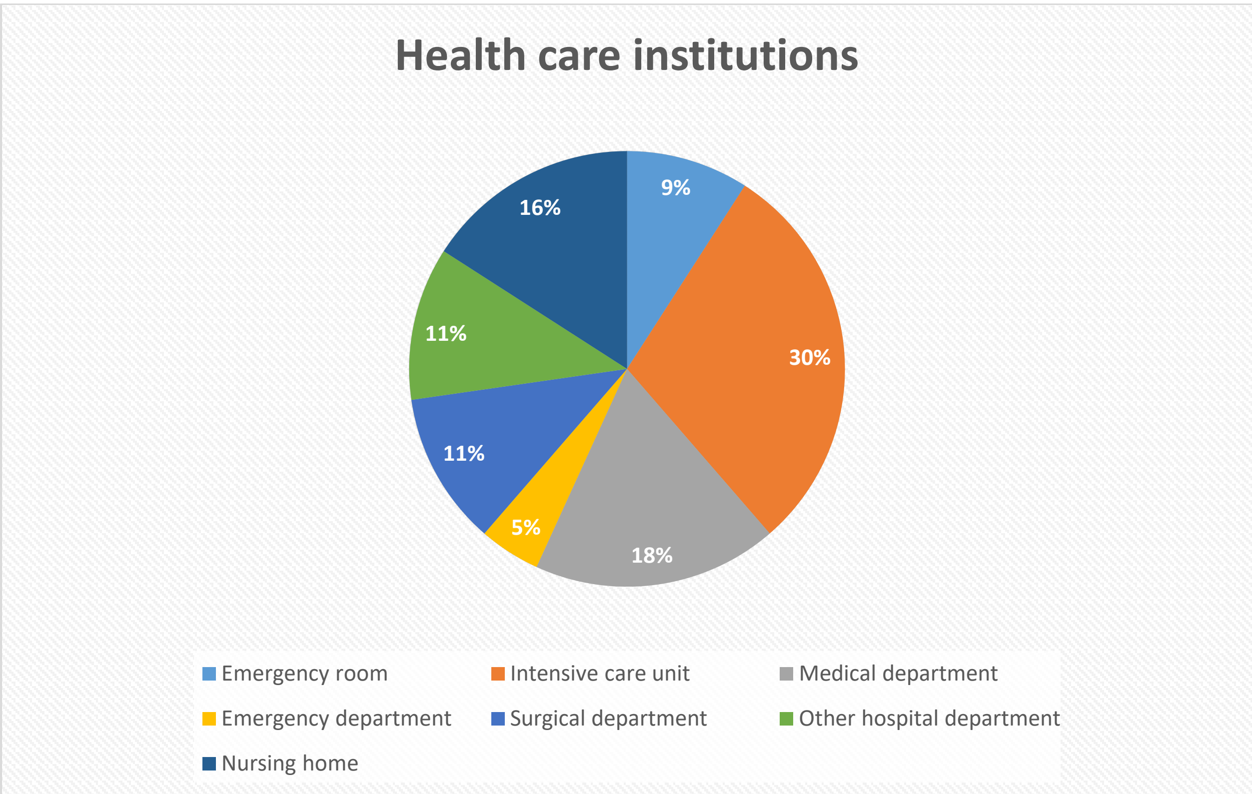

Figure 7: Pie chart presenting the health care institutions of respondents to the survey sent in March 2020 on the potential role of VR in educating for sepsis treatment.

In addition to the gender, age and associated heath care institutions of the respondents, we also questioned on their knowledge on sepsis and VR. We wanted to get an insight in the amount of time since the participants first learned about sepsis. At first, Figure 8 shows the number of years since a respondent had a learning opportunity about sepsis. More than half of the respondent did not experience learning opportunities for sepsis for at least 10 years, and 25.00 % for at least 20 years. At second, Figure 9 shows the familiarity level of the respondents to VR and demonstrates that most participants were familiar with the technological tool, with a percentage of 59.10 %. It also shows that 22.70 % of the participants had not heard about VR before they were introduced to it in the context of this master's thesis questionnaire.

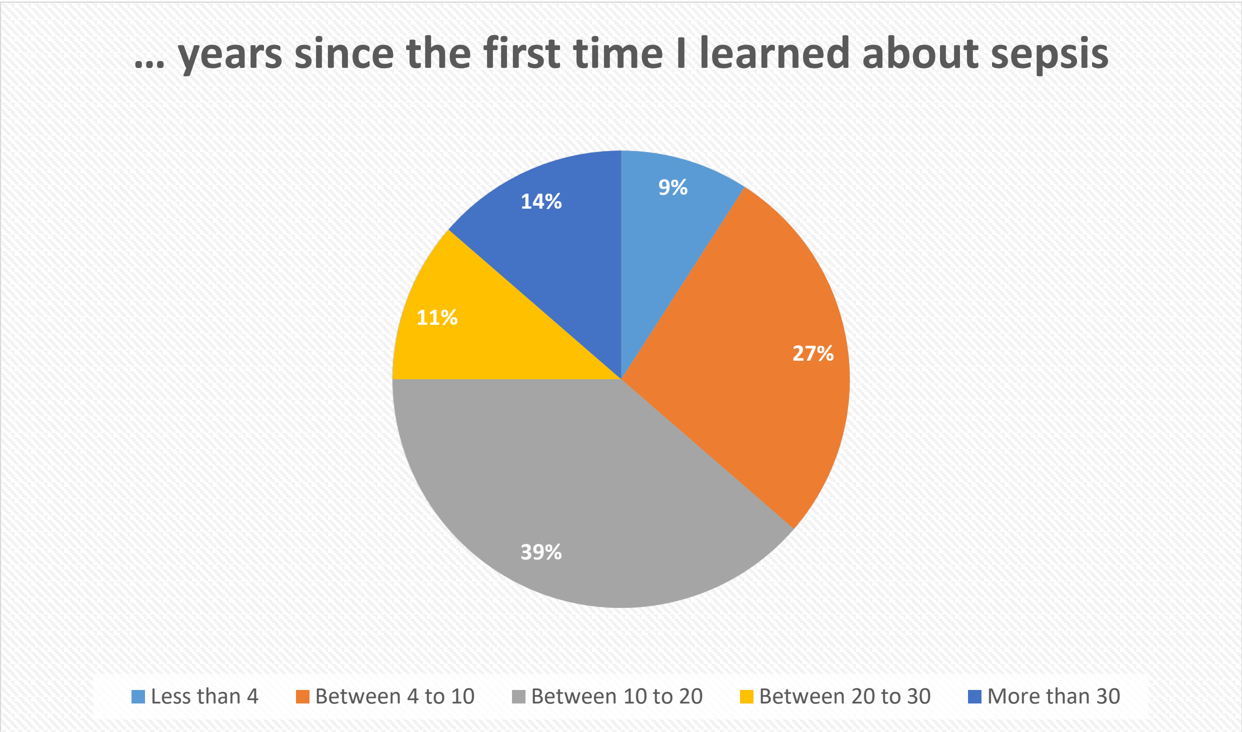

Figure 8: Pie chart presenting the years of sepsis knowledge of respondents to the survey sent in March 2020 on the potential role of VR in educating for sepsis treatment.

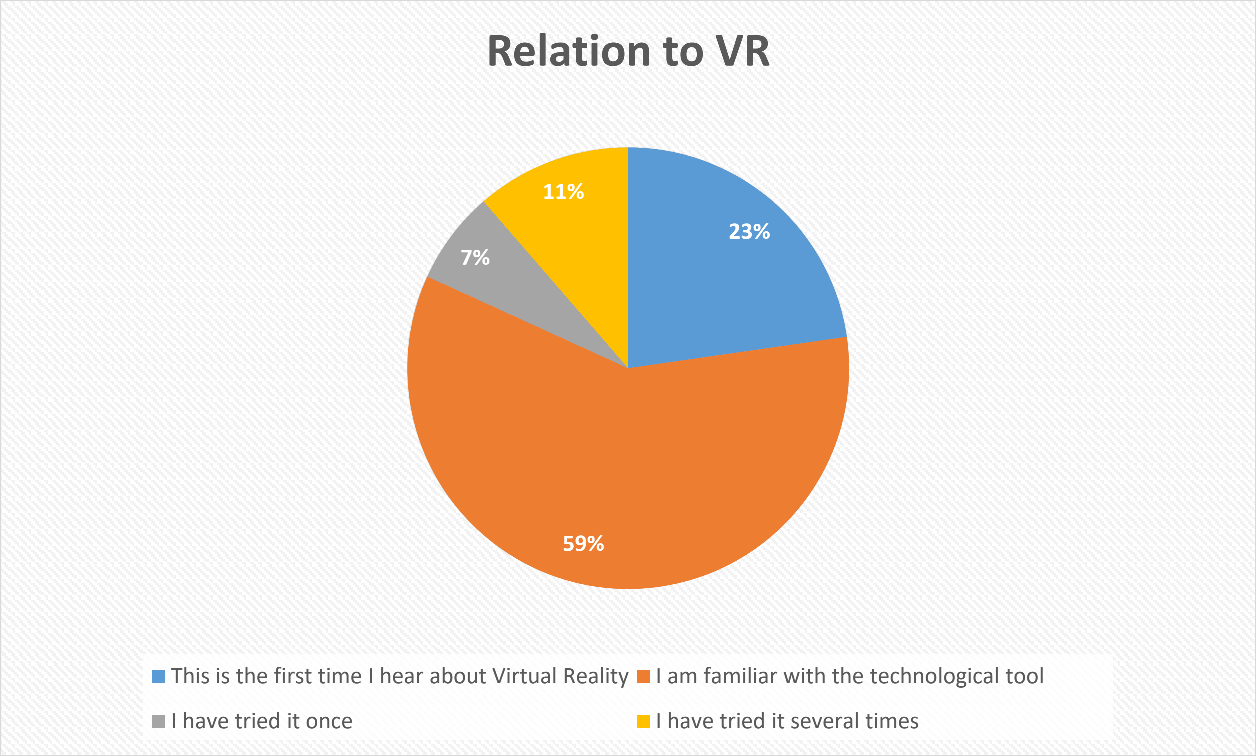

Figure 9: Pie chart presenting the relation to VR of respondents to the survey sent in March 2020 on the potential role of VR in educating for sepsis treatment.

5.2 Measurements on Factor Items

Following the five questions that aimed at defining the characteristics of the respondent pool, the questionnaire was composed of thirteen multiple-choice questions oriented toward the role of VR in treating sepsis and are presented in Table 5. For each question is presented the average and standard deviation of the scores given by the respondent over a Likert scale from 1 to 5.

Table 5. Table presenting the descriptive statics (mean and standard deviation) of the respondents to the questionnaire focusing on the potential role of VR on treating sepsis sent on in March 2020

Factor	Item	M	SD
PU	(1) I think VR could help me getting confident diagnosing sepsis.	3.43	.97
	(2) VR facilitates video recording. I think I would be more aware of own performance by watching it.	3.61	.95
PEU	(1) I think VR is easy to use.	3.66	.99
	(2) I think it would be easy for me to become skillful when learning and training on sepsis through VR.	3.23	1.05
Imagination	(1) I think the system can give the reflection of being present in a situation with sepsis.	3.52	0.90
	(2) I think I can transfer the accumulated knowledge from a virtual sepsis case to a real-world case.	3.68	0.91
Immersion	(1) I think I would be more concentrated in a fun and deep learning case in VR than by the conventional classroom learning.	3.68	1.03
Interaction	(1) I think the system could enhance my interaction skills with patients and other health personnel.	3.14	0.98
	(2) I think it would be easy to perform in the interactive world.	3.59	0.76
Authenticity	(1) I think the learning environment in VR could give an authentic feeling, due to its reflection of the real world.	3.30	1.05
Self-efficacy	(1) I feel confident detecting sepsis on an early stage.	3.93	0.90
BI	(1) Given that I had access to refresh the knowledge on sepsis in VR, I would predict to use it.	3.45	1.09
	(2) I wish simulation training in VR get adopted to supply and maintenance health personnel's knowledge on sepsis.	3.70	1.07

The descriptive statistics for each elements of the studied framework are presented in the table above. The results are considered consistent, as the SD is relatively small in comparison to the M. For most of the questions, the mean score was around 3.6 and the lowest and highest means were 3.14 and 3.93, respectively. The statistics revealed an average score higher than 3, nearly 4, meaning that the participants had a positive perception on VR for learning and training on sepsis. This was also confirmed with the medians that showed the middle score through answers’ range. In this survey median values were as high as 4, with two exceptions on questions related to “become skillful” and “interaction skills”, where most participants claimed to be neutral to (score of 3).

Table 6, Rotated Component Matrix, shows the results of this master’s thesis factor analysis. Three different components found, the first component reflects technological tools facilitation of efficiency and proficiency, the second to the characteristics of its simplicity and the third reflects participants thoughts on own sepsis detection knowledge. All the 13 Likert-scale questions are loaded and listed below, with all loadings positive did the matrix give a good indication. A weakness, however, is that three of the items in the table load on two different components. Immersion, imagination and PEU reveal cross loadings. The first element about feeling more concentrated in a learning case in VR showed that the measurement correlated between two components, component 1 and 3. Also the imagination had a cross loading on these on the statement due to transferring knowledge. Similar finding was for PEU question “I think it would be easy for me to become skillful when learning and training on sepsis through VR”, which correlated between component 1 and 2. The last cross loading can be described by the fact that the statement both touched usefulness and easy to use. Despite the results, are the three cross loadings in this table within the limits of reasonableness, meaning that loadings between the components are not close related. As a result, have we kept the highest loading on each of the three statements. The loadings we decided to throw away are crossed over in the table below. The data fulfills criteria to discriminant validity. After removing cross loadings, Table 6 contained indicators between .563 and .883. The numbers reveal solid matrix with convergent validity as the measurements in each column together well explain the respective components. The survey results show construct validity by revealing discriminant and convergent validity, meaning that the questions measured what they were supposed to. This table gives us a clear indication on validity.

Table 6. Table presenting the factor loadings of items (factor loadings lower than .35 are excluded, and so crossed out) of the respondents to the questionnaire focusing on the potential role of VR on treating sepsis sent on in March 2020

Rotated Component Matrix[a]

	Component		
	1	2	3
Getting confident	.867		
Authentic feeling	.864		
Predict to use it	.794		
Adopted	.789		
Present	.752		
Become skillful	.691	~~.546~~	
Transfer	.617		~~.376~~
More concentrated	.612		~~.413~~
Video recording	.586		
Interaction skills	.563		
Easy to use		.883	
Easy to perform		.840	
Feel confident			.881
% of Variance	40,29 %	15.75 %	12.00 %
Cronbach's Alpha	.911	.724	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

We also conducted a reliability analysis of the components to see whether we could trust the different items – the higher reliability, the lower amount of random errors. Component 1 and 2 show high data reliability, especially component 1 with a Cronbach's Alpha (α) on .911. Component three only contains one item, and therefore a validity or reliability analysis could not be conducted for this component. The results obtained from that item, showing a normal distribution where most participants felt confident detecting sepsis symptoms on an early stage, are presented in Figure 10.

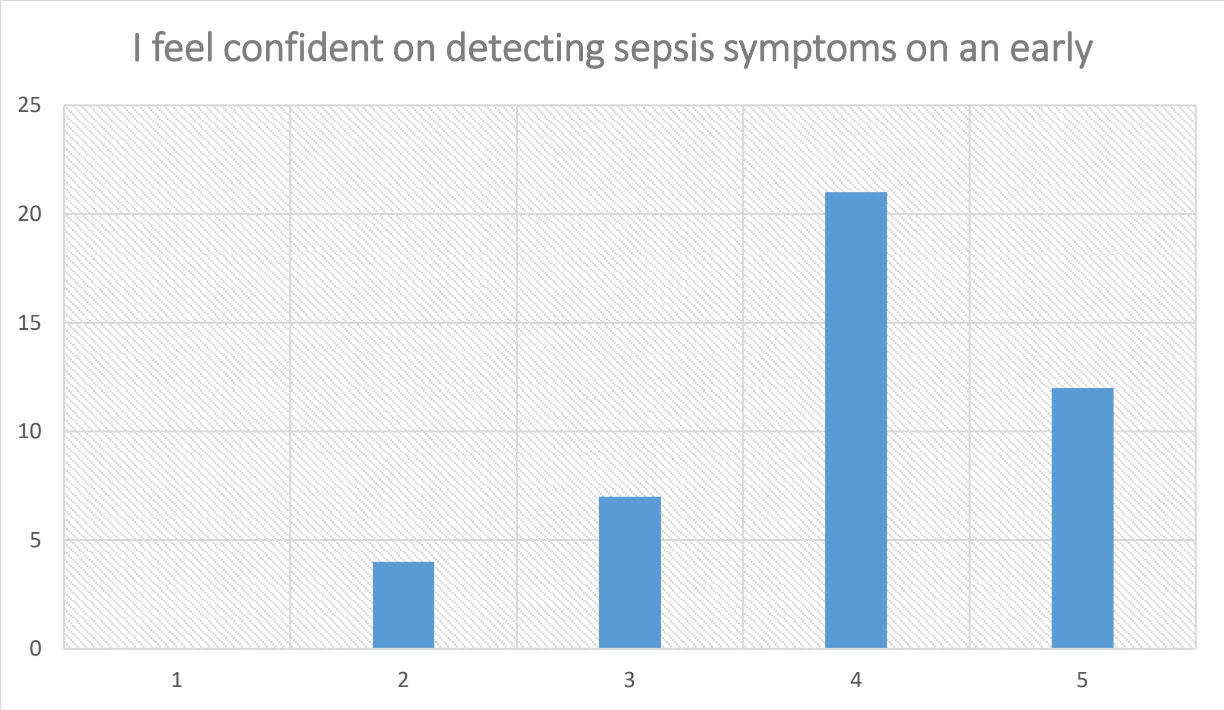

Figure 10: Diagram presenting the confidence level on sepsis detection of respondents to the survey sent in March 2020 on the potential role of VR in educating for sepsis treatment.

5.3 Multi Regression Analysis

The relations between the dependent and independent variables that we for this master's thesis wanted to investigate are presented below in Table 7 and 8, as six different constructs. Table 7 presents the first research question, investigating the relationship between PU, PEU, self-efficacy and BI. Results for the second research question is presented in Table 8 and it presents relations between authenticity, immersion, interaction and imagination, and the three Is relation to the framework's main elements, PEU and PU. The theoretical framework we based this study on supposed that PEU affected PU, and therefore this relation was tested for this study and results are shown in the bottom of Table 8. Regression analysis through SPSS provided relations beta coefficient, explained variation, F-value and significance level. Results from these analyses are further detailed below.

Table 7 and 8 shows an overall high beta coefficient, meaning that the elements in the final model have large impact on each other. The first dependent variable shows PU, PEU and self-efficacy with a beta coefficient on .535, .235 and .211, respectively. The numbers show that PU has the highest impact on BI. Further does Table 8 reveal that authenticity had a significant impact on all the three technology characteristics, immersion, interaction and imagination. Immersion had a low, and negative impact on PU, whereas interaction had a positive impact on PU with .312 and imagination strong impact with a beta coefficient on .646. Immersion also had a negative impact on PEU. Two of the beta coefficients are negative, meaning that they would have an opposite effect on PEU and PU. However, are these not considered significant due their P-value. PEU was, as for PU, affected by the characteristic's interaction and imagination. Interaction and imagination had almost the same impact on the dependent variable, PEU. At the bottom of Table 8 is the regression results on PEU impact on PU, with an indication on .445.

Are also in Table 7 and 8 presented the total variation, R Square, of the six constructs. The first element in the table shows an R Square on .499, indicating that the three predictors PU, PEU and self-efficacy, explain 49.90 % of the variation in BI. This means that almost half of the variance of the dependent variable is explained through the three predictors. Also, PU and PEU demonstrated high levels of variance explained from the technology characteristics. PEU explained 1/5 of the variance in PU as it had a R Square on 19.80 %. Authenticity had an explained variation on the three Is, from 19.00 % to 48.20 %. Based on the strong variations, can the model be considered rational. The overall high F-values strengthen the answers as they illustrate that the values have by small chances occurred randomly.

In order to evaluate whether the beta coefficients and explained variations are applicable, we need to evaluate each construct significance level. Each construct significance level is presented in the right column in Table 7 and 8. Most p-values were declared statistically significant. Almost all constructs analyze revealed a significant level at 0, the only exception was authenticity and interaction, which had a significant level on .003. Our set threshold of significance was at a p-value of up to 0.1. All elements assigned were significant, except from immersion, whom neither had a significant effect on PU or PEU (Table 8). This means that we cannot conclude that the variable impacts PEU and PEU, and neither does it contribute to explain construct variations.

Table 7. Table presenting the regression analysis results of Research Question 1 (acceptance of VR as an educational learning tool) of the respondents to the questionnaire focusing on the potential role of VR on treating sepsis sent on in March 2020

Dependent variable	Independent variable	β	R^2	F	P
BI			.499	13.29	
	PU	.535			.000
	PEU	.235			.067
	Self-efficacy	.211			.067

Table 8. Table presenting the regression analysis results of Research Question 2 (enhanced learning through VR usage) of the respondents to the questionnaire focusing on the potential role of VR on treating sepsis sent on in March 2020

Dependent variable	Independent variable	B	R^2	F	P
			.271	15.63	
Immersion	Authenticity	.521			.000
			.190	9.85	
Interaction	Authenticity	.436			.003
			.482	39.04	
Imagination	Authenticity	.694			.000
PU			.470	11.82	
	Immersion	-.212			.179
	Interaction	.312			.024
	Imagination	.646			.000
PEU			.516	14.21	
	Immersion	-.140			.350
	Interaction	.498			.000
	Imagination	.483			.001
			.198	10.36	
PU	PEU	.445			.002

In Figure 11 we see the path coefficients between the different measurements in our investigated model. The model shows that all elements, expect from immersion, had a direct effect on their dependent variable. The effects were explained through the significant levels this analyze revealed. The relations between the independent and dependent variables were labeled on Figure 11 if significant, and the model below presents thereby in overall strong significant relations.

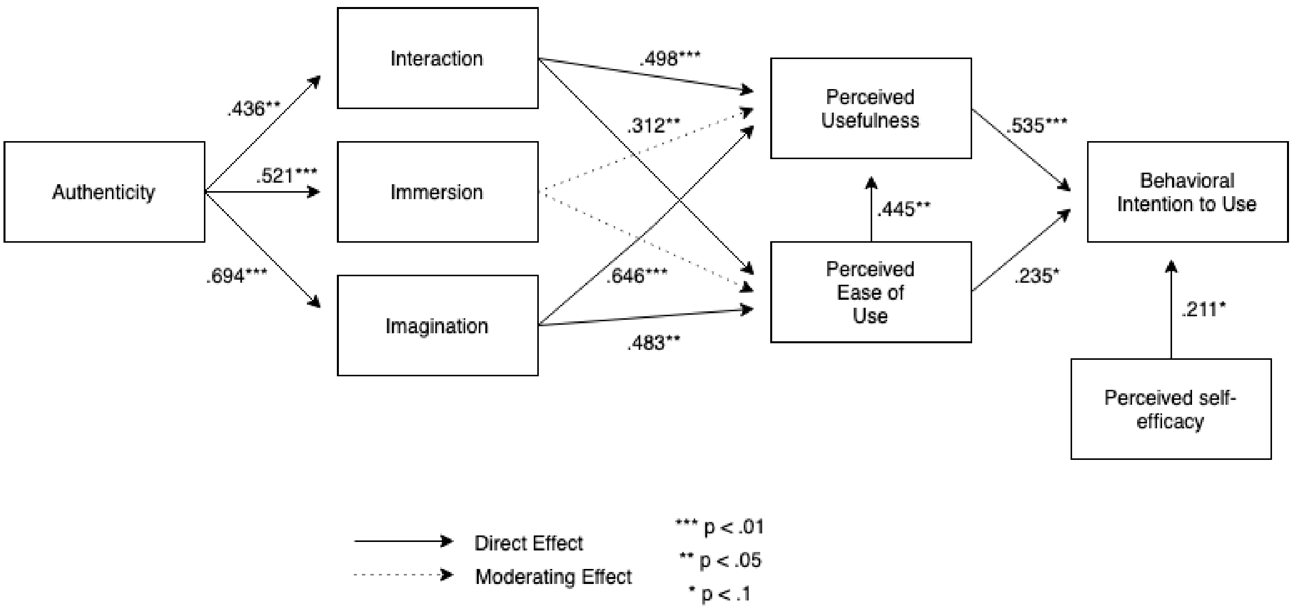

Figure 11: Model presenting the target groups perception on the survey sent in March 2020 on the potential role of VR in educating for sepsis treatment.

5.4 Case Results

Forty-four participants volunteered and participated to the questionnaire. This means that we received 44 different case results, several of these are presented in this subsection in Table 9, 10, 11 and 12. The items in the tables are labeled with keyword, complete questionnaire is found in Appendix II. All items are based on ratings from a five-pointed Likert scale, where 1 refers to strongly disagree, 3 neutral and 5 strongly agree. The first table, Table 9, gives an overview on all the 44 participants answers on the two questions defining their perceived usefulness. The table shows that the majority of the participants perceived the technological tool to be useful for health education on sepsis. It also shows that some respondents had a negative perception (ratings on 1 and 2), these are further presented in Table 10. Table 11 presents the ratings from participants with VR experience, whereas Table 12 presents participants being unconfident or neutral to own sepsis detection.

Table 9. Table presenting the perceived usefulness of the respondents to the questionnaire focusing on the potential role of VR on treating sepsis sent on in March 2020

	1	2	3	4	5
Getting confident	2	5	13	20	4
Video recording	1	3	16	16	8

Table 10. Table presenting a summary of perceived uselessness of the respondents to the questionnaire focusing on the potential role of VR on treating sepsis sent on in March 2020

CASE	6	7	18	25	28	35	40	41
GENDER	M	F	M	F	M	F	F	M
AGE	31-40	31-40	31-40	31-40	31-40	31-40	31-40	41-50
HCI	EME	EME	ICU	ICU	ICU	EMD	MEDIC	ICU
FIRST TIME SEPSIS	10-20	10-20	10-20	10-20	10-20	4-10	10-20	10-20
VR-RELATION	S	F	F	F	F	F	F	O
FEEL CONFIDENT	4	4	3	5	4	2	5	5
GETTING CONFIDENT	1	1	2	2	2	3	2	2
VIDEO RECORDING	2	1	3	4	3	2	4	2
EASY TO USE	5	3	4	3	3	4	4	4
BECOME SKILLFUL	4	1	2	1	2	2	2	3
PRESENT	3	1	3	2	2	2	2	3
TRANSFER	2	1	2	4	4	4	4	4
AUTHENTIC FEELING	1	1	2	1	3	4	1	2
MORE CONCENTRATED	3	1	4	5	3	4	2	4
EASY TO PERFORM	5	3	5	4	3	4	4	3
INTERACTION SKILLS	3	1	1	3	2	4	2	2
PREDICT TO USE IT	1	1	3	2	3	2	3	3
ADOPTED	1	2	1	3	3	3	4	4

Table 11. Table presenting a summary of the VR experienced respondents to the questionnaire focusing on the potential role of VR on treating sepsis sent on in March 2020

CASE	2	6	12	24	26	34	44	43
GENDER	F	M	M	F	M	F	M	F
AGE	41-50	31-40	50 <	41-50	41-50	31-40	41-50	31-40
HCI	NUR	EME	OHD	ICU	ICU	MEDIC	ICU	ICU
FIRST TIME SEPSIS	< 4	10-20	30 <	10-20	< 4	10-20	10-20	4-10
VR-RELATION	O	S	S	S	S	O	O	S
FEEL CONFIDENT	4	4	3	4	5	4	5	4
GETTING CONFIDENT	4	1	4	4	3	4	2	4
VIDEO RECORDING	5	2	5	4	4	3	2	4
EASY TO USE	5	5	4	5	4	4	4	5
BECOME SKILLFUL	5	4	4	4	3	4	3	5
PRESENT	5	3	4	4	4	4	3	4
TRANSFER	5	2	4	4	4	4	4	4
AUTHENTIC FEELING	5	1	4	4	3	4	2	4
MORE CONCENTRATED	5	3	4	5	4	4	4	3
EASY TO PERFORM	4	5	4	4	4	4	3	4
INTERACTION SKILLS	4	3	4	4	4	4	2	3
PREDICT TO USE IT	4	1	4	5	3	4	3	4
ADOPTED	5	1	4	5	4	4	4	5

Table 12. Table presenting a summary of low or medium sepsis confidence level of the respondents to the questionnaire focusing on the potential role of VR on treating sepsis sent on in March 2020

CASE	1	3	4	5	9	11	12	17	18	31	35
FEEL CONFIDENT	2	3	2	3	3	2	3	3	3	3	2
GETTING CONFIDENT	4	3	4	4	4	4	4	4	2	4	3
PREDIT TO USE IT	4	3	4	4	2	2	4	4	3	4	2
ADOPTED	4	4	4	4	2	3	4	3	1	5	3

6. DISCUSSION AND ANALYSIS

In the following section we will discuss the results obtained and attempt to draw main conclusions from our investigation. As mentioned above, the overall goal of this study was to test the potential appreciation of VR tools to improve the education of health professionals toward sepsis. At first, we will address individually the original research questions of the master's thesis, then we will present the belonging elements, before we discuss and present conclusions.

6.1 Research Question 1

RQ 1:

> "Is VR accepted as an educational tool to a certain degree that health personnel will use it to learn and train on sepsis?"

Through the framework used in this study, the acceptance of a user on a technological tool is based on its PU and PEU. The results for this study showed a high PU and a moderate PEU, meaning that the first mentioned element had a higher impact than the second. In the following subsections, we will analyze and discuss the participants' acceptance based on the PU and PEU from our theoretical framework. It will be natural to include self-efficacy as the element in this master's thesis defines whether the participant feel confident on sepsis detection.

6.1.1 Perceived Usefulness

The study results showed that PU, PEU and self-efficacy almost explained 50 % of the total variance of BI (Table 7). Also, our study supports previous finding that PU have the greatest impact on BI (Chow, Herold, Choo, & Chan, 2012; Venkatesh & Davis, 2000; Verhagen, Feldberg, van den Hooff, Meents, & Merikivi, 2012). In the following part of this subsection we will analyze and discuss the two different questions that constituted PU. The first question was whether the participants thought they could get confident on sepsis detection by using VR, and the second whether they thought the tool could facilitate awareness of own performance. The participants response on PU are summarized in Table 9 in subsection 5.4.

A substantial number of the participants were neutral to the questions, which can be explained by that they had not tried yet the technological tool. One-minute introduction video may help to give an insight, but cannot be a rich experience opportunity similar using the technology for the purpose of practicing treatment of sepsis. However, few respondents had a negative perception, and we therefore found it relevant to investigate these closer. In Table 10 are presented the participants that rated the construct of usefulness on 1 or 2. Overall, most cases that disagreed reported a score of 1 or 2 on the first question. Case 35 remained neutral to the first question, but negative to the second question on whether video recording could make her more aware of own performance. Results presented in Table 10 will be further discussed in the following paragraph of this section.

GETTING CONFIDENT

Half (54.60 %) of the participants agreed to the first statement of PU, testing the agreement of participants on "I think VR could help me getting confident diagnosing sepsis". Thirteen of the participants remained neutral, while seven disagreed to the statement. Despite that participants disagreed to the statement that VR could help them getting confident, most respondents saw some advantages to the VR system, such as being able to transfer accumulated knowledge from a virtual sepsis case to a real-world case. In addition, several respondents believed that they would be more concentrated using the system than by the conventional classroom learning, improving the learning outcome. Furthermore, a majority of the respondents that disagreed to the same statement still considered that the system could provide to the users a near authentic feeling to the reality. Related to the answers on authenticity could be the answers on VR's reflection of being present, as most participants had similar ratings between the two mentioned questions. The participants that disagreed to the statement on whether VR could help them getting confident on sepsis detection did not think it would be easy for them to become skillful when learning and training on sepsis through VR. Neither did they think the system could enhance their interaction skills with patients or other health personnel. Despite this, did the participants view the system as easy to use, furthermore did they think it would be easy to perform in the interactive world.

Only two of the participants who have tried VR before once or several times, responded that the technology would likely not help them getting more confident than with currently use teaching methods for treating sepsis, based on their results to question 7 (Appendix II). Despite their experiences using the technology, it was not possible to detect any clear differences between the answers from these two participants that had tried the tool and the rest that had not (Table 10). One question that was low rated from all participants, with the exception of the two participants mentioned above, was “I think it would be easy for me to become skillful when learning and training on sepsis through VR”. As presented in Table 6, this question is loaded on two components, where one component reflects the tools facilitation of efficiency and proficiency and the other its simplicity. Case 6 agreed to that statement, however he did not think the technology would help him to get confident. He also rejected the idea to adopt such technology to provide and sustain health personnel’s knowledge on sepsis. Case 41 was neutral to the statement above, but wished in contrast to case 6 for the technological tool to be adopted. While he did not think the technological tool could help him to improve his competence on sepsis, he highlighted that it could help to train people under education or people with a lower competence on sepsis detection. The participant expressed the following:

> “The steps needed to diagnose sepsis I believe would be easier to learn and remember by using VR, in the sense that it seems a safe and entertaining way to "muscle memory" the steps and investigations needed to make sure you have done what you should. Findings, however, I am more skeptical to learning by VR, the feel of the patient`s skin, their color and response is something which I believe should be learned by the bedside. Although I have answered negatively on several of the above questions, this is partly because I myself would not benefit much from VR in sepsis now, or some years ago. However, for people new to sepsis, and emergency medicine as a whole, I believe VR is a very good way of having the opportunity to go through the many steps needed to evaluate an emergency patient.”

Through feedbacks from participant 41 we noticed that, despite low rating, the participants still saw benefits from using the system. He mentioned to have tried the technological tool once, when and which kind of application he tried would have been valuable information for further analyzations. The same applies to the eight other participants that had tried it (Question 5, Table 11). Three of them had tried the tool only once, cases 2, 34 and 44. Case

44, similarly to case 41, did not think that VR could help him to gain confidence on detecting sepsis. The participant already felt very confident on detecting the illness, and filled the survey with varied answers and highlighted several strengths and weaknesses of the VR tool. Case 34 agreed to all statements, with the exception on question 8 about video recording. Case 2 had the most positive perspective on the tool of the three where she strongly agreed to most of the questions, and agreed to the rest. This shows that the ones who had tried it once, overall, had a positive perspective on VR characteristics and its potential to educate sepsis treatment. Similar findings could also be noticed for the ones who had tried it several times, cases 6, 12, 24, 26 and 43. Case 24 gave all statements a score of 4 or 5. Case 12 also answered similarly, with an exception on question 6 about confidence level on sepsis detection, where it received a neutral score. Case 43 had a positive perception where he strongly agreed to statement 9, 10 and 18. Furthermore, he agreed to 8 other statements, but remained neutral on statement 14 and 16 for the VR tool to improve learning outcome from increased concentration and enhancing interaction skills. These three cases, in addition to case 26 agreed to several statements. However, did case 26 have a neutral perspective on if VR could help her gain confidence on sepsis detection. Among participants that only had tried the tool several times, only case 6 did not think it could help increasing the confidence (Table 11).

Naturally, some health care institutions have more sepsis cases than others. Case 35 had learned on detecting and treating sepsis 10-20 years ago and worked in the emergency department, a workplace where one can expect professionals to feel confident at detecting illnesses such as sepsis. She disagreed to the “I feel confident” statement (Question 6), while however a colleague of her at the emergency department strongly agreed to the statement. About 30 % of the survey’s participants worked in the intensive care unit and this department reveals thereby differences in confidence level of sepsis detection. The four participants from the emergency room that filled in agreed or strongly agreed to the statement. A good sign considering that patients with sepsis can seek this department. However, could there have been substantial differences in confidence level if we had the same amount of participants filling in the questionnaire from the emergency room as from the intensive care unit. In total 11 of our 44 participants disagreed or remained neutral to feeling confident on sepsis detection, this is a high percentage as sepsis is an illness with high death rate that require rapidly detection and treatment (Tromp et al., 2009). In this paperwork, we listed several sources to discontent on education of health personnel, both for general and for sepsis knowledge (Nguyen et al., 2009; Norsk sykepleierforbund, 2019; Tromp et al., 2009). In order to fulfill the educational goal, we firstly need to work on getting the competence level more even. This would be by investing more in sepsis courses, either by improving traditional courses or by implementing new learning tools. VR could, as presented in this master's thesis, be a potential learning tool for sepsis learning and training. Our results show that more than half of the participants think VR could help them getting confident on sepsis detection, meaning that the target group is open for the solution.

VIDEO RECORDING

Along with asking the participants whether they thought VR could help them getting confident on sepsis detection by using VR, we asked whether they thought video recording in VR could help them to become more aware of own performance. The participants did not conform to the same degree on the second measurement for PU as they did for the first. Overall, seven people disagreed to the first statement of PU (Question 7), whereas four disagreed to the second (Question 8) – leaving means on 3.43 and 3.61, respectively. As we can see in table 9, almost the same number of participants agreed to the two statements, however, did more participants strongly agree to video recording and more remain neutral, leaving the two means close.

Table 9 shows that four participants did not see advantage to video recordings of sepsis training for being more aware of own performance. The summary in Table 10 showed that three of the seven participants that had a negative perception on the first question of PU about getting confident on sepsis by using VR, also had a negative perception on the second question related to video recording. One of the three participants had a negative perspective on all the questions of the survey except about the ease of usage and the ease to perform (Questions 9 and 15). Non-negative answers were instead on a neutral position, suggesting that the participant is likely not considering that the VR tool for sepsis education can be beneficial for sepsis treatment education. The two others accepted it to a certain degree, viewing other qualities to VR as valuable. For example, did one of the participants think that it would be easy for him to become skillful when learning and training on sepsis through VR, whereas the other thought he would be more concentrated in a VR case than a case in the conventional classroom.

Responses from the participants to “I think I would be more aware of own performance by watching it” can be influenced by several reasons. Firstly, is it an individual evaluation. For some can video recordings help, while for others not. Some might consider it as helpful as they can be able to replay their performance in stressful procedures, whereas others might feel it would be unnecessary and unhelpful. All survey participants got introduced to a patient room in VR and was shown performance both in and outside the virtual goggles. By so they could have gotten an impression of how it would be to get immersed and interact in a virtual world, and how a medical procedure could look like. When it comes to video recording on performance, this is something that conventional classrooms cannot facilitate. This means that low ratings on the statement presented at the beginning of the paragraph would not change the perspective of users on the tool’s advantages in comparison to the conventional classroom. However, high ratings can show that participants think it could help them and that VR by so have an additional strength.

6.1.2 Perceived Ease of Use

In this second section of the discussion, we will address the acceptance of users on sepsis training through VR using the PEU. As mentioned above, the PEU corresponds to the systems ease of use and is an element of interest because it together with PU affect the BI.

EASY TO USE

It is natural to think demographic variables, such as age, gender and working place, will have an effect on the answers provided by the respondents, and these variables can likely influence their relation to VR. For instance, we can have a closer look to the feedback obtained from the statement “I think VR is easy to use”. To that statement, four participants disagreed, two of them had familiarities to the technological tool, while the two others never heard about VR before they responded to the survey. Age groups could be an important factor, as older generation that did not grow up with a lot of technological tools can be more skeptical to use and handle technological tools. In our study, contain participants from 41 years old and above represented almost 40 % of the participants. We could expect thereby that a large fraction of skepticism on the usage of VR may originate from the high fractions of people in the age groups of 40 years old and above. However, this did not seem to be the case, as the results on this question was not affected by the age of the respondents. Participants that disagreed were between 21 and 40 years; three between age 21-30, and one between 31-40 years. One explanation from their dissidence could be caused by the possible interpretation of the statement from two angles. They could be disagreeing and supported that they do not think it will be easy to use (for instance based on their experience with other complex technologies), or that they disagreed do not know about the technology, and therefore can't confirm that VR would be simple to use. Before sending the survey, the question got changed, where it previously read as "I have the impression that VR is easy to use". We consider that this question might have been better to ask for our participants as it would have been more suitable for both the ones who had tried VR and the ones who had not. However, despite these four cases that disagreed that VR would be easy to use, the 40 other participants had a neutral or positive perception on the same statement. Sixteen of them rated 3 (neutral) to "I think VR is easy to use", while the rest 4 (agree) and 5 (strongly agree). These lead to a relatively strong mean on 3.66, as most people thought the tool would be easy to use.

BECOME SKILLFUL

While it is important for potential users of VR to learn about treating sepsis to address their confidence in the technology and their perception on whether the tool would be easy to use or not, it is also crucial to see if participants are expecting a better learning outcome, and gain additional skills. Therefore, we looked closer to see if there were any connection between this question, "I think it would be easy for me to become skillful when learning and training on sepsis through VR", and the questions presented in subsection 6.1.1 on whether participants thought they could get confident diagnosing sepsis by using VR or not. As we could expect, most of the four cases presented in the paragraph above that reported that they did not think the technological tool could help them getting confident, reported also that they did not think they could become more skillful on treating sepsis. However, results showed that more people reported that they thought it was easy to use than people reporting it to help them become skillful when learning and training on sepsis through VR. This insinuate that even though participants thought the tool would be easy to use, they did not necessarily think it would be the appropriate tool for sepsis education. Our interpretation of that less supported statement on the potential seen by participants to become more skillful may come from the difficulty of clearly imagining the advantages of VR, such as interactivity or authenticity, into learning the treatment of sepsis. Again, neither here did the answers seem to be affected by the age or relation to VR. All cases reported that VR could have some sort of characteristical strengths, meaning that they might be feeling unsecure on analyzing the potential of VR due to their lower technological competences. Within the survey, including a question to address technological competence of the participants could have therefore helped us to explain dissidence among the respondents on the potential of VR to increase their set of skills in sepsis treatment. Another reason could be that most likely answered that despite the skills to be developed through this tool, these may not be solely caused by the technological tool, and other education methods could be producing similar learning outcome.

6.1.3 Self-Efficacy

The statement for the construct self-efficacy sounded as following "I feel confident detecting sepsis on an early stage". Self-efficacy is thereby defined as participants own perception on sepsis performance (Hassankhani, Aghdam, Rahmani, & Mohammadpoorfard, 2015). It is a crucial characteristic in our analyses as it could affect the participants learning motivation, and therefore its answers to survey questionnaire. The results indicated that self-efficacy, in addition to PU and PEU, also made an impact on BI, which was representing the behavioral intention to use VR for sepsis training. As presented in Table 10, participants did not think VR could help them getting more confident, despite that had the majority of the participants a neutral or positive BI. In Table 11 did however most participants think VR could help them getting confident, and they had a strong desire for adoption and prediction of usage (BI). Common for the two tables, Table 10 and 11, was the high confidence level on sepsis detection. As recently mentioned, could the participants own perception on sepsis performance have an impact on their answers. It is reasonable to predict respondents to be more open for new technology if they do not feel they get enough knowledge through the conventional teaching methods. This can be explained by the fact that it can be difficult and time consuming for them to learn or maintain their proficiency themselves on detecting and treating sepsis. Furthermore, they can come across outdated information as there have been several consensus definitions on diagnosing of sepsis (Singer et al., 2016). An application on sepsis in VR would, as most of the current technological applications, be able to be updated, and so up to date with the latest finding from the medical community. By offering an attractive learning platform and by making it easily accessible, we could reduce the burden health personnel face on learning and maintaining their sepsis knowledge. Dagens Medisin (2017) presented that many nurses have the desire to increase their competence and several of them spend their own money on taking courses during their vacation days to feel more confident in emergency care. The sacrifices show clearly motivation and dedication, as the nurses are willing to spend their own time and money to educate themselves. However, can this over time turn into less productive work, which over time can burn the nurses out. Motivation is a powerful resource, and by giving health personnel having different confidence levels the opportunity to train and refresh their knowledge, we can take advantage of this source.

Through the survey, 25.00 % of the respondents rated 2 or 3 on feeling confident detecting sepsis at the question 6. Table 12 shows a summary of all the participants that disagreed or remained neutral on their confidence to detect sepsis on an early stage. Among others, one participant revealed that she did not feel confident detecting sepsis symptoms on an early stage and she found VR useful for potentially improving her skills on sepsis diagnosing. However, her neutral attitude to the three questions defining her perspective on how the technological tool would be easy to use (Questions 9, 10 and 15) may affect her confidence in VR to improve self-efficacy (Question 7). This could be explained by her relation to VR, as she only heard about the technological tool and have not experienced it. Furthermore, her age could have had an effect to her insecurity toward using the tool. Being between 41 and 50 years, we mentioned above that older age groups may have more dissidence toward using technology tools due to their general lower affinity with new technologies. Still, she had a positive BI, meaning that she thought she could learn to train in the virtual world. She wished for sepsis training in VR to be adopted and predicted to use it. Table 12 shows overall high numbers on getting confident through VR usage, prediction to use it and wish for adoption. Most of the participants that did not feel confident at treating sepsis thought that VR could help them getting confident. Only one of the participants did not feel that VR could help him, case 18. The 18th participant claimed a low rating on the usefulness of the technology (Table 10), and explained the following “I'd accept VR if there was solid evidence that it was superior to other forms of learning (such as real world simulation, non-VR computer games).” This means that the perception of the participant is based on scientific evidence and experimentations demonstrating that VR is better than other learning forms. As previously presented did studies compare traditional training to training in VR, results showed the virtual world could be the key to a more efficient and proficient training (Larsen et al., 2012; Seymour et al., 2002). We predict the participant's answers to have had higher ratings if he read this article's theoretical section before answering the questionnaire.

As explained, sepsis can be considered as a common illness because of its high number of global incidents (Slade, Tamber & Vincent, reviewed in Tromp et al., 2019). Health personnel's motivation is to help patients, and in this case to give them a treatment as fast as possible to prevent long term consequences. Health personnel likely want therefore to have the best knowledge to handle it. If VR can facilitate the superior training of these professionals, however, remains unknown. Still, Table 11 and 12, showed high ratings on BI as the participants wanted sepsis training in VR to be adopted and as they predicted to use it. Table 11 contained, overall, participants that felt confident on their own performance of sepsis detection, whereas Table 12 contained participants that felt rather unconfident or neutral to their competence on sepsis detection. As expected, did participants with VR experience want the tool to be adopted for sepsis education, furthermore did they predict to use it. For our questionnaire, did we receive quick and positive response, we can from that conclude that the interest on sepsis learning and training in VR is there.

6.1.4 Behavioral Intention to Use

One of the very first to fill and send in our questionnaire revealed she worked on a nursing home and that her age was between 41-50. Her overall answers agreed or strongly agreed to our survey questions. In the questionnaire, the participant informed to have already tried the technological tool once and that she recently learned about sepsis. We could have valued her answers more as she both had tried VR and as she recently went through the education course for sepsis. However, will participants with longer working time with sepsis most likely have experienced real-life sepsis cases, and therefore contain a different perspective of how one could learn and train to handle the situation. We suggest that a combination of the two relations are appropriate for addressing whether VR would be suitable for sepsis education. The recently mentioned participant assigned to VR positive opinions as she thought the tool could give an authentic and present feeling. She felt comfortable detecting sepsis, and also thought that VR could help her gaining additional confidence. Her answers could have been to the fact that she thought she still could learn more about sepsis, and that the conventional teaching method could not facilitate that. She expected to become more concentrated on training in VR than in the conventional classroom, anticipating that she could transfer more easily the accumulated knowledge to a real-world sepsis case. From her answers, she strongly wished simulation trainings in VR to be adopted in health care institutions to improve and maintain excellency of health personnel's knowledge on treating sepsis.

Cases 40 and 41 also felt confident on sepsis detection, where both strongly agreed to the very first Likert-scale question, "I feel confident detecting sepsis on an early stage". Despite neutrality to future usage of VR (Question 17), they both wish for the tool to be adopted in health care education (Question 18). Browsing through the 44 participants, we observed this pattern of rating many times. We also found confident sepsis detectors predicting to use the tool, but to remaining neutral to the adoption of VR for sepsis training. Overall, did the survey participants have a high motivation on VR usage for sepsis training. This motivation and the engagement from the participants toward using VR in educating sepsis treatment are a result of the system characteristics, such as its ability to give a reflection on being present in a sepsis situation and its ease of use. As explained in section 3, are these some of the characteristics defining the educational benefit. The more realistically the users perceive the learning case in the virtual world, the more motivated they will be to use the tool to learn and train. Similarly, for a sepsis application in VR as the participants would want to use a learning method that could make them better prepared to handle a real sepsis case. We expected that PU, which is representing the participants perceived usefulness, would have had a bigger impact on BI than PEU, which is presenting the participants perceived ease of use, that it would be reasonable to think that people would be more open to use a new tool on its potential to improve skills, rather than just be easy to use. We will address these characteristics of VR further in the next subsection.

6.1.5 Summary

Several participants thought that VR technology could help them getting more confident on diagnosing sepsis, and that video recording could help them getting more aware of their own performance. When considering participants who had tried the technological tool one or several times, most had a positive perception on learning and training on sepsis in VR. The overall numbers indicate that the participants see the usefulness of VR, and that they think it could help them to gain knowledge on sepsis. All the participants have been taken sepsis courses, some a long time ago and others recently, meaning that they all possess some knowledge to have a perception whether a new learning platform would be suitable. The participants got an introduction on the potential platform through a video on VR, in order to help them evaluating and judging if they would use the tool with greater learning outcomes. Furthermore, most of the participants got an impression that the technological tool would be easy to use. PU, represented by tools perceived usefulness, and PEU, represented by tools perceived ease of use, affected BI, which revealed prediction of use and wish for adoption of VR for sepsis learning and training. PU had the highest impact on BI, and many participants could see themselves using the tool to strengthen their knowledge on sepsis. Based on the previous results, analyze and discussion do we claim VR to be accepted as an educational tool to the certain degree that health personnel will use it to learn and train on sepsis.

6.2 Research Question 2

The second research question is based on PEU and PU. These elements are affected by the three Is; interaction, immersion and imagination, whom are defined by technological tools perceived authenticity.

RQ 2:

> "Could VR enhance todays learning along with being an alternative for Norwegian Health Care for more efficient and proficient education program?"

6.2.1 Authenticity

Authenticity, which characterize the designs ability to create a realistic case, is an important characteristic of VR systems for educating sepsis treatment as the best learning conditions would be to give the best reflection of an actual scenario. As briefed in the theoretical part of this thesis does a full-scale world help strengthening the sense of authenticity (Mandal, 2013). The introduction video sent to the participants for answering the survey showed them that VR could facilitate this by having human looking avatars, medical equipment and a screen revealing the measurements results during virtual scenarios. From these capacities of VR systems, this technology makes it able to create a sepsis case more realistically and similar to the real ones, rather than in the situations simulated in today's training through conventional education methods. However, a participant commented that the awareness of the capabilities of the educating tools need to be further improved. Despite agreeing the improved learning outcomes for people under education and for people with a lower competence on sepsis, he did not feel that the system would be fully efficient for in-depth training as the technology could hardly reflect patient's skin or response well. It is true that tactile manipulation and sensing is limited in VR technologies, and the closest VR has been to skin feeling over the latest years, has been to temperature changing in controllers when touching an avatar. Real case scenarios definitely overcome this obstacle, however, it remains not an important factor for sepsis detection. A real patient clearly overcome this characteristic, however, is this not an important factor for sepsis detection. Skin color is on the other hand an important sign of symptoms for sepsis detection. Facial flushing and skin discoloration were two sepsis symptoms mentioned due to skin (C. P. Davis, 2019). In traditional learning and training exercises, these symptoms are more difficult to simulate. In contrast, VR can overcome these obstacles as skin colors can be changed on the avatars.

Authenticity is important in order to present to the health personnel a case scenario of sepsis similar to a real case. There are several advantages of facing a sepsis situation in VR before integrating emergency cares. As previously described, the three Is would determent how well the virtual world could reflect a world similar to the real one. If a learning case in VR is not perceived as authentic, it will affect the capacity of transferring knowledge gained in the educational platform to the real one. Our results showed that authenticity had a significant impact on the three Is, imagination, immersion and interaction. It had a high impact on imagination, with a beta coefficient on .964. Authenticity also had a high impact on the characteristic of immersion, which is user's engagement, as it influenced the degree to which participants thought they would be more concentrated through VR tools, than by the conventional classroom. The last technological characteristics, interaction, which is user's ability to perform, does not get affected by authenticity as much as the previously mentioned characteristics. This makes sense as the authenticity would not affect the actual performance as much as it would affect the user's perception of being immersed, or its capability to address and solve issues (Huang et al., 2010; Huang et al., 2016). However, will tools authenticity be important to adequately simulate interactions between the user and patients or other health personnel.

6.2.2 Imagination and Interaction

Overall, participants had a positive perception of the four different constructs, i.e. authenticity, immersion, interaction and imagination, as they all had a mean above 3 (five-pointed Likert scale). By having the perception that VR could be authentic, did the participants believe it could create a realistic case. Furthermore, did they think they could get engaged to the certain degree that they could address and solve issues through performances, these elements describe immersion, imagination and interaction, respectively. Particularly imagination scored well as most participants thought the system could give a good reflection of being present in a sepsis case and that they could transfer the knowledge gained to real-world cases (Question 12). It can be discussed whether the participants would have rated differently to the question "I think the system can give the reflection of being present", than to "I think the system can give the reflection of being present in a situation with sepsis" (Question 11). However, did we need to know their perception for this specific case. After all, had the survey's participants been educated on sepsis. Furthermore, had most likely several of the volunteers been in a real-world sepsis case, this would be reasonable to consider when a third of the respondents worked in the intensive care unit, that is the department that treat most sepsis cases (C. P. Davis, 2019). By having the competence, they would be likely to know what a sepsis case required of tools, knowledge and setting. 65.90 % wished simulation training in VR would get adopted to supply and maintenance knowledge on sepsis. This suggests that they do not think today's learning and training frameworks give enough feeling of presence, as conditions of real-world case scenarios of sepsis are difficult to re-create in current teaching methods.

Interaction is another important feature of VR, affecting the ability of the user to perform in sepsis cases. The answer to the first question of this construct showed that the majority (43.20 %) of the respondents thought that the technological tool could enhance their interaction skills with patients and other health personnel. However, 25.00 % of the participants did not think VR could help them on this, leading to the item with the lowest mean on 3.13 (Table 5). Their answers could have been based on their perspective on VR's capability to create a case where they realistically could interact with other people. Also, could the answers have been based on their general perspective on technology as it until today has had several limitations. If the technology cannot create a case of interaction, there can be difficult to improve interaction skills. The question was asked due to the importance of communication in diagnosing sepsis to patients. As previously mentioned, mental status of an affected patient is likely altered, and this characteristic is one of the three statements identified that needs to be filled to confirm sepsis (Singer et al., 2016). Typically, the mental status of patients is tested by health personnel through observing verbal and physical responses of a patient to do different stimuli. Results from the Glasgow Coma Scale presented in Table 2 showed that the patients eye response could be spontaneously, it could also make response to speech or to pain (Sternbach, 2000). Further did the table present that patients answers could be oriented, confused, or inappropriate. There could also be just no response at all. Motor response corresponds to whether or not the patient could make moves, or its body make abnormal flexion or extension. The design possibilities of VR tools likely can simulate these different types of responses, as users in other contexts have had communicating patients with responses to pain (Lok et al., 2006). As mentioned in last subsection, did one participant give an ample comment to his concerns. One of them were due to patient responses. Still, despite these challenges, actors used in training sepsis treatment in today's educational programs are also facing similar challenges of replication. Furthermore, we highlight that VR is a technology under ongoing development and that it may get new capabilities in the near future to face these obstacles.

The characteristics of VR has improved, and similarly has the learning outcome. In section 3, we presented several studies that showed that the learning outcome on health issues using VR could be better than the through conventional classroom (Larsen et al., 2012; Nguyen et al., 2009; Seymour et al., 2002). For example, it was revealed that professionals that trained on VR had lower operation time, suggesting that they were better prepared through a case in VR. This support the implementation of VR tools also in the education for sepsis treatment. In addition of getting access to scenarios closer to reality, trainees would have an easy access to repeat the experience, without the rising costs that would be involved in repeating simulated cases in classrooms. Through this master's thesis, we showed that the participants could see themselves training on sepsis by using the innovative computer simulation. The second question to the construct interaction (Question 15) addressed whether the participant thought it would be easy for them to perform in an interactive world. This statement had a higher mean than the first question (Question 16) due to enhancing interaction skills with patients or other health personnel. The fact that they think it would be easy to perform shows that they do not think there will be many obstacles due to VR usage, this both when it comes the tools characteristics to facilitate interactions and when it comes to their own technological competence. We consider this as an important factor for health personnel, as it will define their initiative to try and to further use the technological tool for learning and training. A study showed that respondents without VR experience claimed VR to be easy to use and that others easily could learn to use it quickly (Sankaran et al., 2019). We suggest that our participants also would have claimed this after trying performance in the virtual world.

6.2.3 Summary

The capacity of VR demonstrates that it is possible to create a sepsis case similar to a real one using such tool. It also seems, based on the benefits gained from developing the education on treating other health issues, that the technological tool can enhance today's learning on sepsis treatment. While our study didn't aim at precisely demonstrating that VR has a clear an impact on learning outcome of that health condition, we still underline through our results that participants of our survey, all having medical expertise, mostly supported its potential. The tool characteristics that we investigated in this study, i.e. immersion, interaction and imagination, had overall high means, meaning that the average participant thought the tool could provide the important characteristics needed to develop an application for the given purpose. It was tested which impact had the characteristics on the construct PU and PEU, and both imagination, which illustrates the user's capability to address and solve issues, and interaction, which presents user's ability to perform, had significant impacts. Participants thought that a sepsis training application tool could provide a more realistic approach and that it would be possible to use the gained knowledge in a real case. Furthermore, the participants thought it would be easy for them to learn through performing in the virtual world, in addition of improving their interaction skills with the patient or other health professionals. This results that many think that the tool could help them gaining confidence on identifying sepsis, and therefore many stated they would use such opportunities if the tool would be accessible. From the interpretation of our results, we demonstrate that VR represents an alternative teaching method that could help Norwegian Health Care to design more efficient and proficient education program.

6.3 Other Considerations

In the section above, we have focused on interlinking the defined component of our model to explain the perceptions of the participants toward the use, advantages and challenges of VR in education programs for sepsis treatment. However, other external factors that were not considered could have an impact on the results from the survey. In this subsection, we address these and weight their roles in the interpretation of the results.

LANGUAGE

This master's thesis was built on the use of English language, and therefore was the questionnaire sent to the participants also written in English. We did this to make sure we had the correct content, and that translation would not affect or modify our interpretation from the answer of a participant if written in a different language. During the preparation phase of the questionnaire, one respondent that participated in the pre-test and one professor suggested to adopt instead Norwegian as the core language. Considerations were done, however did we find the English version more appropriate. We were confident that the English level in Norway is sufficiently high, and we also considered that there might be health personnel not speaking Norwegian. The questionnaire remained in the original language.

Yet, language could still be an obstacle for some people, and we therefore made sure to pre-test this survey by people who did not feel comfortable with their English. One of the first participants filling in the form left a comment where she said she wished the questionnaire had been in Norwegian. While it represents a small fraction of our data collection, other participants might have just not expressed their preference for Norwegian, or even might not have answered the survey because of language barriers. For further investigations, we therefore suggest to use both an English and a Norwegian version of the questionnaire, and to give special attention at reducing the impacts that translation between languages could create in the interpretation by participants to the different questions or statements.

RELATION

Personal relations of the participants to VR most likely had also an effect on their perception of its utility for improving learning outcome on sepsis treatment. Yet, the closest relation to VR that some participants could relate is the gaming console Nintendo Wii, which display deformed human avatars and not an optimal interaction between the user and the environment for health care education purposes. As described in the introduction of this master's thesis, VR has for a long time been in development. Improvements made on this technology led to an increase of its adaption to educational purposes. Over the last years, several actors, such as Walmart, made huge investments on the technological tool, seeing its potential to train employees (Incao, 2018). VR is today considered to be in the slope of enlightenment (Panetta, 2017), which means that the system characteristics and system adaption improve and increases, respectively. We therefore predicted that more and more people will become familiar with the technology, acknowledging its growing potential, and their knowledge will likely have a significantly effect on their answers if they would retake the survey. For instance, the participant that commented that he would accept the technological tool if there were solid evidence, would most likely change several of the answers after reading the theoretical framework that we present in this study. Furthermore, participants overall perception could have been even more positive if we in the questionnaire revealed that recently VR tools facilitated performance in the virtual world without controllers. Performing without controllers means that the user could use its own hands to interact, just as it would do in a sepsis case in the real world. By using the latest VR tools, the goggles would be all the equipment the user would need to get immersed and interact in the virtual world.

A VR tryout, instead of an introduction video would most likely have affected the participants questionnaire ratings on the three different tool characteristics, imagination, immersion and interaction. For example, would it be easier to know if one could imagine using knowledge gained from virtual case to real-world case after actually have been in a virtual setting. 22.70 % said this was the first time they heard about the VR, meaning that the introduction video was all they knew about VR before filling out the questionnaire. None of the participants gave all 18 questions (Appendix II) neutral ratings, meaning that all did see some strength or weaknesses of the technological tool's characteristics. One of the participants that gave an overall low rating commented the following "poor view of video.

difficult to understand. might be having sound could have helped me understand better", this comment shows that the participant viewed the video muted, it would naturally not make sense without sound, and it could thereby cause irritation for the viewer. We predict different answer if the participant had watched the video with sound. Furthermore, do we predict different answer by actually have based this research on testing in VR. However, would we most likely have had few respondents. Which also would not have given a clear perception whether respondents overall accepted VR as a technological tool for learning and training on sepsis.

7. CONCLUSION

This master's thesis built on the need for increased competency in detecting and handling patients with sepsis. A VR solution is presented as prior studies have shown exceptional results from the implementation of VR in improving learning outcomes for other medical conditions by providing a more efficient and proficient outcome. This paper contributed therefore to answer the following research questions (RQ):

RQ: What are VR's potential users' thoughts about computer simulations as an educational learning tool? And which elements should be considered to determine the users' perception?

The prime question is divided into two research questions:

RQ 1: Is VR accepted as an educational tool to a certain degree that health personnel will use it to learn and train on sepsis?

RQ 2: Could VR enhance todays learning along with being an alternative for Norwegian Health Care for more efficient and proficient education program?

As we mentioned in the introduction, a sepsis application in VR would be unique as it would be one of the first of its type. It is therefore crucial to include the target group in the development as their perspective is important for the implementation on the tool and its future usage. Participants that answered to the survey covered a wide range of demographic groups through their gender, their age group and their associated health care institutions. The pool of respondents also contained participants with different levels of sepsis knowledge and relation to VR.

Our results indicated that overall participants to the survey thought the technological tool would be useful and that it could help them to gain knowledge on the important illness. The study also demonstrated that most of the participants anticipated an ease to use the technology. The end-users had a positive perspective as they predicted use and wished for adoption of VR. The distinction between the different demographic groups of the participants have strengthened the representativeness of our population of interest. Furthermore, by having well rounded sample, with different levels of sepsis knowledge and relation to VR, our result can be generalized well beyond the sample.

The high PU and PEU, that represented perceived usefulness and perceived ease of use respectively, that we assessed in this study were based on the new technology's features, which were imagination and interaction. As they could facilitate the simulation of a sepsis case similar to the real world, they could therefore enhance today's learning outcome. Participants expressed that VR could give an authentic experience for simulation and that they could use the accumulated knowledge from the virtual sepsis case to a real-world case. They also thought it would be easy for them to perform in the virtual world, improving their interaction skills with the patients and other health professionals. VR is thereby a solution that is accepted as an educational tool to the certain degree that health personnel will use it to learn and train on sepsis. By using the technological tool, we can maximize the utility, as the average cost for educating health personnel on sepsis can be lower, and we make them better prepared for actual sepsis cases. Overall, our study shows that VR can be an alternative for more efficient and proficient education program, and it can support Norwegian Health Care to move toward faster and more accurate sepsis detection in its different health care institutions.

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9. APPENDICES

Appendix I

Table presenting the demographic characteristics (gender, age and associated health care institutions) of the respondents to the questionnaire focusing on the potential role of VR on treating sepsis sent on in March 2020

Variable Groups	Items	N	Percentage
Gender	Female	26	59.10 %
	Male	18	40.90 %
Age	21-30	5	11.30 %
	31-40	22	50.00 %
	41-50	8	18.20 %
	50<	9	20.50 %
Health care institution	Emergency room	4	9.10 %
	Intensive care unit	13	29.50 %
	Medical department	8	18.20 %
	Emergency department	2	4.50 %
	Surgical department	5	11.40 %
	Other hospital department	5	11.40 %
	Nursing home	7	15.90 %

Appendix II

Survey questionnaire

Question 1:

Gender *

- ○ Female
- ○ Male

Question 2:

Age *

- ○ 21-30
- ○ 31-40
- ○ 41-50
- ○ 50 <

Question 3:

Health care institution *

- ○ Emergency room (legevakt)
- ○ Intensive Care Unit (intensiv avdeling)
- ○ Medical department (medisinsk avdeling)
- ○ Emergency department (akuttmottaket)
- ○ Surgical department (kirurgisk avdeling)
- ○ Other hospital department
- ○ Nursing home

Question 4:

... years since the first time I learned about sepsis *

- ◯ Less than 4
- ◯ Between 4 to 10
- ◯ Between 10 to 20
- ◯ Between 20 to 30
- ◯ More than 30

Question 5:

Relation to VR *

- ◯ I have tried it several times
- ◯ I have tried it once
- ◯ I am familiar with the technological tool
- ◯ This is the first time I hear about Virtual Reality

Question 6:

I feel confident on detecting sepsis symptoms on an early stage *

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Question 7:

I think VR could help me getting confident diagnosing sepsis *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 8:

VR facilitates video recording. I think I would be more aware of own performance by watching it. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 9:

I think VR is easy to use. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 10:

I think it would be easy for me to become skillful when learning and training on sepsis through VR. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 11:

I think the system can give the reflection of being present in a situation with sepsis. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 12:

I think I can transfer the accumulated knowledge from a virtual sepsis case to a real-world case. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 13:

I think the learning environment in VR could give an authentic feeling, due to its reflection of the real world. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 14:

I think I would be more concentrated in a fun and deep learning case in VR than by the conventional classroom learning. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 15:

I think it will be easy to perform in the interactive world. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 16:

I think the system could enhance my interaction skills with patients and other health personnel. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 17:

Given that I had access to refresh the knowledge on sepsis in VR, I would predict to use it. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 18:

I wish simulation training in VR get adopted to supply and maintenance health personnel's knowledge on sepsis. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Question 19:

Comments

Svaret ditt