UNIVERSITY OF KWAZULU-NATAL

The adoption of virtual reality for medical training in the context of South African higher education

By

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ABSTRACT

Virtual reality (VR) is progressively being acknowledged as a useful tool for medical training. The adoption of VR for medical training in developing countries is at a slow pace compared to developed countries. The paucity of innovative systems such as VR training systems and the lack of exposure to these systems in developing countries tend to widen the gap in competency between medical professionals from developed and developing countries. VR in South Africa is a new concept and, therefore, limited literature exists from a South African educational perspective. This study aimed to fill the gap in literature from a South African perspective by investigating the determinants of the adoption of VR for medical training at the University of KwaZulu-Natal. The Unified Theory of Acceptance and Use of Technology (UTAUT) was used as the guiding framework to investigate the perceived usefulness of using VR, the perceived effort required to use it, and the social factors and facilitating conditions that can influence its adoption for medical training. The study further aimed to determine the challenges associated with the adoption of VR for medical training within the South African higher education context.

Findings from interviews with 12 purposively sampled lecturers revealed that most respondents perceived that VR would be easy to use for medical training should the necessary training and support be provided. Some respondents had not previously experienced VR immersive environments and hence felt that using VR for medical training would be difficult. The researcher deduced from the responses that the respondents would be influenced to adopt VR for medical training by other medical professionals who were currently using VR and that the degree of influence would be an important factor in adoption. Although the respondents perceived VR to be useful, they voiced that the adoption of VR for medical training at South African educational institutions could be hampered by challenges associated with the lack of infrastructure, knowledge of VR, finance, resistance to change, user's inability to differentiate simulated environments from the real-world and poor design of the VR system (interface). The respondents suggested a gradual approach to VR adoption, forming partnerships with VR companies and seeking sponsorships or donations from alumni to address the finance-related impediments. Furthermore, to ensure the successful adoption of VR for medical training by South African educational institutions, they mentioned the need for: government to address financial constraints by increasing the budget allocated to South African healthcare; an effective change management process to address resistance to change; a cost-benefit analysis; and, finally, training to surmount the challenges.

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LIST OF ABBREVIATIONS

AI:	Artificial intelligence
DOI:	Diffusion of Innovation Theory
HMD:	Head-mounted display
ICT:	Information communication technology
IoMT:	Internet of medical things
IoT:	Internet of things
IT:	Information technology
MM:	Motivational Model
MPCU:	Model of Personal Computer Utilisation
NHI:	National Health Insurance
RLC:	Resource-limited countries
SA:	South Africa
SCT:	Social Cognitive Theory
TAM:	Technology Acceptance Model
TPB:	Theory of Planned Behaviour
TRA:	Theory of Reasoned Action
UK:	United Kingdom
UKZN:	University of KwaZulu-Natal
USA:	United States of America
UTAUT:	The Unified Theory of Acceptance and Use of Technology
VR:	Virtual reality

CHAPTER ONE: INTRODUCTION TO THE STUDY

This chapter provides a background to the study and highlights the research problem, the objectives of the study and the research questions. The chapter further presents the theoretical framework adopted. The limitations of the study are also outlined.

1.1. Introduction

According to Israel, Wang, and Marino (2016), technology offers a way to enhance and improve the accessibility of learning materials, promote scientific literacy, and improve students' attitudes toward pursuing medical training. The number and range of commercially available technologies used in training healthcare professionals are rapidly growing. However, Halili (2019) stated that simply introducing technology to students and other users does not necessarily enhance learning. Technology can only become a powerful learning tool if it is customised to suit the learning needs of students. Halili (2019) further stated that educators can either introduce students to simple technologies such as videos, video games, two-dimensional (2D) computer learning programs and 2D media or to highly sophisticated computer systems such as virtual reality (VR).

According to Popoola, Omonisi, and Odesanmi (2020), training is considered as fundamental to a healthcare delivery system. However, there is a lack of information on the level of utilisation of information technology (IT) among healthcare professionals in developing countries (Seretse, Chukwuere, Lubbe, and Klopper, 2018). Seretse *et al.* (2018) further noted that currently in developed countries, advanced technologies such as 3D simulations, VR and robotics are used for training medical students. However, many developing countries do not have advanced technological equipment for medical training because such equipment is beyond the scope of healthcare priorities in those countries (Seretse *et al.*, 2018). On the other hand, developed countries find it more feasible to implement advanced technologies for medical training to improve their healthcare systems (Seretse *et al.*, 2018). The absence of innovative systems such as VR-based training techniques and the lack of exposure to advanced concepts of VR-enabled medical training programs tend to widen the gap in competency between medical professionals from developed countries versus those from developing countries (Seretse *et al.*, 2018).

In developing countries such as South Africa, VR is slowly being recognised for its benefits in teaching and learning. However, its adoption for educational purposes is lagging compared to developed countries (Ng'ambi, Gachago, Ivala, Bozalek and Watters, 2012; Buliva, 2018). Both Mbarika (2004) and Monakise (2019) agreed that most African countries cannot afford the advanced technological solutions such as VR, which may explain why VR adoption for medical training purposes remains latent in resource-limited countries.

On the other hand, developed countries have acknowledged the benefits of VR for educational purposes and have implemented it in the classroom to assist with various aspects of teaching (Ng'ambi *et al.*, 2012). Both Satava (1996) and Lalys and Jannin (2014) suggested that medical training requires the adoption of advanced computer-based systems like VR. However, the implementation of VR needs *a priori* knowledge of factors that could influence its adoption or non-adoption and the challenges related to its implementation in a specific context.

Burger and Christian (2018) stated that although the post-apartheid government has made significant progress towards reforming and improving access to healthcare for the public sector, the healthcare system in South Africa remains inequitable. In terms of progress, approximately 1600 healthcare facilities have been built or upgraded since 1994 - a significant investment affecting approximately 40 percent of existing health facilities (Burger and Christian, 2018). Burger and Christian (2018) further noted that the availability of healthcare services has improved with some people from rural communities reporting reduced travelling times to healthcare facilities (for example, clinics). Affordability-centric policies in South Africa have decreased patient fees and have expanded priority programs with the aim of making healthcare more accessible to people residing in rural areas.

However, Burger and Christian (2018) noted that studies show that healthcare access will not necessarily improve if the costs of healthcare are decreased. Hypothetically, if public healthcare services were to be ‘free’ or cost-effective, patients could perceive the services to be of poor quality which may cause them to refuse treatment from those healthcare facilities. Similarly, Honda, Ryan, Van Niekerk and McIntyre (2015) argued that improvements in the accessibility and cost-effectiveness of public healthcare in South Africa are unlikely to improve health outcomes if patients do not find the quality of the services acceptable. Therefore, the South African government needs to understand patients’ experiences with accessing public healthcare services prior to making investments in advanced healthcare technologies such as VR (Honda *et al.,* 2015; Burger and Christian, 2018).

In their study, Burger and Christian (2018) found that regardless of measures implemented by the South African government to promote equal access to healthcare, there were several areas of inequity in healthcare which remained. Burger and Christian (2018) added that although acceptability levels of good quality healthcare were high, availability and affordability of it remain constrained. Thus, the lower levels of availability and affordability implied that only 53 percent of South African patients had full access to acceptable healthcare that was also available and affordable (Burger and Christian, 2018). Hence, the researcher believes that if advanced technologies were to be adopted, the South African government would need to ensure that they are accessible to all users (residents, doctors and other medical professionals) working in public healthcare.

Kirby (2019) noted that it is imperative to understand the reasons for the affordability and availability constraints. One of the main reasons for a lack of access to primary healthcare by most South Africans is remoteness. These South Africans reside in rural areas and have to travel further to the health facilities subsequently paying more to do so. The constraints arose as a result of the apartheid regime and hence are not simple or easy to resolve (Kirby, 2019). Additionally, another constraint patients' residing in rural areas face is South Africa's underdeveloped public transport system which increases travel times and costs to patients. However, these constraints fall outside the realm of the Department of Health (DoH) (Kirby, 2019). Thus, as South Africa embarks on major healthcare reforms under the umbrella of the National Health Insurance (NHI) Bill, there will be an increased need for empirical evidence to guide and inform policy prior to advancements in the healthcare field (Salt and Lopes, 2019).

The South African DoH details ten priorities (the 10-point plan) in its service delivery agreement, one of which is the need to improve healthcare infrastructure which includes using information communication technology (ICT) and advanced technology to improve patient care (part of the National Electronic Health Strategy) (Govender and Mars, 2018). However, the South African government recently passed the NHI Bill. NHI will be an enormous government-run medical scheme consisting of all South African citizens as members. The NHI will include primary healthcare, for example, doctor visits, medicines, operations and hospital stay which will be 'free' for all South Africans. Taxpayers would need to pay an additional amount of tax from their income rather than paying for medical aid. There is much speculation about whether the South African government can afford and manage the NHI (Salt and Lopes, 2019). McIntyre (2019) stated that recent or newly implemented health-related technologies should only become available for use once the cost and the impact of the NHI is realised. However, Leong (2019, p. 4) noted that the evidence of the comparative value and effectiveness of technology (including medical devices and advanced technological medical systems) would be evaluated against the current standard of care. The NHI Bill states that the Benefits Advisory Committee must determine, review, and assess detailed and cost-effective treatment guidelines that consider the emergence of new technologies (Leong, 2019, p. 8). This does mean that there is a possibility for technologies, such as VR, to be adopted in the healthcare industry.

1.2. Research problem and significance of the study

South Africa has recently joined the VR revolution. Hence, some organisations in the country are competing extensively to be recognised in the VR international market (Naidoo, 2017). These South African organisations produce VR devices to be used in the fashion and entertainment (music and gaming) industries (Naidoo, 2017). However, VR adoption in South African educational institutions is slow and stagnating (Buliva, 2018). Hence, little is known about the factors that may influence its adoption or non-adoption. Buliva (2018) further noted that the use of VR in education in Africa has not been investigated extensively. Govender and Mars (2018) pointed out that there is limited literature relating to medical training of students using advanced technologies such as VR in South Africa.

Similarly, Swart, Duys and Hauser (2019) noted that the current use of simulation-based education using technologies such as VR is unknown in South Africa.

This study, therefore, investigated lecturers' perceptions of the adoption of VR for medical training. It focused on the determinants of, and the challenges to, the adoption of VR to train medical students from a South African educational perspective. The use of VR in other contexts has been investigated extensively (Weiss and Jessel, 1998; Freeman *et al.*, 2001; Hoffman, Murray, Curlee and Fritchle, 2001; Mazziotta *et al*., 2001; Zimand *et al*., 2002; Glanz, Rizzo and Graap, 2003; Rizzo, Schultheis, Kerns and Mateer, 2004; Fridhi, Benzarti, Frihida, and Amiri, 2018) and its potential to enhance learning outcomes has been proven. Therefore, failure to conduct this study would have meant that the determinants of, and challenges to the adoption of VR for medical training purposes in South Africa remained unknown. Findings from this research could be a point of reference for future research on the adoption of VR for medical training purposes and for its use in the treatment of medical conditions, for example, stroke, cancer, orthopaedic illness and cerebral palsy.

According to Tyrone Rubin, starter of the VRSA (Virtual Reality South Africa) Project, VR in South African education is still being explored and is a work-in-progress (Friederici, 2018). South Africa has not joined the trend of VR in education. VR requires a high-speed network infrastructure to be used effectively, and because South Africa has recently adopted fibre Internet connections, the adoption of VR in South African education is not a far-fetched idea (Ma, Jain and Anderson, 2014; Friederici, 2018). However, there is a need to identify other factors beyond high-speed network infrastructure that must be considered within the context of South Africa to make VR adoption for medical training a reality. There are studies that have looked at the adoption, acceptance and reluctance to use VR (Fetscherin and Lattemann, 2008; Hussin, Jaafar and Downe, 2011). One of the many benefits of using VR for medical training is that the technology enables medical students to train without using real-life patients (Freina and Ott, 2015; Nickel *et al*., 2015; Ruthenbeck and Reynolds, 2015). Seretse *et al.* (2018) noted that in South Africa medical students use real-life patients to practice diagnosis and treatment of illnesses. However, there is a high risk of harming real-life patients during the training sessions and hence it is important to develop and adopt advanced technologies such as VR to increase students' exposure to surgical procedures and to decrease the risks to patients (Pelargos *et al*., 2017).

Based on the above discussion, VR in South Africa is a new concept and, therefore, limited literature exists from a South African educational perspective. This study investigated what the participants view on VR use in higher education for medical training is. And in doing so, aimed to add to the limited literature from a South African educational perspective.

1.3. Research questions

i. What is the perceived usefulness of using VR for medical training?

ii. What is the perceived effort required to use VR for medical training?

iii. What are the social factors that can influence the adoption of VR for medical training?

iv. What are the facilitating conditions for the adoption of VR for medical training?

v. What are the challenges to the adoption of VR for medical training?

vi. What could be the solutions to overcome the challenges to the adoption of VR for medical training?

1.4. Research objectives

i. To identify the perceived usefulness of using VR for medical training.

ii. To identify the perceived effort required to use VR for medical training.

iii. To identify the social factors that can influence the adoption of VR for medical training.

iv. To identify the facilitating conditions for the adoption of VR for medical training.

v. To identify the challenges to the adoption of VR for medical training.

vi. To propose solutions to overcome the identified challenges.

1.5. Methodology and theoretical framework used in the study

The study adopted a qualitative research approach and a purposive sampling strategy was used. The researcher interviewed 12 respondents using semi-structured interviews (refer to Chapter four for a detailed explanation of the methodology used in the study). The study also adopted the Unified Theory of Acceptance and Use of Technology (UTAUT) as a framework (refer to Chapter three for a detailed explanation). In the context of this study, the UTAUT framework was used to identify the perceived ease of use of VR in medical training and the anticipated benefits related to its adoption. The framework also served as a guide in identifying the social factors and facilitating conditions that may contribute to the adoption of VR for medical training in the South African context.

1.6. Limitations of the study

The study was based on a sample from only one school within the College of Health Sciences at the University of KwaZulu-Natal (UKZN), namely, the School of Laboratory Medicine and Medical Sciences. Due to time constraints, potential respondents from the other schools within the College (School of Clinical Medicine, School of Health Sciences, and School of Nursing and Public Health) could not be included in the study. The perceptions of the respondents comprising the sample could add insights into the potential adoption of VR within the context of South African higher education.

1.7. Overview of the study

This study comprises the following chapters:

Chapter one: 'Introduction to the study' is an overview of the adoption of VR for medical training and lists the research questions underpinning the study.

Chapter two: 'Literature review' outlines the adoption of VR for medical training and also describes the uses of VR for treating patients.

Chapter three: 'Theoretical frameworks' details the theoretical framework adopted in the study along with other theoretical frameworks used in information systems research.

Chapter four: 'Research methodology' provides a detailed explanation of the research methodology adopted in the study.

Chapter five: 'Findings and discussion' presents and discusses the findings of the study.

Chapter six: 'Summary, conclusions and recommendations' concludes the study and provides recommendations as well as suggestions for further research.

1.8. Conclusion of Chapter one

This chapter introduced the study. The background, research problem and significance of the study were outlined along with the research questions and objectives. In addition, the chapter briefly introduced the theoretical framework and the methodology adopted. The limitations of the study were also highlighted.

The following chapter (Chapter two) provides a review of the literature pertaining to the use of VR for medical training and the treatment of patients.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

This chapter presents a review of the literature pertaining to the adoption of VR for medical training from the perspectives of both developed and developing countries. While the focus of the review is on the use of VR for medical training, it also deals with its use in treating patients. Pouris and Inglesi-Lotz (2014) noted that higher education and training contribute to economic growth as it enables the creation of knowledge through research and academic development. Shay (2017) stated that investment in human capital through higher education has become one of the South African government's core strategies to promote economic growth and development.

Tun, Alinier, Tang, and Kneebone (2015) noted that simulation-based training is standardised in industries like aviation, nuclear power, and the military to maximise training safety and minimise the loss of human lives. However, the South African medical industry has not fully adopted VR for simulation-based training for various reasons including cost, the lack of significant proof of effect and resistance to change (Tun *et al.*, 2015). Hence, limited literature exists on the adoption of VR for educational and training purposes in the medical field from a South African perspective. The aim of this chapter is to provide a review of the literature to help understand the VR concept and its applications in medical training and other contexts.

2.2. The use of VR in simulated medical training

Salam *et al.* (2016) noted that healthcare professionals and educators recognise that VR systems that are used in simulated medical education and training can contribute significantly to the medical discipline by enhancing students and medical professionals' performance, as well as patients' safety. Afkhami (2012) indicated that an expert group of medical educators identified simulation-based education and training as the optimal method for learning medical procedures. VR is utilised in simulation-based education to train medical students to become nurses, doctors, or surgeons by creating a safe environment where students can practice medical procedures (Salam *et al.*, 2016). Similarly, Al Kuwari (2018) stated that VR provides a danger-free environment to practice medical procedures. According to Afkhami (2012), VR provides students with the opportunity to practice rare procedures and diagnostic interventions that are often only read about.

The following section discusses model-driven and instructor-driven VR simulators.

2.2.1. Model-driven VR simulators

Smith, Navaratnam, Jablenska, Dimitriadis, and Sharma (2015) observed that VR simulators are sometimes integrated with sophisticated life-like mannequins. They stated that the mannequins are used for respiratory, cardiovascular and pharmacological modelling of drugs to simulate a real-life scenario. This type of VR simulation system may be referred to as a model-driven VR system (Smith *et al*., 2015). Similarly, Lopreiato and Sawyer (2015) observed that some simulators allow clinicians to interact with the virtual patient as they would in the real world. There are speakers in the mannequin's head that play sounds that imitate the way a real patient talks and there are also physical signs from the mannequin to show that the artificial patient is 'alive' such as mimicking a real-life patient's pulse, breathing, heartbeat, contraction and dilation of pupils, and urine output (Lopreiato and Sawyer, 2015). Other authors have also pointed out that VR simulators can be built as automated mannequins designed to provide realistic physical, auditory and visual stimuli (Gaba, Howard, Fish, Smith and Sowb, 2001; Friedrich, 2002; Gordon, Oriol and Cooper, 2004; Tun *et al.*, 2015; Omer, 2016).

Lopreiato and Sawyer (2015) stated that the signals created for these mannequins are recorded onto routine clinical monitors to allow for both simple procedures (non-invasive blood pressure and oxygen saturation) and complex procedures (pulmonary artery pressure and cardiovascular pressure) to be conducted. Drugs injected into the mannequin are automatically detected and have appropriate effects and responses. Students and other users who train using VR-enabled simulations and programmed mannequins are exposed to different situations that will prepare them for real-world situations (Lopreiato and Sawyer, 2015). Students can increase the oxygen saturation level and administer fluid and adrenaline to the mannequins. In this way, students gain experience from the interaction with the virtual patient (Kothari, Shah, and Barach, 2017; Kodikara, Karunaratne, and Chandratilake, 2019). Tun *et al.* (2015) explained that the mannequin's internal components connect to different types of patient monitors and medical devices such as anaesthesia machines, ventilators, and defibrillators.

VR mannequins may be used to teach basic sciences such as pharmacology and physiology and could also be used to teach the management of complex medical cases, including drug administration, cardiopulmonary resuscitation, endotracheal intubation, tracheostomy, and insertion of chest tubes. This allows students to practice procedures, make errors and learn from those errors to ensure competency in the real-world (Tun *et al*., 2015). Similarly, Rabkin (2002) discussed the situation in the Harvard Medical School which used a VR simulator to practice bronchoscopy. The simulator assisted students to develop medical and interpersonal skills. However, due to their complexity, model-driven VR simulators are costly, both in terms of the purchasing and maintenance costs and, therefore, tend to be found in specialist medical centres which confine the adoption of the simulators to facilities that can afford them (Rabkin, 2002; Tun *et al*., 2015; Casso, Schoettker, Savoldelli, Azzola, and Cassina, 2019).

2.2.2. Instructor-driven VR simulators

Instructor-driven VR simulator systems are simpler than model-driven VR simulator systems as they lack the complex programming and mathematical models that the latter are built upon (Lopreiato and

Sawyer, 2015). Furthermore, the computer software embedded in the instructor-driven VR simulators produce signals that are displayed on a computer screen rather than on a standard clinical monitor (Lopreiato and Sawyer, 2015). An instructor (educator, therapist, or medical professional) is required to interpret and adjust the signals to reflect real-life patient responses (Lopreiato and Sawyer, 2015). Therefore, no automated responses and detections are made through instructor-driven VR simulator systems. This makes it more difficult for students to verify the information they have acquired from the VR-simulated environment because signals must be manually interpreted and, because of human error, it is not always possible to accurately interpret the information. However, Gaba and De Anda (1998) stated that instructor-driven VR simulation training was increasingly being considered for medical training because of its affordability. Similarly, Kothari *et al.* (2017) and Kodikara *et al.* (2019) noted that instructor-driven VR simulator systems are progressively being incorporated within the educational syllabus in developed countries and some developing countries such as Nigeria and Malaysia because they are cost-effective.

2.3. The use of VR simulations to promote skills development

With the evolution of technology, simulations are beginning to support students' attainment of medical skills including communication, surgical, diagnostic and radiography analysis (Grantcharov *et al.*, 2004; Lopreiato and Sawyer, 2015; Tun *et al*., 2015; Kothari *et al.*, 2017; Casso *et al.*, 2019; Kodikara *et al.*, 2019). Several authors have noted that medical students are trained using clinical simulations that mimic the real-world environment to ensure that they learn and retain sufficient knowledge which is then transferred to the real-world (Chaudhry, Sutton, Wood, Stone and McCloy, 1999; Grantcharov *et al.*, 2004; Lopreiato and Sawyer, 2015; Tun *et al*., 2015; Kothari *et al.*, 2017; Casso *et al.*, 2019; Kodikara *et al.*, 2019).

2.3.1. The use of MIST-VR for skills development

Chaudhry, Sutton, Wood, Stone and McCloy (1999) found that MIST-VR, a VR surgical simulator, enabled students and surgeons to gain surgical skills because they received feedback from the errors they made in the simulated environment. Similarly, Wilson, Middlebrook, Sutton, Stone and McCloy (1997) contended that MIST-VR provided a new way of training and assessing surgical skills acquisition as compared to the traditional way where students had to utilise training boxes which contained inanimate objects. In the traditional training environment, medical students had to manipulate inanimate objects using physical instruments (Wilson *et al*., 1997; Baby, Srivastav, Singh, Suri, and Banerjee, 2016; Vaughan, Dubey, Wainwright, and Middleton, 2016). However, in the VR environment, these inanimate objects are not needed.

MIST-VR creates a medical VR avatar using a patient's image, separates an individual's organs and tissues from the body and thereafter displays the reconstructed 3D anatomy on a monitor or other VR display device for students to manipulate (Satava and Jones, 2000; Baby *et al.*, 2016). However, Torkington, Smith, Reest and Darzi (2000) and Vaughan *et al.* (2016) noted that the MIST-VR simulator has no haptic interface, meaning that there is no feedback from the instruments and/or objects when they make contact. This simply translates to its inefficiency to maintain an immersive 'feel' in the VR environment. According to Playter and Raibert (1997), haptic feedback may be defined as the sense of touch between the user and the virtual environment. Playter and Raibert (1997) added that computer programs used in a VR system should be able to detect when virtual objects touch each other and with what force they do so to ensure that the feeling of being physically present in the VR environment is maintained.

A study conducted with medical students who used the MIST-VR system for basic surgical skills training found that they displayed fewer errors and completed more surgical tasks efficiently when compared to students who did not use the system (Chaudhry *et al.*, 1999). Similarly, Hamilton *et al.* (2002) discovered that students who used MIST-VR for training demonstrated improvements when performing real surgical operations. Al Kuwari (2018) also found that students who learned technical skills from both simple interfaced simulators and from VR systems that have complex interfaces (such as MIST-VR) had shown a transfer of skills to real-life surgical operations.

A number of other studies have shown a transfer of learning and skills acquisition from the VR simulated environment to real-life surgical operations in the operating room (OR) (Westwood, Hoffman, Stredney and Weghorst, 1998; Gallagher, Richie, McClure and McGuigan, 2001; Hamilton *et al.*, 2002; Hyltander, Liljegren, Rhodin and Lönroth, 2002; Seymour *et al.*, 2002; Grantcharov *et al.*, 2004; Lopreiato and Sawyer, 2015; Tun *et al.*, 2015; Baby *et al.*, 2016; Vaughan *et al.*, 2016; Kothari *et al.*, 2017; Al Kuwari, 2018; Casso *et al.*, 2019; Kodikara *et al.*, 2019). In contrast, Ahlberg *et al.* (2002) found no improvements in students' surgical skill acquisition and learning retention after three hours of using MIST-VR for training. However, in this instance, students were using the MIST-VR for the first time and had difficulties understanding the design (interface) of the VR system. As a result, they did not utilise it effectively. Furthermore, McGrath *et al*. (2018), referring to haptic feedback, stated that it allows residents to 'feel' a physical object and to manipulate it in a realistic manner and that without such feedback residents would not be aware of the amount of force they are applying to a scalpel or the tissue resistance they would normally encounter during a surgical procedure. A lack of haptic feedback illustrates a major hurdle for the adoption of VR for medical training (McGrath *et al*., 2018).

2.3.2. The use of VR in simulated medical training to enhance skills development

A VR system, Anatomic VisualizeR, was developed at the University of California for medical students (Hoffman *et al.*, 2001). This VR system contained several 3D anatomic models and allowed students to virtually dissect the models. A similar virtual anatomy project, 3D Human Atlas, was developed in Japan to assess students' understanding of human anatomy (Mazziotta *et al*., 2001). VR systems that focus on human anatomy allow students to gain experience and receive real-time feedback (Hoffman *et al.*, 2001). Similarly, Reznek, Rawn and Krummel (2002) found that VR enhances medical training by standardising such training and providing students with the opportunity to repeat tasks until competency is reached.

Some authors have emphasised that advanced surgical VR systems for training purposes must provide feedback mechanisms to improve the learning of medical skills (Asano, Yano and Iwata, 1997; Tseng, Lee, Chan, Wu and Chiu, 1998; Ottensmeyer, Ben-Ur and Salisbury, 2000; Smith *et al.*, 2015). Smith *et al.* (2015) stated that training devices (such as VR devices) that have feedback mechanisms tend to improve skills acquired in the virtual environment and may, therefore, lead to a transfer of training to the real-world. Similarly, both Issenberg *et al.* (1999) and Pulijala, Ma, and Ayoub (2017) noted that an effective VR simulation exposes a student to life-like situations in the virtual environment and provides real-time feedback on decisions, actions and questions to assist the student to learn and successfully retain information and skills acquired from that environment. Subsequently, this leads to a transfer of knowledge and skills to the real-world (Issenberg *et al*., 1999; Pulijala *et al.*, 2017).

Tendick, Downes, Cavusoglu, Gantert and Way (1998) developed a laparoscopic camera and cholecystectomy VR simulations that were graphics-driven to provide real-time feedback. Studies that investigated the use of these simulators concluded that there were several differences (including surgical techniques and levels of comprehension) between experienced and novice surgeons because experienced surgeons were familiar and accustomed to the surgical process (hands-on experience), unlike inexperienced surgeons who simply had theoretical exposure to the process. These studies reported improvement in students' competency because of the VR training over time (Westwood, Hoffman, Stredney and Weghorst, 1998; Weghorst, Airola and Oppenheimer, 1998; Gorman, Lieser and Murray, 1999; Lopreiato and Sawyer, 2015; Smith *et al.*, 2015; Tun *et al*., 2015; Baby *et al.*, 2016; Vaughan *et al.*, 2016; Kothari *et al.*, 2017; Pulijala *et al.*, 2017; Al Kuwari, 2018; Casso *et al.*, 2019; Kodikara *et al.*, 2019).

Hamza-Lup, Bogdan, Popovici and Costea (2019) observed that several companies in the United States of America (USA) have developed integrated systems that have defined training simulations. One example, LAP Mentor, is a laparoscopy VR simulator that enables concurrent practice for one student or a group of students. The VR system allows residents and/or surgeons to improve their laparoscopic skills and knowledge by practicing laparoscopic surgical procedures. Another USA developed system, Virtual Endoscopic Surgery Training System One (VSOne), gives feedback using three haptic devices (for example, joysticks, mice, motion-sensing gloves, stylus, or a fingertip cover) and a virtual endoscopic camera. VSOne's components provide an optimally simulated learning environment similar to a real-life situation. It contains two built-in application modes, that is, VSOne Cho and VSOne Gyn. VSOne Cho mode is used for laparoscopic cholecystectomy training while VSOne Gyn mode is used for laparoscopic gynaecological procedures (Hamza-Lup *et al.*, 2019). Hamza-Lup *et al*. (2019) stated that the benefits of using the VSOne system include a reduction in the time and cost of training.

Hamza-Lup, Rolland and Hughes (2018) argued that VR can be used to safely train medical professionals (doctors, residents, nurses, and paramedics) on cardiopulmonary resuscitation (CPR). Similarly, Semeraro *et al*. (2019) noted that a VR environment was being used for CPR training in the USA to create a comprehensive learning platform for basic life support and automated external defibrillation training. The VR-CPR system uses a VR headset and a tracking system allowing the user to interact with the environment using motion-sensing VR equipment (Semeraro *et al.*, 2019). In the VR environment, a patient suffering from cardiac arrest is virtually replicated with a high graphical realism imitating critical, real-life clinical signs and reactions. During a cardiac arrest situation, a user (for example, a resident, doctor or nurse) is able to check the patient's condition to begin the resuscitation process. The tracking system accurately estimates the virtual patient's chest compression quality (CPR parameters) to measure correct chest compression rate (CCR) and depth (CCD) compared to a standard physical mannequin used for training (Semeraro *et al*., 2019).

Bing *et al*. (2019) conducted a study in Zambia using VR to train residents to enable them to acquire the cognitive skills, sensory alertness and knowledge needed to perform a radical abdominal hysterectomy (RAH) (a surgical procedure for the treatment of early-stage cervical cancer). The study was conducted with ten surgical trainees who were randomly assigned to either VR training or standard training. The findings showed that the residents who were assigned to VR training made fewer errors, performed the procedure faster, and required approximately half the time to reach an intermediate skill level of a skilled surgeon when compared to residents assigned to standard training. The authors concluded that the acquisition of knowledge and skills from VR training could result in a transfer of knowledge and skills to the real-world (Bing *et al.*, 2019).

2.4. The use of VR simulations for emergency situations

Simulation-based training is also utilised to train emergency medical (EM) personnel. This type of training allows the EM personnel to gain exposure to disaster situations. The exposure prepares EM personnel to deal with both physical and emotional stresses (Andreatta *et al.*, 2010). Freeman *et al*. (2001) conducted a study on the training of EM personnel using a VR laboratory built around the Simple Triage and Rapid Treatment (START) program. The authors concluded that students acquired, improved and maintained skills over time as a result of using a replicated VR emergency environment (Freeman *et al*., 2001). Lopreiato and Sawyer (2015) stated that VR-enabled medical tasks can be created on-demand to allow for skills to be acquired from the continuous practice of the tasks in the VR emergency environment. Doing so may result in an increase in students' information retention and performance accuracy. Roy, Sticha, Kraus and Olsen (2006) also found that educational VR programs developed for training students on bioterrorism showed improved learning retention and performance accuracy. Similarly, Hu, Shao, Ye and Jin (2019) noted that VR enhances the ability to learn through experience. However, Roy *et al.* (2006) pointed out that although VR simulations enhanced learning of medical procedures, they were expensive to adopt on a wide scale and, therefore, could only be used to train a relatively small number of students.

2.5. The use of VR for patients' rehabilitation

VR is used for therapeutic and rehabilitation purposes (Weiss and Jessel, 1998; Glanz, Rizzo and Graap, 2003; Zimand *et al*., 2002; Rizzo, Schultheis, Kerns and Mateer, 2004; Fridhi *et al.*, 2018). VR offers the capability of customising treatment for effective therapy (Zimand *et al*., 2002). In this regard, VR-enabled interventions can be designed to meet the patients' needs. Sveistrup *et al.* (2003) noted that some VR systems assist with rehabilitation by allowing the user (patient or therapist) to interact with the virtual environment in real-time to gain feedback. This helps the user to learn how to employ treatments effectively for successful rehabilitation (Sveistrup *et al.*, 2003). Similarly, Gambhir, Narkeesh and Arumozhi (2017) stated that VR-based interventions that incorporate real-time graphics and imaging technology, allow patients to experience various visual and auditory stimuli in the virtual environment suited to their rehabilitative needs. The visual and auditory stimuli allow patients to learn.

Sohlberg and Mateer (2001) emphasised that real-time feedback is an essential component for most forms of learning or skill acquisition within the context of patients' rehabilitation. VR simulators allow students to interact with the virtual patient, and to administer therapy to the patient as they would in the real environment (Lopreiato and Sawyer, 2015). The Emergency Care Simulator (ECS), GestureTek, Human Patient Simulator (HPS), MedSim Patient, and the PaediaSim are examples of commercially available VR systems used for rehabilitation purposes (Glegg, Tatla and Holsti1, 2014; Seretse *et al.*, 2018).

2.5.1. Applications of VR for therapeutic treatment and rehabilitation

Dr Brennan Spiegel, a pioneer of VR in the healthcare sector in the USA, experienced the positive impact of using VR for therapeutic treatment (Tashjian *et al*., 2017). Dr Spiegel investigated how technologies like smartphone applications, VR, wearable biosensors, and social media can improve health outcomes. His team was successful in using VR to help patients reduce high blood pressure

(Tashjian *et al*., 2017). Dr Spiegel tailored the VR environment to educate patients on the effects of consuming food containing high levels of salt by showing them images of the food. Subsequently, the VR environment immersed the patients in the human body to show and educate them on the impact of higher salt intake (Tashjian *et al*., 2017).

Dascal *et al*. (2017) detailed that using VR for treating patients could lead to a decrease in patients use of pain relievers such as morphine. This was because the VR environment when compared to the pre-VR-enabled treatment, can help patients focus less on the pain they are experiencing thereby reducing the amount of morphine intake required for pain relief (Dascal *et al*., 2017). Dascal *et al*. (2017) further elaborated that using VR for therapy gives patients the motivation to get better by showing them life outside the hospital which, in turn, motivates them to continue with therapy so that they may return home sooner. In a similar vein, Burdea (2002) stated that using VR for therapy enhances patients' rehabilitation experience.

Kizony, Katz and Weiss (2003) conducted a study on two individuals with different conditions who used the same VR system for rehabilitation. Both respondents had issues with mobility. The first individual had a spinal cord injury requiring the use of a wheelchair while the second had a right hemispheric stroke and walked with a cane due to poor control of foot movement and poor standing balance (Kizony *et al*., 2003). The authors discovered that as sessions with the VR system progressed, both individuals began to maintain body balance much longer and they reported enjoying using the VR environment which motivated them to continue the therapy (Kizony *et al*., 2003). Similarly, Burdea (2002) stated that one of the advantages of using VR for rehabilitation and therapy is the increase in patient motivation to persist with the therapy.

However, due to their complexity VR systems are very expensive, specifically because of the purchasing, operational and maintenance costs and, therefore, often located in specialist or private medical facilities (Maran and Glavin, 2003). In contrast, Parsons and Rizzo (2008) observed that VR systems have become increasingly available, less costly and user friendly when compared to their initial adoption. Similarly, Elliman, Loizou and Loizides (2016) noted that the Google Cardboard VR device is cost-effective and has limited hardware restrictions, thus making it easier for students and other users to access healthcare training without having to commit to formal training at a brick and mortar institution. Cost-effective devices and systems are making the adoption of VR for medical training a possibility (Elliman *et al*., 2016).

2.6. The use of VR to treat medical conditions

Although the use of VR to treat medical illnesses is not part of the scope of this study, it is worth presenting the literature pertaining to this type of use. Doing so stems from the fact that medical students need to be aware of the various ways in which they can assist their patients, not only to recover from an illness but also to lead healthy lifestyles post-hospitalisation. Patients are also required to learn and retain knowledge. In addition, medical professionals such as doctors and surgeons would also undergo medical training and they too would want to know the benefits that VR could provide to their patients. Hence, the following section depicts the benefits of using VR with patients

2.6.1. The use of VR to treat patients with cerebral palsy

According to Witmer and Singer (1998) a VR system, VIVIDGX, was used to provide leisure opportunities to adults with cerebral palsy and severe intellectual disabilities. The respondents were unable to speak and used wheelchairs for mobility (Witmer and Singer, 1998). It was found that the respondents' demonstrated enthusiasm during the VR experiences by reacting with appropriate, goal-oriented responses to assist with mobility (Witmer and Singer, 1998). In this case, VR provided simulated exercises that helped patients with cerebral palsy to stretch and strengthen their leg muscles to alleviate pain. However, Weiss, Bialik and Kizony (2003) in a study which also used the VIVIDGX VR system, found that a small number of the respondents with cerebral palsy displayed involuntary movement synergies, increased reflexes and non-adaptive postures, which were attributed to the level of task difficulty in the VR environment. The complexity of the VR environment hindered patients' ability to learn and practice how to walk after surgery (Weiss *et al*., 2003; Fuertes Muñoz, Mollineda, Gallardo Casero, and Pla, 2019).

2.6.2. The use of VR to treat patients with orthopaedic illness

Yano, Kasai, Saitou and Iwata (2003) stated that a motion interface, GaitMaster2 (GM2), was developed to provide the user with the sense of forward movement even though his or her actual position was constant in the physical environment. The GM2 was tested with two individuals with semi-paraplegia (Yano *et al*., 2003). The results showed that the respondents displayed moderate improvements in walking speed, improvements in leg muscle activity, and increased body symmetry and balance. Similarly, Fung *et al.* (2004) and Kimel-Naor, Gottlieb, and Plotnik (2017) stated that the results from two experimental VR sessions with a patient who suffered from complete paraplegia showed that the respondent demonstrated improvements in self-confidence, higher levels of optimism and motivation as well as increased relaxation. The patient also showed further improvements in mobility (Fung *et al.*, 2004; Kimel-Naor *et al.*, 2017).

2.6.3. The use of VR to treat stroke patients

Piron, Cenni, Tonin and Dam (2001) used VR to assess progress towards functional movements of a group of 20 post-stroke patients undergoing rehabilitation. The respondents were required to move an envelope equipped with a magnetic receiver to a virtual mailbox. The authors found that the respondents showed improvement in velocity and upper body voluntary movements (Piron *et al*., 2001). Holden and Dyar (2002) conducted a study on eight chronic post-stroke patients with a VR training system embedded with pre-recorded movements of the upper body region and a virtual teacher. The results showed that the respondents demonstrated improvements in the upper body region functioning including upper body strength (Holden and Dyar, 2002). Boian *et al*. (2002) described how a VR system equipped with a VR glove was used to rehabilitate four post-stroke patients in the chronic phase of the illness. Each of the patients had to perform a variety of VR exercises (regarding motion, speed, and strength) to reduce damages in their fingers. The results showed that three of the four respondents had an increase in their thumb movement and finger speed. The respondents also displayed a consistent increase in finger strength up to a month after the VR therapy sessions were completed (Boian *et al.,* 2002).

Similarly, Holden, Dyar, Schwamm and Bizzi (2005) described how a VR laboratory conducted with stroke patients demonstrated positive results for restoring the speed and strength of hand movement. Patients' demonstrated complete use of their hands for simple daily activities after the therapy was completed (Holden *et al*., 2005). This indicated a transfer of learning from VR environments to real-life situations (Jack *et al*., 2001). Similarly, Brooks *et al*. (1999) reported success in treating a stroke patient using an error-free VR training approach for rehabilitation that produced a positive transfer of learning to the real-world. However, Harrison, Derwent, Enticknap, Rose and Attree (2002) reported mixed results regarding learning retention associated with the use of stimuli in a VR system designed to train mobility and route finding for motorised wheelchair users. This was because the virtual stimuli were reported to be difficult to understand and prolonged sessions were required to become accustomed to them.

Burdea (2002) pointed out that VR systems were not designed as medical equipment and some therapists, therefore, found it difficult to use them. Burdea (2002) further pointed out that some VR equipment posed usability constraints and could not accommodate all the patient's needs. Patients that underwent hand surgery or suffered a stroke, for example, had difficulty wearing VR motion-sensing gloves that were designed for people who had not undergone surgery. The feedback equipment that was mandatorily worn by patients who were treated using VR, can cause usability constraints by decreasing the naturalness of the VR interaction in the virtual environment (Burdea, 2002). According to Elliman *et al*. (2016), the possibility of adopting VR for medical training would be greater if VR systems that are used for training medical students and healthcare professionals incorporated medical information such as symptoms of diseases or physical behaviour of patients suffering from certain conditions and diseases. This would enable students to gain additional knowledge from the virtual environment.

2.6.4. The use of VR to treat patients with cancer

Zeng, Zhang, Cheng, Cheng and Wefel (2019) conducted a meta-analysis of six cancer-related studies. Participants from all six studies were adult cancer patients or survivors. The studies focused on VR interventions that included both immersive and non-immersive aspects and the duration of the therapeutic interventions differed from 30 minutes to four months. All the studies examined the effects of VR-based interventions on health-related outcomes, including anxiety, depression, fatigue, pain reduction, cognitive function, and physical fitness after radiotherapy or chemotherapy. The findings showed that VR-based interventions improved patients' emotional, cognitive and physical well-being. There was also improvement in cancer-related symptoms of fatigue. The findings also showed that other cancer-related symptom management issues such as anxiety, depression, pain and cognitive dysfunction improved through the use of VR-based interventions.

However, because of the small sample sizes of the studies that were used for the meta-analysis, there were no statistically significant differences (Zeng *et al*., 2019). Kim, Chun, Kim and Park (2011) noted that when compared with traditional symptom-management interventions in cancer treatment, VR-based interventions such as VR-based cognitive training can allow cancer patients to learn how to cope with their cancer-related symptoms. VR-based interventions offer real-time feedback on patient performance. Treatment can be adjusted to the difficulty level to suit patient needs. Similarly, Gambhir, Narkeesh and Arumozhi (2017) stated that VR-based interventions incorporate real-time graphics and imaging technology, thus allowing patients to experience various visual and auditory stimuli in the virtual environment suited to their rehabilitative needs. The visual and auditory stimuli allow patients to learn how to cope with their cancer-related symptoms.

2.6.5. The use of VR for pre-operative planning

Yule, Flin, Paterson-Brown and Maran (2006) stressed that pre-operative planning is important to ensure that medical professionals are prepared for surgical operations. Hu *et al.* (2019) noted that pre-operative planning is a difficult task which requires knowledge and rational thinking to decrease complications during surgery. Pre-operative planning entails the surgical team discussing their respective duties prior to entering the OR (Yule *et al*., 2006). Yule *et al*. (2006) further noted that several ORs rooms utilise a surgical safety checklist of questions for each team member to answer before a procedure begins. In this way, each team member is aware of and is prepared for, his or her role in the team. The goal of the checklist is to avoid errors and to improve patient safety during surgery. However, training students on this aspect of surgery, called the surgical time-out, can be difficult. VR could, therefore, be utilised to ensure that students are fully aware of their responsibilities as a team prior to the operation without the use of a checklist. VR could be used in this regard as a valuable, standardised method of improving communication amongst medical team members and patient safety (Yule *et al*., 2006).

Similarly, Rabkin (2002) discussed how a VR simulator can assist students to develop medical skills including communication skills prior to interacting with a real-life patient. Hu *et al.* (2019) emphasised that communication between doctors and patients is vital. The authors pointed out that in most medical situations there is a lack of communication between patients and doctors because patients and their families lack the understanding of medical jargon and hence lack understanding of the medical procedures (Hu *et al*., 2019). VR can, therefore, promote communication between those with insight and knowledge (doctors) and those seeking understanding (patients and their families). Patients and their families will have more understanding of the operation process if medical professionals use VR to simulate the operation during the pre-operative conversation phases with the patient (Hu *et al*., 2019). Moline (1995) noted that VR could be used to enhance the way medical professionals (for example, surgeons, therapists and residents) plan for medical procedures before a surgical operation. Similarly, Hu *et al*. (2019) stated that surgeons or residents training to be surgeons can utilise VR pre-operative patient simulations to determine the optimal surgical procedural method. The authors suggested that pre-operative surgical planning using VR provides more realistic predictions for surgical results (Hu *et al*., 2019).

2.7. The use of VR to treat phobias

Wiederhold *et al*. (2002) stated that VR is used to assist patients with severe phobias or post-traumatic stress disorder (PTSD) symptoms. Similarly, other authors have noted that VR can be used as a part of therapeutic treatment to deal with phobias by exposing patients to graphic simulations of their fears or phobias such as fear of heights, fear of flying in aeroplanes, fear of public speaking, as well as chronic PTSD (Burdea, 2002; Hoffman, 2004). Burdea (2002) found that the prolonged use of VR therapy to treat Vietnam War veterans led to a reduction in PTSD symptoms. Similarly, Hoffman (2004) found that some patients showed a significant and stable reduction in their PTSD symptoms and depression after continuous treatments using VR simulations. Beck, Palyo, Winer, Schwagler and Ang (2007) conducted a study on treating PTSD symptoms after a road accident using VR. The results showed that a majority of the respondents demonstrated a reduction in their PTSD symptoms over a ten-week period.

Similarly, McLay *et al*. (2011) in their study on patients suffering from PTSD, found that the patients showed clinical improvement, that is, a reduction in the severity of their PTSD symptoms after several weeks of treatment using VR. However, Beck *et al.* (2007) established that although most patients showed a reduction in their PTSD symptoms, there were some who did not manifest any change before and after the VR-enabled treatment sessions. The authors indicated that the VR environment must improve the learning process by motivating users (trainers, therapists, and patients) to utilise it (Beck *et al.*, 2007; Maples-Keller, Yasinski, Manjin, and Rothbaum, 2017). In addition, the benefits derived from using a VR environment must outweigh the cost of purchasing or developing a VR system to ensure the wide-scale utilisation of VR for treatment and therapy. Krijn, Emmelkamp, Olafsson and Biemond (2004) stated that VR environments should be immersive. Patients need to feel a sense of presence in the virtual environment to enhance their therapeutic treatment experience. The term 'presence' is theorised as the belief that the virtual environment is real (Krijn *et al*., 2004). Beck *et al*. (2007) and Maples-Keller *et al.* (2017) stated that 'presence' in the virtual environment may be defined as objects, events, entities, and environments within VR that makes the virtual experience 'real'.

2.8. The use of VR by patients and healthcare providers

As mentioned above, some medical procedures are complex and although medical professionals can explain the procedure to patients, patients often find it difficult to understand the procedures they undergo. Hence, by using VR medical professionals would be able to better explain medical procedures to their patients. Patients who find it difficult to understand the technical aspects of a medical procedure will, therefore, use VR to assist them in understanding these technical terminologies (Johnson, Liszewski and McGuffin, 2018). Additionally, healthcare providers such as hospitals (private and public) and other healthcare facilities (for example, clinics) could utilise VR to train their staff and assist their patients in understanding complex medical procedures (Aziz, 2018).

2.8.1. The use of VR to teach patients

Bickmore, Pfeifer and Jack (2009) and Haldar, Mishra, Khelifi, Pollack, and Pratt (2019) stated that some patients find post-hospital discharge difficult because they are bombarded with too much information about check-up dates, medicine times and periods of use, and over the counter medicine purchases. The discharge process is even more complex for patients who have difficulty reading and following basic written medical instructions (also known as inadequate health literacy) especially those coming from rural areas to seek treatment in urban hospitals (Bickmore *et al*., 2009; Haldar *et al.*, 2019). A medical research team at Boston Medical Centre developed an automated VR system that teaches patients about their post-discharge schedule while they are still in their hospital beds. The VR system comprises an animated virtual nurse (VN) which represents best practices in health communication for patients with inadequate health literacy. The VN is set up on a mobile kiosk with a touch screen display (an Internet of things (IoT) device) that can be positioned in front of patients while they are in bed.

The VN spends approximately thirty minutes with each patient, reviewing the layout and contents of a patient-specific after hospital care plan booklet that is given to them and which contains their medical information. The paper booklet is given to patients before their conversation with the VN, and the VN reviews a digital version of the booklet in the interface so that patients can follow along with the agent's explanation in their paper booklets (Bickmore *et al*., 2009; Zhang and Bickmore, 2018). Johnson *et al*. (2018) conducted a study on the use of VR for the education of patients who had limited knowledge of radiotherapy treatment procedures. The authors noted that patient education for radiation therapy was traditionally delivered by verbal or written methods and that these traditional educational methods did not provide a thorough understanding of the technical aspects of the radiotherapy treatment. The study found that when compared to traditional educational methods**,** using VR improved existing teaching methods, increased understanding of the radiotherapy treatment and decreased the anxiety that patients were experiencing (Johnson *et al*., 2018).

2.8.2. The remote use of VR by healthcare providers

Rodrigues *et al*. (2018) noted that in developed countries such as the USA and the United Kingdom (UK), remote health monitoring technologies are adopted by doctors for patient home care and hospital environments. These technologies remotely monitor the nurse responsible for communicating in real-time with patients or parents/close family members of the patient thereby decreasing the doctor's time spent on a patient. This enables doctors to treat more patients, a decrease in hospital costs and an improvement in the quality of healthcare. Similarly, Hussein, Burbano-Fernandez, Ramírez-González, Abdulhay and De Albuquerque (2018) stated that in the USA, cloud-based virtual medical systems are used for monitoring patients suffering from chronic illnesses (for example, cardiovascular disease and cardiopulmonary disease) and living in rural areas where they cannot seek prompt medical services. Remote healthcare monitoring is performed by systems that obtain medical data from the patient needing remote assistance. These VR system applications include a user interface (smartphones, tablets, and computers), a data collector (biosensors), and Internet connectivity. VR systems are generally integrated with the IoT, mobile computing and cloud storage (Aziz, 2018).

Aziz (2018) stated that EcoHealth is a middleware IoT-platform that connects patients, healthcare providers, and devices. It is a web-based platform that allows for data management and aims to simplify and standardise IoT application development, addressing issues like interoperability between different devices. U-Healthcare is another healthcare system that collects medical data, processes it, and stores it in the cloud for remote access (Aziz, 2018). However, Hussein *et al*. (2018) argued that storage and transfer of medical data (for example, acquired vital sign data, biomedical videos, or images) between doctors can subsequently lead to several concerns related to the patient's privacy.

Remote surgery can be done effectively even though the surgeon is not in close proximity to the patient. The simulated medical procedure in the virtual environment is transmitted to a robotic instrument that mimics the surgeon's actions (Aziz, 2018). Surgeons can execute non-invasive remote surgery, surgical pre-operative planning, surgical preparation and practice, image-guided surgery and surgery simulation using a virtual surgery console. VR surgical simulation was developed to conduct minimally invasive surgery (MIS) which encompasses carrying out operations through minimal incisions with the surgeon controlling robotic arms (Aziz, 2018).

Currently, VR systems can run on personal computers (for example, U-Healthcare) thus reducing their implementation cost. Hence, based on the above studies, the researcher believes that VR can be used by healthcare providers (public and private healthcare facilities) to remotely assist their patients, train staff and improve the quality of healthcare while also reducing costs associated with travelling to patients residing in rural areas.

2.9. Use of the IoT in conjunction with VR in the medical industry

Cecil, Gupta, Pirela-Cruz and Ramanathan (2017) observed that there is growing interest in discovering IoT devices that can be used in healthcare. The IoT is an evolving area and can be described as a network-based approach that supports interaction and data exchange between sensors (also known as things) embedded in physical devices linked through the Internet (Cecil *et al*., 2017). These 'things' collaborate with other physical devices through the use of cyberinfrastructure (Cecil *et al.*, 2017; Istepanian, Hu, Philip and Sungoor, 2011; Jia, Wang, Guo, Gu and Xiang, 2017; Long and Hoang, 2017; Santamaria, Serianni, Raimondo and De, 2016; Seymour *et al*., 2002; Xu *et al*., 2014). In healthcare, the IoT is termed the Internet of medical things (IoMT). The IoMT can be used in remote medical supervision of chronic patients resulting in improved healthcare for patients in rural areas (Cecil, Xavier-Cecil and Gupta, 2017; Jia *et al*., 2017). The IoMT includes designing a robotic device to provide mobility rehabilitation for the elderly (Long and Hoang, 2017) and developing a system to collect, integrate and access patient information to support medical emergencies (Xu *et al*., 2014).

Rodrigues *et al*. (2018) stated that the IoMT is a network architecture that allows the connection between a patient and healthcare facilities, for example, electronic health systems for electrocardiography (commonly known as ECG which is a non-invasive method to record electrical activity in the heart using electrodes placed on the skin), heart rate, electroencephalography (commonly known as EEG which is a non-invasive monitoring method to record electrical activity in the brain), diabetes and several other medical monitoring systems based on biomedical sensors including pulse rate, blood oxygen levels, body temperature, blood glucose levels and blood pressure. The IoMT is accessible through the use of computers, smartphones and smartwatches. Similarly, Hussein *et al*. (2018) stated that wearable wireless biological sensors that are attached to a patient's body (using elastic straps, skin electrodes or smart fabrics) are used by patients for cost-effective, real-time, cloud-based monitoring. Similarly, Imani *et al*. (2016) observed that these wearable wireless sensors provide reliable, fast and high-quality medical services, which are continually available. This is beneficial to patients residing in rural areas and who require medical services urgently.

Haleem, Javaid and Khan (2019) noted that the IoMT is currently used in the USA for training orthopaedic surgeons and has a significant impact on medical education and clinical outcomes. The authors found that implementing IoMT resulted in a significant improvement in medical education, training and performing orthopaedic surgery. The IoMT will support the "management of all orthopaedic tools, instruments, implants and devices for proper and efficient running" (Haleem *et al*., 2019, p. 7). Hu *et al*. (2019) conducted a study of a VR system combined with an advanced tracking system which was used to display a patient's anatomy and surgical plans within the operating theatre in real-time. A surgeon using a VR head-mounted display could see a 3D model of the patient's liver or heart structure above the incision site (the intended area to 'cut' during surgery), thereby improving the surgeon's action and view of the area for operation. Results from the study indicated that using VR with tracking systems shortened operation times and improved efficiency (Hu *et al*., 2019).

Zhang, Park and Biyi (2019) stated that in the USA, VR and motion-sensing devices are being used for immersive and interactive training and physical exercise. Some VR systems capture user movements to inform sensory stimuli displayed to the user via the head-mounted display (HMD) to create an illusion of being immersed in the VR environment, therefore, resulting in user interaction with the virtual environment. Information about user movements can be captured using an IoMT sensor attached to or integrated into VR motion sensing devices that are used by the user (Zhang *et al*., 2019). An HMD device comprises a processor linked to a storage memory containing instructions which, when executed by the processor, causes the processor to analyse captured user movements to create an analysis of user movement information and to create a VR environment in which the analysed information is displayed (Zhang *et al*., 2019).

2.10. Implementation of the IoT in South Africa (non-VR related)

Although this section does not relate to the adoption of VR at a South African educational institution, it was included to enrich the study and to show the attempts made by the South African government to deliver eHealth systems to South African citizens.

Mehl, Tamrat, Bhardwaj, Blaschke and Labrique (2018) stated that MomConnect is a rare example in South Africa of a nationally scaled and government-supported electronic health initiative. Some of the core system functionalities of MomConnect include registration of pregnant women, targeted communication (based on pregnancy stages) and an interactive help desk for pregnant women to provide feedback on the quality of services received or to try to find additional information and/or support. The targeted communication encourages pregnant women to visit healthcare facilities for regular check-ups and, post-delivery, to attend to critical new-born care, for example, infant feeding, immunisations and hygiene (Mehl *et al*., 2018).

Although MomConnect is not a virtual system, the South African government was able to invest in the technological initiative by analysing the South African market, for example, MomConnect enrolment is dependent on access to a mobile phone, of which 89 percent of South Africans are estimated to have (Mehl *et al*., 2018). Consideration was given to how the national investment in MomConnect could be leveraged in a gradual manner as an initial investment towards an interoperable national health information system. MomConnect consists of a technical architecture that includes a master patient index (Open Enterprise Patient Index), a medical record system (OpenMRS), a master facility index and a health management information system (District Health Information System 2), along with an interoperability layer for exchanging data between the various systems (Mehl *et al*., 2018).

Additionally, MomConnect shifted an existing paradigm of targeting messages to a group of people with only knowledge of their phone number, to one where clients were formally registered by health workers, allowing both remote and in-person services to be delivered to them. System interoperability allows MomConnect to serve as a component of a health service package that combines both digital and face-to-face services (Mehl *et al*., 2018). Mehl *et al*. (2018) noted that the extensive investment in digital health architecture prior to deploying MomConnect laid the foundation for future capabilities such as VR.

2.11. Integration of artificial intelligence with VR in the medical industry

Artificial intelligence (AI) and machine learning technologies (for example, robotics) contribute significantly to various areas of healthcare such as remote surgery and VR (Zhang *et al.*, 2019). Yu *et al*. (2019) noted that the combination of VR and AI can enhance healthcare training. An AI system can record the number and analyse the behaviours of students after virtual learning. Subsequent to the analysis, the AI system can provide additional corresponding training for the students to ensure teaching and training effectiveness. Before the next training session, the AI system can provide each student with a review of their training to identify their weaknesses. Educators can also obtain a report containing analyses of student training data and statistics (Yu *et al*., 2019). With regard to surgery, Aziz (2018) noted that surgeons use a virtual surgery console which provides real-time feedback during surgery. The use of VR surgical simulation and AI-based real-time feedback was developed to conduct minimally invasive surgery (MIS) with the surgeon controlling robotic arms to operate on the patient (Aziz, 2018).

Rosenthal, Das, Hsueh, Barker, and Chen (2020) pointed out that the IBM Watson Care Manager system is a USA-based AI cloud-based healthcare management solution which assists healthcare facilities to focus on healthcare for individuals. Healthcare teams (dedicated healthcare managers to check on home-based patients, nurses and on-call doctors) from the healthcare facilities (clinics and hospitals) capture and evaluate structured and unstructured medical information, select specific medical programs tailored to a patient's needs, and create healthcare plans based on the medical program a patient is undergoing (Rosenthal *et al*., 2020). The IBM Watson Care Manager system enhances data management, improves drug identification methods, and allows medical professionals (doctors, nurses and surgeons) to view the patient's medical information in real-time (Zhang *et al*., 2019).

However, Strickland (2019) argued that the IBM Watson Care Manager system is not entirely successful because although the development of the system was to optimise post-hospital treatments, curb doctor shortages, assist medical professionals to do their jobs and, therefore, improve healthcare, it rather seemed to replace doctors (Strickland, 2019). IBM Watson is also used for cancer treatment, where the system is completely AI-driven and is able to 'make decisions' based on a summary of patients' medical records accessed via searches through patient databases to provide treatment recommendations. Strickland (2019) believed that IBM Watson faces a major hurdle between the way machines learn (machine learning for AI) and the way real-life medical professionals work.

Greci *et al*. (2013) in their pilot study adopted a virtual training system combined with AI, called Play2Train Virtual Hospital. It had an emergency section with a patient waiting area, virtual medical rooms, for example, an operation theatre and staff room, and a playing field and parking bays with emergency areas. The emergency areas outside the hospital were used to stabilise critical patients if it would take the nurse too long to take the patient into the hospital for treatment. Additionally, the virtual environment contained a video conference and meeting rooms with virtual video screens displaying multimedia content (videos and slides) to educate students. Students were given gaming laptops with high-quality graphics and accompanying video processors (Greci *et al*. 2013). Microphone headsets were used to allow for voice communication. Students had Internet access through the University of California's gigabit ethernet local area network.

Students created avatars to match their roles, for example, nurses, doctors and a training facilitator. The authors stated that 30 robots were developed and programmed to simulate a patient requiring medical assistance. However, in the context of the study, these robots comprised weak AI because each stored a pre-recorded audio (approximately two sentences of symptoms and/or complaints), pop-up vital signs (through text), and the ability to put on a respiratory mask. Each patient's audio recording, pop-up vital signs and mask could be activated by a student avatar through touching an allocated tag on the patient's body or face (Greci *et al*., 2013). During the virtual training, students had to identify the medical issue by promptly examining the patient and thereafter transporting the patient to the appropriate treatment areas either in the hospital (for example, in the treatment rooms) or outside the hospital (at the emergency stabilisation areas in the parking bay area or playing field). Additionally, the students had to plan the allocation of treatment areas for patients based on the infection control practices of the USA (for example, respiratory isolation for patients displaying influenza symptoms) (Greci *et al*., 2013).

The findings of the study showed that students displayed improved medical emergency knowledge because the AI-VR system allowed them to repeatedly practice medical examination and decision-making in a controlled environment. Furthermore, students were able to see the outcomes of their decisions in real-time and were able to experience a life-like emergency environment to prepare them for the real-world (Greci *et al*., 2013). Lu, Li, Chen, Kim and Serikawa (2018) stated that AI will be used in augmented reality for future remote electronic health monitoring. They further indicated that many companies (for example, Amazon, Apple, Artificial Solutions, Assist AI, Creative Virtual, Google, IBM, IPsoft, Microsoft and Satisfi) are investing in AI because it is a growing trend globally (Lu *et al*., 2018).

2.12. The efficacy of VR in medical training

Medical professionals need a thorough understanding of the human body hence the use of 3D training methods. Adams, Shinn, Morrel, Noble and Bodenheimer (2019) asked experts to discuss the use of VR systems in terms of usefulness and potential for medical developments. One expert stated that the progression of a comprehensive understanding of the human body to prepare future doctors or medical practitioners to interact with real-life patients is vital in medical education (Adams *et al*., 2019). Furthermore, anatomy of the middle and inner ear presents a challenge for medical and surgical training because it is difficult to only focus on one part of the ear (outer, middle or inner) disregarding the other parts of the ear. However, with 3D technologies such as virtual reality it is possible to train medical professionals on one part of the ear (Adams *et al*., 2019, p.10).

The most commonly used visualization tools for learning complex 3D medical relationships rely on 2D illustrations. However, when 2D illustrations are used to represent 3D structures, there is a risk of information loss and important interactions between anatomical structures may be absent (Adams *et al*., 2019). Immersive virtual environments may provide a more effective method for promoting a student's understanding of 3D anatomy. Semi-immersive and fully immersive virtual displays were used to develop learning and visualization training programs for the anatomy of the heart, breast and abdomen (Adams *et al.*, 2019). Research on educational anatomical simulations for the ear also exists. Adams *et al.* (2019) noted that VR is suited for the medical curriculum because of its ability to allow students to practice medical procedures repeatedly. Similarly, Yu *et al.* (2019) pointed out that a VR training simulator for laparoscopic surgery (MIST-VR) can assist surgeons in improving efficacy and lessening errors in the OR by repeatedly practising surgical procedures.

VR allows users to experience an immersive medical environment. Yu *et al.* (2019) explained that the virtual environment for radiotherapy training (VERT) system at the University of Sydney was successfully implemented as an add on to traditional lessons. The system offered students the chance to gain knowledge and improve skills in an interactive, risk-free radiation therapy environment. Based on the students' feedback, the VERT system was considered a useful learning and training tool. The system was found to provide a more relaxed environment and helped students to have a thorough understanding of complex medical illnesses (Yu *et al*., 2019).

2.13. Challenges to the adoption of VR for medical training

According to Seretse *et al.* (2018), developed countries have invested heavily in ICT integration in medical education and made it possible for medical students to have access to the latest updates in the medical fields. On the other hand, developing countries are lagging because of several economic, social and infrastructural limitations (Seretse *et al.*, 2018). Additionally, IT knowledge and computer skills among medical undergraduates and medical professionals are higher in developed countries compared to developing countries (Seretse *et al.*, 2018). This is mainly due to infrastructural limitations in developing countries such as the limited availability of computers and Internet connections (Seretse *et al.*, 2018). In Sri Lanka for example, IT-based components are not included in the medical curricula in most medical schools, and experiences with IT-based activities in these medical schools are limited (Ghosh, 2017). It is a similar situation for most developing countries like South Africa and IT-related publications from those countries are limited (Ghosh, 2017).

2.13.1. Reluctance to use VR for medical training

Banszki *et al.* (2018) conducted a study with a virtual patient who displayed antagonistic behaviour towards accepting treatment. Although residents were exposed to patients who displayed difficult behaviour, most of the students felt uncomfortable interacting with the virtual patient and preferred to interact with a real-life patient. Hence, these students were reluctant to use VR to learn about patient behaviour.

A study by Datta-Paulin and Salt (2019) involved nursing employees working in inpatient care in the UK. The authors examined the impact of virtual training on the participants' (the nursing employees) confidence in interacting with patients in difficult situations and the emotional stresses related to training virtually. Findings from the study showed that the participants were reluctant to try new techniques of training such as VR because they preferred the old training techniques (Datta-Paulin and Salt, 2019). Similarly, Mazurek *et al*. (2019) found that older users (senior medical professionals) were more likely to be reluctant to use VR for medical purposes because they were accustomed to traditional training methods.

Fejzic, Seric-Haracic and Mehmedbasic (2019) assessed the role of ICTs including VR in veterinary medical training including the management and training of new recruits in animal health, animal production and food safety. The findings from their study showed that the participants (veterinary professionals) were reluctant to use ICT technologies such as VR for training new recruits and to provide services to customers because they also preferred the traditional methods of executing their duties.

2.13.2. Financing and sustainability of VR

De Rosis and Nuti (2018) described several ramifications in Italy for the sustainable adoption of VR. These included budget constraints for public healthcare facilities and difficulties in justifying the adoption of technologies such as VR without a plausible cost-benefit analysis. In addition, there were challenges related to acquiring additional financial resources to ensure the sustainability of VR-enabled interventions. They noted that there was less emphasis on change management when introducing VR and a lack of long-term VR project planning which hampered the effectiveness of VR interventions (De Rosis and Nuti, 2018). However, to overcome the listed challenges, De Rosis and Nuti (2018) stated that initiatives to finance healthcare interventions (for example, VR) should come from the national government. De Rosis and Nuti (2018) were of the view that to promote sustainable long-term investment in VR, the government needs to integrate policies and scale up current infrastructure by including technological innovation in the healthcare strategy and in its healthcare financing models. Furthermore, there needs to be communication and collaboration between the public and private healthcare sectors when introducing VR initiatives. The difference in interests (that is, public service requirements versus profit) could be resolved if these sectors shared goals, responsibilities and financial risks of the adoption of electronic healthcare technologies such as VR (De Rosis and Nuti, 2018).

Fischer (2018) suggested that VR systems similar to the VR Health Arena be developed and utilised by medical professionals and the general public as a platform to express suggestions and spark debate on maintaining the sustainability of the adoption of VR in the medical industry. The VR Health Arena outlines its vision of healthcare using a virtual environment that mimics an engaging, conversational television (TV) show setting. In the virtual environment, the audience would discuss issues of technology sustainability in healthcare using a competitive gaming approach. The audience would also be able to voice suggestions about maintaining the sustainability of long-term investments in technologies such as VR (Fischer, 2018). Fischer and Heinrichs (2018) assessed the VR Health Arena as part of their study and found that although the VR Health Arena's adoption and implementation would require advanced technologies in terms of the necessary VR equipment, it was an entertaining platform that could be used effectively for public discussions around the sustainability of technology adoption for healthcare.

2.13.3. Infrastructural issues related to the adoption of VR for medical training in developing countries

Buliva (2018) reviewed the adoption of VR for educational purposes from a sub-Saharan African perspective. The review found that there is a lack of technological infrastructure in sub-Saharan Africa that could subsequently result in the inability to sustain the use of VR for education. Similarly, Koçak, Yilmaz, Küçük and Göktaş (2019) noted that the adoption of VR requires infrastructure (for example, software and equipment) which most developing countries do not have. Buliva (2018) also found that in some parts of Africa there is an inadequate supply of electricity. In addition, some African educational institutions are burdened by the cost of hardware required for VR educational systems. There is also inadequate bandwidth to support VR systems and a limited number of trained educational personnel who could teach students to interact with and learn from, VR (Buliva, 2018). Koçak *et al*. (2019) pointed out that VR program development for virtual environments may be complex and time-consuming for users from rural or non-technical backgrounds. The authors added that it is often difficult to maintain VR infrastructure because it is a new technology (Koçak *et al*. 2019).

Buliva (2018) stated that in Africa, national educational policies do not sufficiently address learning via simulation-based educational technologies. Furthermore, educators who are required to teach courses remotely are not sufficiently trained to teach in virtual and technological environments, and some educators often lack adequate knowledge and experience with such technologies. Similarly, Govender and Mars (2018) noted that the lack of skilled educators to facilitate the training of healthcare professionals is an impediment to sustaining VR for healthcare service delivery. A study conducted in the UK on the inclusion of VR for medical training found that it can be used by students residing in rural areas. However, Dhai (2018) noted that due to the lack of infrastructure (including skilled academics) at South African educational institutions, students often have limited or a lack of knowledge relating to the use of, and exposure to VR. Limited exposure to virtual training during the undergraduate curricula contributed to challenges affecting the adoption of the technology (Govender and Mars, 2018).

Buliva (2018) suggested that if VR were to be successfully combined with the curricula of educational institutions in sub-Saharan Africa, national policies would need to be adjusted to accommodate students' use of the technology. Moreover, the cost of VR hardware could be mitigated by deploying it on personal computers (PCs). PCs are available in African countries, and they can process the 3D graphics used in immersive virtual environments (Buliva, 2018). Countries in sub-Saharan Africa can form partnerships with established VR providers in developed countries to learn from them and facilitate the transfer of technology. There is also a need to assist local educators and medical trainers to fully use VR systems (Buliva, 2018). Buliva (2018) noted that cost-effective VR devices could subsequently result in the adoption of VR for educational purposes provided that other factors such as infrastructure and the training of educators are also addressed. Google Cardboard Kit, for example, is a cost-effective solution to mitigate the cost of purchasing VR hardware.

2.13.4. Factors affecting the potential adoption of VR for medical training

i. Age of users

Venkatesh, Morris, Davis and Davis (2003) pointed out that younger generations value technology usefulness more than older generations when deciding on usage intentions. The younger generation (for example, students and/or residents) are often called digital natives and the older generation are often referred to as digital immigrants. Nikou, Brännback and Widén (2019) noted that individuals born in the 1980s are referred to as digital natives because they have grown up with digital technology and have been exposed to digital media since their birth with the Internet being a vital part of their lives. In contrast, people who were born before 1980 are referred to as digital immigrants (for example senior doctors, surgeons and nurses). Apart from age, these two groups of people are different in several ways. An example is digital natives reading content on their device screens (for example, phone or computer), while digital immigrants may print an email attachment instead of reading it on the device screen. Furthermore, digital immigrants may call the email recipient to confirm that an email was received (Nikou *et al*., 2019).

Digital immigrants' skills in using technology are lower than digital natives as they often exert a lower self-efficacy and more technology anxiety than digital natives (Harrison and Rainer Jr, 1992; Ellis and Allaire, 1999; Czaja *et al*., 2006; Chung, Park, Wang, Fulk and McLaughlin, 2010; Nikou *et al*., 2019). Nikou *et al*. (2019) noted that a common perception is that young people have higher competency and capabilities to use technology than older people. Additionally, technology acceptance (Czaja *et al*., 2006; Arning and Ziefle, 2007; Kuerbis, Mulliken, Muench, Moore, and Gardner, 2017) and perceived usability (Ijsselsteijn, Nap, de Kort and Poels, 2007), which are affected by age (Czaja *et al*., 2006; Arning and Ziefle, 2007; Kuerbis *et al*., 2017), play a major part in technology adoption. Older generations emphasise ease of use more when assessing the usefulness of a given system (Arning and Ziefle, 2007; Nikou *et al*., 2019). The process of learning to use and understand new technological systems becomes time-consuming because of the age factor and there is a trade-off between perceived ease of use and perceived usefulness of the system (Melenhorst, Rogers and Caylor, 2001; Nikou *et al*., 2019). However, Chung *et al*. (2010) found that the age factor has no effect on perceptions of ease of use or usefulness of the technologies.

ii. Prior use of a technology

The match between a technology and the user's past experience with it is an important aspect towards continuous use of the technology (Rogers, 1995). Thompson, Higgins and Howell (1994) stated that experience with a specific technology is associated with a greater likelihood to adopt and use the technology. Kim and Malhotra (2005) assessed the effect of past use on users' beliefs and behaviours and found that prior use of a technology positively influences perceived usefulness and perceived ease of use, as well as the behavioural intention to use the technology and actual usage of it. However, Falck, Mang and Woessmann (2018) found that students' exposure to technologies such as computers at school had little to no effect on students' computer literacy. Reed, Oughton, Ayersman, Ervin Jr and Giessler (2002) also found that the number of years of experience with technology does not automatically result in high levels of technological competencies. Similarly, Nikou *et al*. (2019) noted that exposure to technological devices and the number of years of experience using them are not reliable measures for analysing technological competencies. The positive influence of past use on perceived ease of use and behavioural intention has been confirmed by Bajaj and Nidumolu (1998), Dishaw and Strong (1999), Jackson, Chow and Leitch (1997), and Dwivedi, Rana, Jeyaraj, Clement, and Williams (2019) whereas the results regarding the influence of past use on perceived usefulness are inconsistent, with some studies finding a positive effect (Dishaw and Strong, 1999; Dwivedi *et al.*, 2019) and others showing non-significant results (Jackson *et al*., 1997; Kwon and Wen, 2010). The inconsistent results coupled with the paucity of studies that incorporate past use as an antecedent to technology adoption, call for further study into these relationships by examining them in the context of VR hardware acceptance, use and purchase intention.

iii. Purchasing price

The purchasing price of any technology, including VR hardware, plays a significant role in the buyer's decision-making process. Buyers (for example, governments, universities and private hospitals) would assess the value of purchasing a VR system while concurrently considering its price (Zeithaml, 1988; Fornell, 1992; Anderson and Sullivan, 1993; Anderson, Fornell and Lehmann, 1994; Cronin, Brady and Hult, 2000; Yadav and Pathak, 2017; Nikou *et al*., 2019). Price should be one of the main factors for buyers attempting to determine the usefulness, ease of use, and utility prior to purchase (Zeithaml, 1988; Yadav and Pathak, 2017; Nikou *et al*., 2019). Monroe and Petroshius (1981) and Yadav and Pathak (2017) reviewed numerous price-based studies and found that price is most likely to be used as a determining factor for good quality under the following conditions:

1. When the price of a technology is the primary disparity information available.
2. When there are alternative, cost-effective technologies available; and

3. When comparative price variances are fairly large.

These three conditions often emerge in the VR hardware market as the cost of VR hardware ranges from $15 to over $1000 depending on the functionality of the VR system. In previous studies, the purchasing price was not included as one of the factors that may inform VR adoption. However, in the context of the emerging VR hardware market, it is very important to include the aspect of potential adoption (price) as an antecedent to the adoption of VR (Nikou *et al*., 2019).

2.14. An ethical perspective of the adoption of VR for medical training

Several authors have noted that the use of VR for medical training purposes addresses some ethical concerns because students do not need to train using real-life patients (Freina and Ott, 2015; Nickel *et al*., 2015; Ruthenbeck and Reynolds, 2015). Thomsen *et al*. (2017) stated that the use of VR for medical training adheres to ethical practices because students can practice diagnostic and therapeutic interventions at any time without having to wait for a real-life patient to display specific symptoms. However, Alblas, Greyling, and Geldenhuys (2018) referred to the President of the Anatomical Society in South Africa who stated that using a human or animal cadaver helps medical students develop their emotional and interpersonal skills which computer graphics cannot provide. The President elaborated that it is crucial for medical students to learn anatomy 'first-hand' from a human body because experiential knowledge gained from dissecting a human body cannot be substituted by computer programs, systems or by hardcopy books (Alblas *et al.*, 2018, p.15).

Similarly, Lazarus, Sookrajh and Satyapal (2019) found that although technology such as VR for medical training is ethically beneficial, it is simply a tool used to support training and should not replace dissections using human and animal cadavers. Based on the findings from Lazarus *et al*. (2019) and the perspective provided by Alblas *et al.* (2018), the researcher believes that although the use of VR for medical training is ethically beneficial, its use should complement the use of human or animal cadavers instead of substituting them. This, however, defeats the purpose of using VR for medical training from an ethical perspective because utilising VR for medical training should, ultimately, eliminate the need to use human or animal cadavers (instead of complementing their use).

Summary of the literature review

Table 2.1 depicts the various studies that were reviewed in this chapter. As depicted in the table, most research on the adoption of VR in the medical field emanated from the USA, Japan and the UK. Developing countries such as Thailand, Nigeria and Malaysia have also conducted some research on VR for medical training. There is limited literature on the adoption of VR in South Africa. Reviewed literature from the South African perspective (highlighted in bold in Table 2.1) included that of Seretse *et al.* (2018), Mehl *et al*. (2018) and Dhai (2018). Although the above literature review is not exhaustive, it does depict the current paucity of literature that explores the adoption or potential adoption of VR from a South African point of view. Hence, this study aimed to address this gap to a certain extent, by investigating the determinants of and challenges to, the adoption of VR in the context of medical training.

Sources	Context	Country
Al Kuwari (2018), Ahlberg, Heikkinen, Iselius, Leijonmarck, Rutqvist and Arvidsson (2002), Ahmed, Meech and Timoney (1997), Ali, DeMaria, Kaplan, and Mowery (2002), Asano, Yano, and Iwata (1997), Buck (1991), Chaudhry (1999), Chaudhry, Sutton, Wood, Stone and McCloy (1999), **Dhai (2018),** Chopra, Gesink, De Jong, Bovill, Spierdijk, and Brand (1994), Cooper and Taqueti (2004), Freeman *et al*. (2001), Friedrich (2002), Gaba and DeAnda, (1998), Gaba, Howard, Fish, Smith, and Sowb (2001), Gallagher, Richie, and McClure (2001), Gaskin, Owens and Talner (2000), Gordon (1974), Gordon, Ewy and Felner (1980), Gordon, Oriol, and Cooper (2004), Gorman, Lieser and Murray (1999), Gorman, Meier and Krummel (1999), Grantcharov, Kristiansen, Bendix, Bardram, and Rosenberg (2004), Haluck and Krummel (1999), Hamilton *et al*. (2002), Hamilton, Scott,Fleming, Rege, and Laycock (2002), Hoffman *et al.* (2001), Mazziotta *et al*. (2001), Hyltander, Liljegren, Rhodin, and Lonroth (2002), Issenberg *et al*. (1999), Issenberg, McGaghie, and Hart (1999), Pulijala, Ma, and Ayoub (2017), Smith *et al.* (2015)**, Seretse *et al.*** (**2018)**, Maran and Glavin (2003), Tun *et al., 2015*, Kothari, Shah, and Barach, 2017, Kodikara, Karunaratne, and Chandratilake, 2019, Ottensmeyer, Ben-Ur, Salisbury (2000), Grantcharov and Palter (2010), Andreatta *et al.* (2010), Playter and Raibert (1997), Rabkin (2002), Reznek, Rawn, and Krummel (2002), Satava, and Jones (2000), Hoffman, Murray, Curlee, and Fritchle (2001), Riva (1998), Seymour, Gallagher, Roman, O'Brian, and Bansal (2002), Sticha, Kraus and Olsen (2006), Westwood, Hoffman, Stredney, and Weghorst (1998), Tendick, Downes, and Cavusoglu (1998), Torkington, Smith, Reest and Darzi (2000), Tseng, Lee, Chan, Wu, and Chiu (1998), Afkhami (2012), Weghorst, Airola and Oppenheimer (1998), Wilson, Middlebrook, Sutton, Stone, and McCloy (1997), Baby, Srivastav, Singh, Suri, and Banerjee (2016), Vaughan, Dubey,	*The use of VR for simulation-based medical training*	USA, UK, Japan, Thailand, Nigeria, Malaysia, Zambia, South Africa

Wainwright, and Middleton (2016), Salam *et al. (*2016) Bing, Parham, Cuevas, Fisher, Skinner, Mwanahamuntu and Sullivan (2019), **Mehl, Tamrat, Bhardwaj, Blaschke, and Labrique (2018**), Cecil, Gupta, Pirela-Cruz, and Ramanathan (2017), Istepanian *et al*. (2011), Jia *et al*. (2017), Long and Hoang (2017), Santamaria, Serianni, Raimondo, De Rango, and Froio (2016), Seymour *et al*. (2002), Xu *et al*. (2014), Cecil, Xavier-Cecil and Gupta (2017), Jia, Wang, Guo, Gu, and Xiang (2017), Xu *et al*. (2014), Rodrigues, Segundo, Junqueira, Sabino, Prince, Al-Muhtadi and De Albuquerque (2018), Hussein, Burbano-Fernandez, Ramírez-González, Abdulhay and De Albuquerque (2018), Imani, Bandodkar, Mohan, Kumar, Yu, Wang and Mercier (2016), Hu, Shao, Ye and Jin (2019), Aziz (2018), Rosenthal *et al*. (2020), Zhang, Park and Biyi (2019), Lu, Li, Chen, Kim and Serikawa (2018), De Rosis and Nuti (2018), Fischer (2018), Fischer and Heinrichs (2018)		
Elliman, Loizou, and Loizides (2016), Glantz, Rizzo, and Graap (2003), Maran and Glavin (2003), Rizzo, Schultheis, Kerns, and Mateer (2004), Sohlberg and Mateer (2001), Sveistrup *et al.* (2003), Weiss and Jessel (1998), Zimand *et al*. (2002)	*The use of VR for patients' rehabilitation*	USA, UK
Brooks *et al*. (1999), Burdea (2002), Elliman, Loizou, and Loizides (2016), Fung *et al.* (2004), Holden and Dyar (2002), Hoofman (2004), Kizony, Katz, and Weiss (2003), Piron, Cenni, Tonin and Dam (2001), Weiss, Bialik and Kizony (2003),Witmer and Singer (1998), Yano, Kasai, Saitou and Iwata (2003)	*The use of VR for treating medical conditions cerebral palsy, orthopaedic illness and stroke*	USA, UK, Japan
Beck, Palyo, Winer, Schwagler and Ang (2007), Burdea (2002), Krijn, Emmelkamp, Olafsson, and Biemond (2004), Maran and Glavin (2003), McClay *et al*. (2011), Wiederhold *et al*. (2002), Maples-Keller *et al.* (2017)	*The use of VR to treat phobias*	USA, UK

Table 2. 1. Summary of literature

2.15. Conclusion of Chapter two

Most of the South African studies in this chapter focused on technology from a broad perspective and there is thus limited research on advanced technologies such as VR from a South African viewpoint. Most developed countries have implemented VR for medical training and a few developing countries such as Malaysia, Zambia and Thailand are following suit. However, based on the literature from these developing countries, the researcher has deduced that VR could be utilised in South Africa for various purposes apart from medical training. These include the treatment and rehabilitation of patients with various medical conditions such as cerebral palsy, orthopaedic illness, cancer and stroke. However, the use of VR for treating patients is outside the scope of this study. In the context of this study, the literature review depicted several VR systems, such as model-driven and instructor-driven, that can be used to enable medical students to gain exposure to medical environments and to acquire medical skills by practicing medical procedures in the VR environment.

The following chapter describes various theoretical frameworks used in information systems research and discusses the theoretical framework adopted in the study.

CHAPTER THREE: THEORETICAL FRAMEWORKS

3.1. Introduction

Eisenhardt (1991, p. 10) and Eisenhardt and Graebner (2007, p. 15) defined a theoretical framework as a structure that guides research by depending on a formal theory; that is, the framework is constructed by using an established, logical explanation of certain occurrences and relationships. In essence, a theoretical framework is the anchor that supports the research questions and the problem statement (Osanloo and Grant, 2016). It further serves as a theoretical lens through which this study's findings are analysed and discussed.

This chapter discusses some of the theories used in information technology (IT) adoption research with a specific emphasis on the theory adopted in this study, that is, the Unified Theory of Acceptance and Use of Technology (UTAUT).

3.2. IT adoption frameworks

Eight theories are described below starting with the Theory of Reasoned Action and ending with the theory underpinning this study, namely, the UTAUT.

3.2.1. Theory of Reasoned Action

Developed by Fishbein and Ajzen in 1975, the Theory of Reasoned Action (TRA) investigates users' behaviour towards IT adoption based on their attitudes and the norms of society. They postulated that a user would decide to use a technology based on the anticipated outcomes from using the technology (Samaradiwakara and Gunawardena, 2014). Samaradiwakara and Gunawardena (2014) noted that the main objective of the TRA is to understand an individual's voluntary behaviour towards IT adoption by evaluating the individual's motivation towards making a specific decision related to using a technology. Similarly, Reimenschneider, Leonard and Manly (2011) noted that the TRA shows that a user's attitude towards a technology and a user's subjective norm can be used to explain the user's behaviour and his/her decision to adopt a technology. The constructs of TRA are depicted in Figure 3.1.

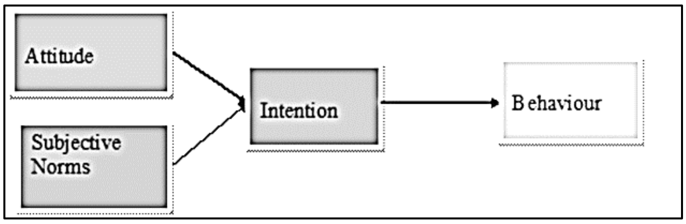

Figure 3. 1. Constructs of the Theory of Reasoned Action
Source: Fishbein and Ajzen (1975)

Liao and Cho (2019) stated that mental assessments (for example, psychometric tests) and interviews are some of the methods used by companies to recruit adequately skilled employees. When compared to mental assessments, interviews are the most common method adopted in the recruitment process. Hence, Liao and Cho (2019) created a virtual environment to simulate the interview process to assist individuals and companies with the process. They conducted a quantitative study about mixed reality with 13 participants using augmented and VR for interview preparation. The TRA was used as the theoretical framework. In the study, Liao and Cho (2019) assessed the attitude of participants towards the use of technology in the interview process. The authors found that users who used virtual environments for interview preparation performed better in job interviews when compared to those who did not do so (Liao and Cho, 2019). Similarly, Kwon, Powell and Chalmers (2013) also adopted the TRA and proposed that virtual environments have the potential to help people overcome phobias, such as anxiety in interviews, and that providing a virtual environment with therapeutic value eliminates the use of traditional interview methods (for example, written, video and face-to-face).

McClelland (1973) stated that factors such as attitude, reasoning and behavioural characteristics are of equal importance and similar to the skills required to perform a specific job. People often display skills, their own techniques, knowledge, values and motivation to perform a task or job which affects their work efficiency (Liao and Cho, 2019). These factors often contribute to the acceptance and reluctance to use a technology related to a specific job (Liao and Cho, 2019). Hence, for instance, some individuals still use paper and pens instead of creating documents online even though the world has advanced digitally (Liao and Cho, 2019). It is, therefore, important to assess an individual's attitude towards using a technology because it contributes to the potential adoption of the technology. The TRA proposes that people's behaviours can be predicted by their attitude toward the behaviour, and the influence of their significant others (such as peers) influence their intentions to perform (or not perform) the behaviour (Salleh, 2005).

The TRA, like the Technology Acceptance Model (TAM) below, also helps investigate an individual's attitude towards using a technology, that is, either a positive or negative attitude toward using an educational technology (Fishbein and Ajzen, 1980). The TRA and the Theory of Planned Behaviour (TPB) (also below) depict the significance of attitude as a direct influence on a user's behaviour. Davis

(1989) stated that attitude serves as a foundational element for user behaviour. However, Davis, Bagozzi and Warshaw (1989) removed it from their proposed theoretical framework because user attitudes do not fully depict the effect of perceived usefulness and perceived ease of use on behaviour. Similar to the subjective norm (from the TPB) and social influence (from the UTAUT), the TRA's construct of subjective norm focuses on an individual's perception of the use of an educational technology, including agreements, and how one is perceived by others (Fishbein and Ajzen, 1980).

Zacharia (2003) investigated the effect of educational tools, that is, interactive computer-based simulations and laboratory inquiry-based experiments, on science educators' beliefs, attitudes and intention to use these tools in their teaching. Zacharia (2003) interviewed 13 educators about their beliefs regarding educational tools and their attitudes towards the use of those tools. Using the TRA model as the theoretical framework, his findings indicated that educators' attitudes towards the use of a technology were influenced by their beliefs and that beliefs and attitudes combined affect their intention to use the technology. However, Chang, Chang and Cheng (2012) noted that Zacharia (2003) only identified teachers' beliefs about the advantages or disadvantages of using a technology, which is the perception of the outcome, but did not examine the perception of the importance of the outcome which affects the intention to use the technology.

3.2.2. Technology Acceptance Model

The Technology Acceptance Model (TAM) (Davis, 1989; Davis, Bagozzi and Warshaw, 1989) was the pioneering framework that identified psychological factors that influence the acceptance of a technology (Samaradiwakara and Gunawardena, 2014). Samaradiwakara and Gunawardena (2014) further noted that this framework was derived from that of the TRA and that its constructs are perceived usefulness and perceived ease of use (refer to Figure 3.2). Manis and Choi (2019) also noted that the TAM was derived from the TRA. The TAM is used to explain the factors of technology acceptance, thereby explaining consumer behaviour across numerous technologies (Manis and Choi, 2019). These constructs are considered to be the factors that influence a user's behavioural intention towards using a technology (Davis *et al.*, 1989). Perceived usefulness refers to the extent to which a user believes that a technology can help him or her to achieve his/her goals while perceived ease of use refers to the extent to which a user believes a technology is easy to use and understand (Samaradiwakara and Gunawardena, 2014). Kim, Mirusmonov and Lee (2010) noted that the TAM was developed by adapting the TRA, the Diffusion of Innovation (DOI) Theory (Bandura, 1986; Rogers, 1995) and social-cognitive theory (Bandura, 1986) to explain the use of technology. The constructs perceived usefulness, which signifies the functional aspects of technology usage, and perceived ease of use, which signifies the control aspects of technology usage, are similar to the TPB (Ajzen, 1985) with respect to behavioural beliefs and control beliefs (Kim *et al.*, 2010).

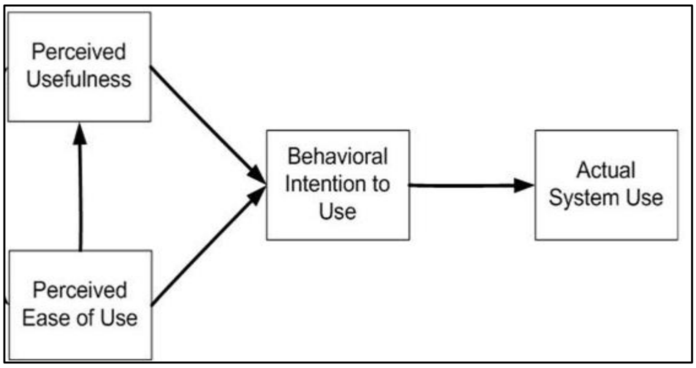

Figure 3. 2. Constructs of the Technology Acceptance Model

Source: Davis, Bagozzi and Warshaw (1989)

Several studies have examined the TAM in a variety of contexts (for example, consumer, business, education and healthcare) and applications (for example, virtual fashion stores, employee training, surgery simulation and real estate tours). The TAM provides a foundation for analysing acceptance and/or reluctance to use a technology, and the behavioural intentions of users (Manis and Choi, 2019). Studies show the TAM as a robust framework for understanding user acceptance of technology in a variety of contexts including banking (Suh and Han, 2002; Chau and Lai, 2003; Dalcher and Shine, 2003; McLean, Al-Nabhani, and Wilson, 2018), mobile-commerce (Bruner and Kumar, 2005; Kalantari and Rauschnabel, 2018), email (Huang, Lu, and Wong, 2003; King and He, 2006; Manis and Choi, 2019), gaming (Hsu and Lu, 2004; Pando-Garcia, Periañez-Cañadillas and Charterina, 2016) and e-commerce (Ha and Stoel, 2009; Iqbal and El-Gohary, 2014). However, some studies noted the TAM's frugality as the main impediment (Venkatesh, 2000; Vijayasarathy, 2004). Vijayasarathy (2004) argued that the variables in TAM are more applicable to decisions involving limited technology usage choices (for example, decisions made in the workplace with limited options) than to situations involving users' voluntary choices (for example, VR). Therefore, the TAM variables may not sufficiently capture key factors impacting attitudes towards VR hardware use intention and purchase intention (Vijayasarathy, 2004).

Fishbein (1963) stated that perceptions (perceived usefulness and perceived ease of use) are critical for any given context. Hence, a recommendation would be to first identify perceptions specific to the study phenomena being investigated. Fishbein and Ajzen (1975, p. 218) indicated that a person may hold a comparatively huge number of beliefs about a specific item, however, only a comparatively small number of beliefs serve as contributing factors of attitude at any point in time. For example, while the perceptions proposed by Davis (1989) for the acceptance of technology are perceived ease of use and perceived usefulness, it is sometimes vital to include the variable of perceived enjoyment (Davis, Bagozzi and Warshaw, 1992). Therefore, variables provided within a theoretical framework may not capture the complete set of factors that may influence technology adoption.

Perceived ease of use is a construct originally defined by Davis (1989) as the extent to which a person believes that using a system would not require effort. Several studies (Bruner and Kumar, 2005; Choi and Totten, 2012; Ha and Stoel, 2009; Oh, Jeong and Baloglu, 2013) have used the original definition proposed by Davis (1989). However, there are some studies that use a modified definition. Davis (1989, p. 15) previously defined perceived usefulness as the extent to which a person believes that using a specific system would improve his or her job performance. Several studies incorporating perceived usefulness use the definition of Davis (1989) above but exclude the term 'job' (Karahanna, Straub and Chervany, 1999; Ha and Stoel, 2009; Choi and Totten, 2012; Iqbal and El-Gohary, 2014; Muk and Chung, 2015). However, Manis and Choi (2019) noted that when considering the definitions of usefulness and perceived usefulness, it is apparent that the original perceived usefulness construct lacks applicability to consumer technology acceptance and a broad scope of usefulness from a company perspective.

Manis and Choi (2019) believed that a more appropriate definition that applied to overall technology acceptance and the perceived benefits a technology may provide to the user, was necessary. Hence, they defined perceived usefulness as the degree to which a person believes using a particular system would be beneficial and advantageous. The relationship between perceived ease of use and perceived usefulness has been assessed across numerous consumer contexts (Porter and Donthu, 2006; Schepers and Wetzels, 2007; Lee, Park, Chung and Blakeney, 2012; Gao, Rohm, Sultan and Pagani, 2013; Oh *et al.*, 2013; Muk and Chung, 2015). However, the relationship has not been assessed in the context of VR hardware (Manis and Choi, 2019). Currently, VR environments are mostly recognised for gaming, and hence the perceived usefulness of VR would, most likely, be much lower than previous research contexts adopting the TAM framework (Manis and Choi, 2019). Manis and Choi (2019), however, noted that a positive attitude towards using VR often translated in the behavioural intention to use it and this is further discussed below.

Attitudes toward using VR

Manis and Choi (2019) stated that a cost-benefit analysis shows that the relationship between perceived usefulness and attitude could be significantly impacted because some users may not find VR hardware very useful. However, where some users have a positive attitude toward using and purchasing VR hardware, there would be a hedonic benefit associated with using it (for example, for gaming or content viewing).

The relationship between perceived usefulness and attitude was studied with products that provided a utilitarian benefit to users. The VR environment provides an opportunity to assess this relationship with a technology product that has strong hedonic benefits with the potential to have strong utilitarian benefits as well (Manis and Choi, 2019). Furthermore, with some aspects of VR in the prototype stage, perceived ease of use may play a greater role because the functionality of the hardware may not provide maximum efficiency or usefulness to the consumer. It is necessary to assess the impact of perceived ease of use and perceived usefulness on attitude to purchase and attitude to use VR hardware (Manis and Choi, 2019). However, Ducey and Coovert (2016) noted that perceived ease of use is not a strong measurement compared to perceived usefulness and hence the effect of perceived ease of use on a user's intention to adopt and use a technology is often moderated by perceived usefulness. In addition, Teo and Tan (2012) have found that the attitude of users to adopt and use a technology is the most crucial factor affecting the use of a technology.

Behavioural intention to use VR

Theoretically, behavioural intention represents an individual's plan to perform or engage in a particular behaviour (Atkinson, 1964; Deci and Ryan, 1987; Ajzen, 1991; Sager and Menon, 1994; Bian and Forsythe, 2012; Manis and Choi, 2019). Bian and Forsythe (2012) noted that the behaviour of a user is situationally specific and dependent on a given research topic (for example, purchase intention, intention to re-visit, and intention to spread positive word-of-mouth). Ajzen and Fishbein (1977) examined the relationship between attitude and behaviour through a review and analysis of past studies. The central thesis of the Ajzen and Fishbein (1977) study is that the strength of an attitude-behaviour relationship is dependent on the correlation between the attitudinal and behavioural entities, that is, the attitude being measured should be assessed in relation to the behaviour (for example, attitude toward purchasing VR hardware and intention to purchase VR hardware). Studies assessing attitude toward using a VR brand and future brand purchase intention show a strong relationship between these two constructs (Compeau, Grewal and Monroe, 1998; Sweeney and Soutar, 2001; Jang and Namkung, 2009; Bian and Forsythe, 2012; Manis and Choi, 2019).

3.2.3. Theory of Planned Behaviour

Hagger (2019) noted that the Theory of Planned Behaviour (TPB) (Ajzen 1985, 1991) was deduced from the TRA framework and it introduced a third independent determinant of the intention to use a technology, that is, perceived behaviour control (PBC). When predicting individual behavioural intentions, only the rational behaviour of people is considered. The TPB expands on the TRA by including an additional factor, that is, perceptions of control over the performance of the behaviour (Ajzen, 1989, 1991). Reimenschneider, Leonard and Manly (2011) also pointed to the TPB being an extension of the TRA (Fishbein and Ajzen, 1975) and that Ajzen (1985, 1989, 1991) expanded the TRA to the TPB by including the construct of perceived behavioural control. Perceived behavioural control is believed to assist with predicting technology adoption intention and user behaviour. Reimenschneider, Leonard and Manly (2011) also added that Ajzen and Madden (1986) found the TPB to accurately predict behavioural intentions when compared to the TRA. Behavioural intention is a user's intention to perform or not perform an act (Fishbein and Ajzen, 1975). Similarly, Han, Tom Dieck and Jung (2019) stated that perceived behavioural control has a direct effect on both user attitude and intention to use a technology, and it explains the availability of resources, opportunities, and other pre-requisites which can change an attitude towards technology and the intention to use it (Han *et al.*, 2019).

Ajzen (1991) suggested that an individual's behaviour is accurately predicted from their intentions to adopt and use a technology. Hence, intentions show a user's motivation behind a behaviour and indicate the amount of effort a user is willing to use to perform a behaviour (Reimenschneider, Leonard and Manly, 2011). Behavioural intention is, therefore, considered a predecessor to the actual behaviour and has subsequently been tested as such (Banerjee, Cronan and Jones, 1998; Leonard, Cronan and Kreie, 2004; Reimenschneider, Leonard and Manly, 2011; Reimenschneider, Manly and Leonard, 2019).

Leonard *et al.* (2004) found that attitude influences behavioural intention to adopt and use a technology. Attitude is an independent variable which is defined as the extent to which an individual favourably or unfavourably evaluates a user's behaviour (Fishbein and Ajzen, 1975). Similarly, Reimenschneider *et al*. (2019) noted that attitude is dependent on a user's beliefs and the assessment of those beliefs. The TRA and TPB confirm that attitude is a reliable measurement of a user's behavioural intention (Reimenschneider *et al*., 2019). Reimenschneider *et al*. (2019) further stated that perceived behavioural control (PBC) is the perceived ease or difficulty of use and of achieving the behaviour in question.

An individual may find certain behaviours easier to achieve which may affect how he or she reacts when using certain technologies. Similarly, Stone, Jawahar and Kisamore (2009) argued that PBC was found to influence user behavioural intention in an academic setting. Robin, Reidenbach and Forrest (1996) proposed an additional variable, termed perceived importance, which affects user behaviour. Perceived importance is defined as "an individual state construct that is believed to be closer to the behavioural intention and behaviour decisions than the moral intensity construct suggested by Jones (1991), and hence, is likely to be a better predictor of those decisions" (Robin *et al*., 1996, p. 17). Similarly, Cronan, Leonard and Kreie (2005) in their study confirmed the impact of perceived importance on user behaviours by focusing on the adoption of a new technology. According to Kripanont (2007), the TPB postulates that an individual's planned behaviour is determined by the availability of skills, resources and opportunities, as well as the perceived importance of those factors (skills, resources and opportunities) to achieve outcomes.

Some of the constructs of the TPB, namely, attitude, subjective norm and PBC (refer to Figure 3.3) were combined with the TAM framework to form the combined TPB (Taylor and Todd, 1995). Taylor and Todd (1995) evaluated the TAM framework and that of the TPB to determine which framework was the most helpful with regards to using and understanding technology. The findings revealed that these two frameworks could be used in conjunction with one another because the constructs of one framework fit well in the other. This framework is adequate to evaluate technology usage with both novice and expert users of a technology (Samaradiwakara and Gunawardena, 2014).

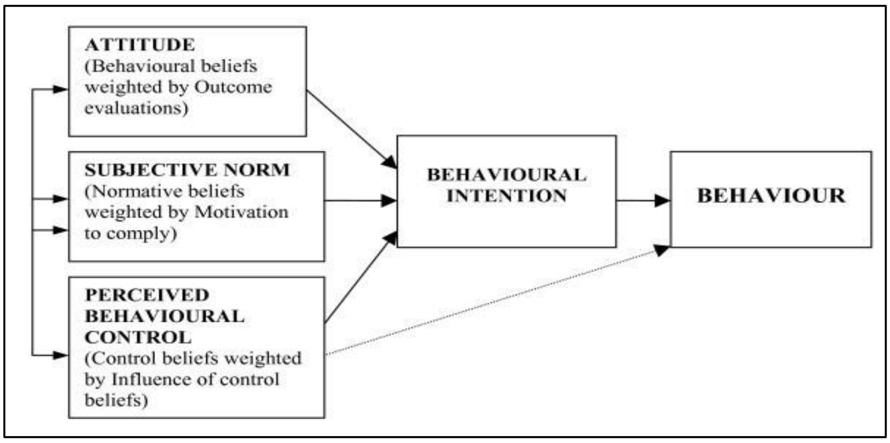

Figure 3. 3. Constructs of the Theory of Planned Behaviour
Source: Francis *et al.* (2008)

3.2.4. Model of Personal Computer Utilization

Van den Berg and Van der Lingen (2019) stated that the Model of Personal Computer Utilization (MPCU) developed by Thompson, Higgins, and Howell (1991), presented a different perspective to the TRA and TPB frameworks. This framework is suited to evaluating individual acceptance and use of a range of information technologies (Venkatesh *et al.,* 2003). Thompson *et al.* (1991) used the framework to predict personal computer (PC) usage behaviour instead of intention to use the system. The theory focuses on the extent to which a user utilises a computer when its use is not mandatory. In such a context, the theory reasons that the use of a PC by a user is most likely to be influenced by factors such as the user's feelings (affect) toward using computers; social factors or the norms of society that people often conform to; behaviour or habits related to using a computer (job-fit); the user's perceived consequences of using computers (long-term consequences); the degree of difficulty that a technological innovation has that makes it challenging to use and understand (complexity); and facilitating conditions (Van den Berg and Van der Lingen, 2019). Training PC users is one aspect of facilitating conditions that can influence computer utilisation (Van den Berg and Van der Lingen, 2019).

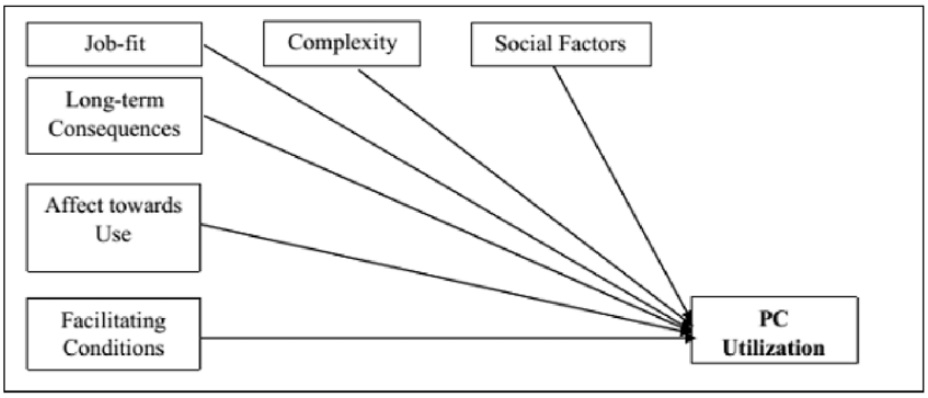

Figure 3. 4. Constructs of the Model of Personal Computer (PC) Utilization
Source: Khater (2016)

Alkhwaldi and Kamala (2017) stated that the MPCU was derived from Triandis' (1977, 1979) Theory of Interpersonal Behaviour. Triandis (1977, 1979) created a theoretical framework to describe how human behaviour occurs by describing the factors that stimulate an individual's behaviour. Alkhwaldi and Kamala (2017, p.6) noted that according to the Triandis framework, behaviour is generally determined by people's attitudes, social norms governing what they should do, habits or what they are accustomed to doing, and by the anticipated repercussions of their behaviour. Additional determinants of behavioural intention and/or actual behaviour include facilitating conditions, relevant behavioural and emotional arousal, and an individual's perception of social normative variables (social factors). The nature of the MPCU framework enables a researcher to predict an individual's acceptance, understanding and use of varying information technologies including VR (Alkhwaldi and Kamala, 2017).

3.2.5. Diffusion of Innovation Theory

The Diffusion of Innovation (DOI) Theory (Rogers and Shoemaker 1971; Rogers, 1995) is used to describe the decision process towards the adoption of an innovation. Teo and Tan (2012) noted that the DOI Theory explains the process through which users adopt technological innovations. Similarly, Samaradiwakara and Gunawardena (2014) stated that this framework is used to determine technology acceptance at both individual and/or organisational levels of analysis. Its fundamental purpose is to provide an interpretation of the way any technological innovation progresses from the stage of the invention to wide-scale use. Rogers (1995) suggested that there are four main influential factors that aid in the development of a new idea: the innovation itself, communication, time and a social system. Samaradiwakara and Gunawardena (2014) stated that not everyone in society adopts technological innovations at the same time. People often adopt an innovation after some time (for instance, an individual will wait for a technology to be used by others before they use it) and this, therefore, enables categorisation of an innovation based on the length of time it takes for the majority of the people in the society to begin using the innovation (Dearing and Cox, 2018).

The DOI Theory suggests that users do not simply adopt a new technology, instead, they first make an informed decision to adopt or not to adopt based on factors such as relative advantage, complexity, trialability, compatibility and observability (Dearing and Cox, 2018). Dearing and Cox (2018) stated that relative advantage is an individual's perception that one innovation will be superior to another when compared to concepts, inventions or procedures that are similar. Those innovations which are identified to be more superior will be adopted more quickly (Dearing and Cox, 2018). Similarly, Min, So and Jeong (2019) stated that relative advantage is defined as the improvement of a technology compared to its competitor or the previous version of the technology. Complexity implies how difficult an innovation is to understand and use. Dearing and Cox (2018) noted an innovation that is found to be too complex would be more difficult to adopt.

Similarly, Min *et al.* (2019) stated that complexity refers to the degree of ease or difficultly related to using and understanding the new technology. Compatibility refers to the extent to which a technological innovation corresponds with current understandings of ideas, products or practices present in an individual's daily life and fit into a person's existing knowledge. The compatibility factor determines whether a technological innovation will be adopted more easily than its predecessor (Dearing and Cox, 2018). Similarly, Min *et al.* (2019) stated that compatibility refers to users being able to effortlessly integrate a new technology into their daily lives. Trialability refers to an individual's approach to an innovation in which testing of the innovation is done before its adoption (Dearing and Cox, 2018). Regarding trialability, users want to test the technology before adopting it (Min *et al.*, 2019). Observability refers to the extent to which the results of using a technology can be observed (Min *et al.*, 2019).

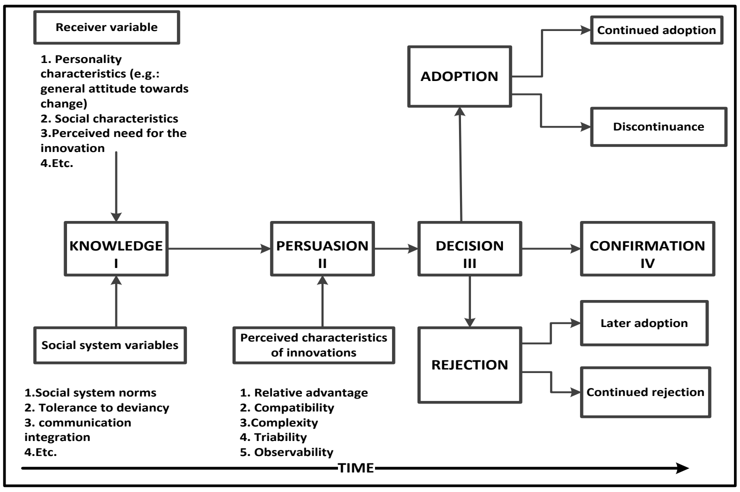

Figure 3. 5. Diffusion of Innovation Theory

Source: Rogers (1995)

The DOI Theory describes users' adoption of technology. Rogers (1995) separated the diffusion process from the adoption process because the focal point of the DOI Theory is how innovation diffuses and how it is adopted by society from both an individual and an organisational perspective. Alkhwaldi and Kamala (2017, p. 5) defined diffusion as the procedure by which an innovation is communicated through specific channels over time among the members of a social system, and adoption as a choice to make a full use of novelty as the best course of action available. Rogers (1995) stated that there are five stages of the innovation-decision process namely, knowledge, persuasion, decision, implementation and confirmation.

Rogers (2003) categorised individuals' adoption patterns into five levels or categories, namely, innovators, early adopters, early majority, late majority and laggards. Min *et al.* (2019) noted that innovators are individuals who are keen to adopt new technologies. Hence, innovators often take more risks than the other adoption categories. Early adopters create their own opinions about new technologies and often set the trend (Min *et al*., 2019). They are similar to innovators in terms of quickly adopting new technologies but they are more concerned about their reputation. The early majority adopt technology after a little while if a consensus of adoption is reached by numerous people within the group (Min *et al*., 2019). This group of people will make decisions based on the utility obtained from adopting a new technology and value practical and logical benefits, unlike early adopters who value 'coolness' (Min *et al*., 2019). The late majority are similar to the early majority but are often more cautious and doubtful before committing to using an innovation. Laggards are slow to adopt new technologies and often only adopt because they are forced to do so (Min *et al*., 2019).

Dearing and Cox (2018) noted that when comparing the adoption groups, the adoption of a new technology or innovation is often gradual and rational. Most often advertisers and business marketers find that closing the gap between early adopters and the early majority is the most difficult and annoying task because it signifies a radical change in behaviour to adopt something (technology, innovation or idea). There is a progression of adoption moving from adopting because it is new and cool, to judging and critiquing prior to adopting some innovation because it is valuable, useful and productive.

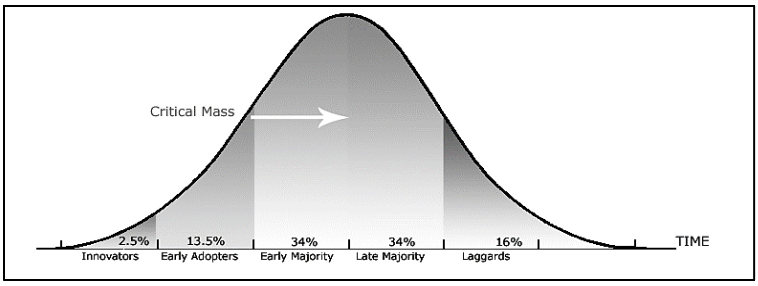

Figure 3. 6. DOI Adopter Categories

Source: Kaminski (2011)

Clarke (1999) stated that although the DOI Theory is best suited as a descriptive tool, it is less strong in its explanatory power, and less useful still in predicting outcomes and providing guidance as to how to accelerate the rate of adoption. Similarly, Karahanna *et al.* (1999, p. 186) stated that the DOI has been restricted with a lack of indication on how the attitudes impact the adoption and rejection decision, or how features of innovations impact this process. Dwivedi, Papazafeiropoulo, Parker and Castleman (2009) added that researchers using the DOI Theory should consider including social contexts in their research to enhance the Theory and make it more effective. However, Min *et al.* (2019) argued that the DOI Theory is an effective social and psychological theory that aims to assist researchers to predict how people make decisions when adopting a new technological innovation by focusing on their adoption patterns and understanding their nature and structure.

3.2.6. Social Cognitive Theory

The Social Cognitive Theory (SCT) (Bandura, 1986) is based on environmental factors such as social pressures or situational characteristics as well as cognitive and other personal factors, including personality and demographic characteristics, that influence an individual to adopt a technology. These factors have been extensively researched to determine the role they play in technology acceptance (Venkatesh and Davis, 2000; Colley and Comber, 2003; Losh, 2004). Alkhwaldi and Kamala (2017) stated that the SCT is one of the most vigorous theories of human behaviour. According to the SCT, people acquire and sustain a behaviour because of a dynamic and shared interaction with environmental factors, personal factors and human behaviours. The SCT was examined together with other constructs in the IT field to explain user acceptance and/or rejection of various information technologies (Alkhwaldi and Kamala, 2017).

Venkatesh *et al.* (2003) considered the predictive validity of the SCT model from the perspective of behavioural intention (BI) and compared it with other IT acceptance models and theoretical frameworks. The core variables of the SCT model are self-efficacy, outcome expectation including personal expectation outcome, performance, anxiety and affect (Venkatesh *et al.*, 2003).

The SCT has been widely applied in numerous studies including computer and Internet utilisation (Alkhwaldi and Kamala, 2017). Ratten (2013) stated that the SCT is advantageous when compared to other IT acceptance or adoption theories because it combines two levels of analysis, namely, organisational and individual. Ratten (2013) added that the SCT includes technological innovations that are not always optionally adopted but are instructed by the organisation(s) in which the individual works. Abbasi (2011) noted that although the SCT offered ground-breaking constructs such as self-efficacy, generalising the theory is considered to be difficult. The SCT can, therefore, be adopted as an umbrella framework with the aim of expanding its constructs into a conceptual model (Abbasi, 2011).

3.2.7. Motivational Model

The Motivational Model (MM) framework was developed by Davis, Bagozzi and Warshaw in 1992 and is applied in studies that seek to understand the motivation behind the use of technological systems (Speier and Venkatesh, 2002; Samaradiwakara and Gunawardena, 2014). The constructs of this framework are extrinsic and intrinsic motivation (Davis *et al*., 1992). Intrinsic motivation is defined as the degree to which using a system is perceived to be enjoyable. Extrinsic motivation is defined as the extent to which an individual believes that a system would enhance his or her job performance (Samaradiwakara and Gunawardena, 2014). Davis *et al*. (1992) advocate that these constructs significantly influence a user's decision to adopt and use a technology.

Some studies in the psychology field were based on the MM (Muftah, 2013; Mugo, 2013; Markova and Yaneva, 2020). These studies included research on the Self-determination Theory (SDT) (Deci and Ryan, 1985). The SDT suggests that the process of self-determination lies in the quality of human functioning which entails the choice of experience, having a choice, and making a choice (Alkhwaldi and Kamala, 2017). Although, Alkhwaldi and Kamala (2017) stated that there are numerous studies that have investigated the MM, however, the authors do not discuss the findings of such studies. The SDT also addresses the ways that social context influences the motivated behaviour. Apart from the two types of motivation (that is, intrinsic and extrinsic), Deci and Ryan (1985) argued that a third variable (that is, amotivation) needs to be acknowledged to understand an individual's behaviour. Davis *et al.* (1992) used individuals' extrinsic and intrinsic motivations to investigate the key factor of an individual's intentions toward IT usage behaviour. The authors added the influence of extrinsic and intrinsic motivations to use the PC at the workplace (Davis *et al*., 1992). In addition, Alkhwaldi and Kamala (2017) noted that perceived usefulness (PU), subjective norms (SN), and perceived ease of use (PEOU) are examples of extrinsic motivations, and computer enjoyment and playfulness are examples of intrinsic motivation.

3.2.8. The Unified Theory of Acceptance and Use of Technology

The theoretical framework adopted in this study was the Unified Theory of Acceptance and Use of Technology (UTAUT). The UTAUT is a unified theory comprising a combination of the Model of Personal Computer Utilisation (MPCU), the Diffusion of Innovation (DOI) Theory, the revised Technology Acceptance Model (TAM2), the Theory of Reasoned Action (TRA) and the Social Cognitive Theory (SCT). The Theory was adopted as the theoretical foundation for the study because it is comprehensive and, according to Venkatesh *et al*. (2003), it accounts for 69 percent of intentions to use a technology (compared to other theories of technology acceptance).

Venkatesh *et al.* (2003) point out that there are four direct determinants of user acceptance and usage behaviour of a technology, namely, performance expectancy, effort expectancy, social influence and facilitating conditions and that these are moderated by the variables of gender, age, voluntary use and experience (as depicted in Figure 3.6). These determinants and moderating variables can be used to determine the likelihood of adopting a technology (Venkatesh *et al.*, 2003). The UTAUT theorises attitude towards using technology, self-efficacy and anxiety as indirect determinants of intention (Venkatesh *et al*., 2003). When the performance of UTAUT was compared to eight individual models, it outperformed them all (Attuquayefio and Addo, 2014). This finding suggests that UTAUT is an effective model for understanding the factors determining a user's acceptance of technology and their intention to adopt it (Attuquayefio and Addo, 2014).

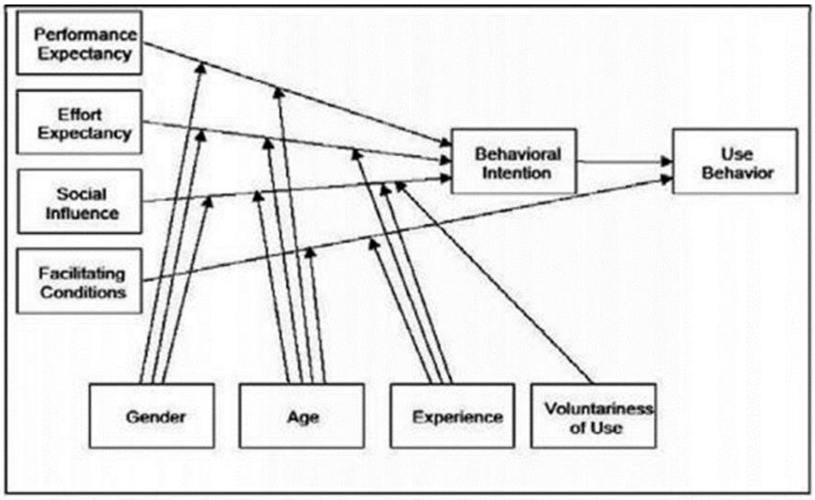

Figure 3. 7. The UTAUT framework
Source: Venkatesh *et al.* (2003)

According to Venkatesh *et al.* (2003), performance expectancy (PE) may be defined as the extent to which an individual believes that using a system will help him or her to attain some benefits in their job. Similarly, Ogourtsova, Archambault and Lamontagne (2019) referred to PE as the degree to which an individual believes that the use of any technology will result in performance gains. In this study, PE referred to the degree to which lecturers believed that using a VR system will help them to accomplish tasks related to training medical students and hence could be seen as the value gained from using a VR system. Similarly, Bracq *et al*. (2019) noted that the main influencers of technology acceptance are perceived utility gained from using a technology. Gunawardana and Ekanayaka (2009) noted that PE is a combination of perceived usefulness, extrinsic motivation, job-fit, relative advantage and outcome expectations. Previous studies on technology acceptance have shown that PE is a strong determinant of technology acceptance intentions (Davis, Bagozzi and Warshaw, 1989; Taylor and Todd, 1995; Venkatesh and Davis, 2000; Venkatesh *et al.*, 2003; Samaradiwakara and Gunawardena, 2014).

Venkatesh *et al*. (2003) defined effort expectancy (EE) as the extent to which a system is easy to use. Ogourtsova, Archambault and Lamontagne (2019) referred to EE as the ease of using any technology. In this study, EE was defined as lecturers' perceived ease of use of VR systems for medical training. Similarly, Bracq *et al*. (2019) noted that the main influencers of technology acceptance are perceived usability of a technology. Venkatesh *et al.* (2003) observed that EE is more significant for individuals with less experience. On the other hand, the more experienced and familiar a person is with a technology, the lesser the effect of EE on the intention to use it (Gunawardana and Ekanayaka, 2009).

Social influence (SI) refers to the degree to which an individual perceives the importance of other people's beliefs regarding the use of a technology (Venkatesh *et al*., 2003). Ogourtsova, Archambault and Lamontagne (2019) referred to SI as the degree to which an individual believes that significant others believe that they should use the technologies. Similarly, Bracq *et al*. (2019) noted that for an individual to accept a technology, a key factor would be for their family, friends and colleagues to support the adoption of the technology. In the context of the USA, Gunawardana and Ekanayaka (2009) found that the effect of SI on the intention to use a technology differed across samples based on people's cultural differences and demographics. Keller (2007) found that SI had a significant impact on the intention to use virtual learning environments in developed countries such as the USA and the UK. Similarly, Yang (2013) found that SI was a significant determinant of the acceptance of technology in developed countries.

Facilitating conditions (FC) refer to other factors and resources, for example, the organisational and technical infrastructure that lecturers believe could facilitate the adoption of VR for medical training. Ogourtsova, Archambault and Lamontagne (2019) referred to FC as the degree to which organisational and technical infrastructure exists to support the use of any system or technology. Similarly, Bracq *et al*. (2019) noted that the organisation's existing resources should support the adoption of a new technology. Previous studies have emphasised the role that FC has on the intention to use a technology (Chiu and Wang, 2008; Teo and Tan, 2012; Abubakar and Ahmad, 2013). Bangert and Doktor (2002) noted that the adoption of advanced systems such as VR entails a shift in the organisational culture and the organisation's capability to learn and adapt to the new technology. In developing countries, factors such as inadequate organisational structure, policies and politics can influence the organisation's ability to adopt and implement VR for medical training (Sood *et al.*, 2008).

There are numerous IT adoption-related studies that have used the UTAUT framework (Sharma and Citurs, 2004; Dadayan and Ferro, 2005; Schaper and Pervan, 2006; Al-Gahtani, Hubona and Wang, 2007; Neufeld, Dong and Higgins, 2007; Venkatesh, Brown, Maruping and Bala, 2008; Suhendra, Hermana and Sugiharto, 2009; Al-Rajhi, Liu and Nakata, 2010; Bandyopadhyay and Bandyopadhyay, 2010; Diaz and Loraas, 2010; Maier, Laumer and Eckhardt, 2011; Nasri and Charfeddine, 2012; Teo and Tan, 2012). Several other studies used the UTAUT framework to investigate VR adoption and implementation (Keller, 2007; Chiu and Wang, 2008; Van Raaij and Schepers, 2008; Jong and Wang, 2009; Tsai, Lin, Chiu and Joe, 2009; Wang, Cui, Yang and Lian, 2009; Šumak, Polancic and Hericko, 2010; Nistor, Wilson, Tamas and Radomir, 2011; Fulton, 2017). These studies focused on online virtual learning systems and investigated hypotheses or research questions based on the UTAUT framework. Most of the studies conducted qualitative research while some other studies adopted a mixed research approach with students and/or educators as the research participants. Findings from all these studies reflected that virtual learning systems are useful to enhance education in their respective countries, that is, the USA, the UK, Japan and Indonesia (Keller, 2007; Chiu and Wang, 2008; Van Raaij and Schepers, 2008; Jong and Wang, 2009; Tsai *et al.*, 2009; Wang *et al.*, 2009; Nistor *et al.*, 2011; Šumak *et al.*, 2010).

3.3. Conclusion of Chapter three

In this chapter, various theoretical frameworks were described. The chapter highlighted the framework adopted in the study, namely, the UTAUT, along with the reasons for adopting it. The theoretical framework was the foundation of the study because it guided both the research objectives and the research questions. The next chapter discusses the methodology adopted in the study.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1. Introduction

The 'Research Onion' was adopted for the study. Developed by Saunders, Lewis and Thornhill (2009), the Research Onion approach demonstrates the stages that should be followed when creating a research strategy. The Research Onion framework is useful because it can be adapted to most types of research (Bryman, 2012). Saunders *et al*. (2009) stated that the layers of the Research Onion provide a detailed explanation of the research process. The framework has six layers, that is, the research philosophy, research approach, research strategies, research choices, research time-horizon, research technique and procedure. These layers (illustrated in Figure 4.1) are discussed, in relation to the study, in detail below. However, to begin with, the research questions are repeated, and the study's theoretical framework briefly outlined.

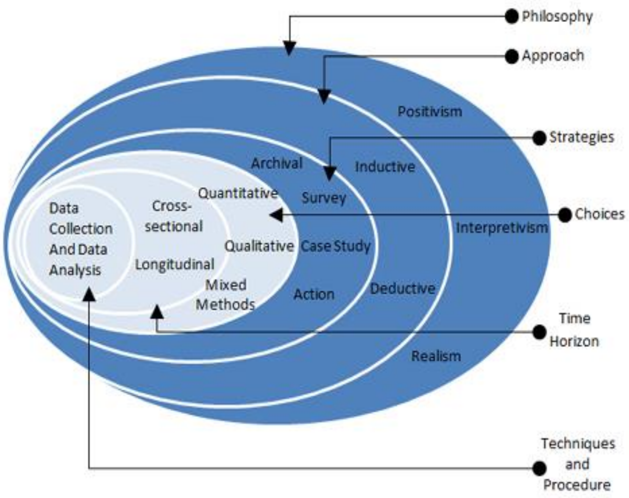

Figure 4. 1. The Research Onion: Saunders *et al*. (2009)

Source: Saunders *et al*. (2009)

4.2. Research Questions

i. What is the perceived usefulness of using VR for medical training?

ii. What is the perceived effort required to use VR for medical training?

iii. What are the social factors that can influence the adoption of VR for medical training?

iv. What are the facilitating conditions for the adoption of VR for medical training?

v. What are the challenges to the adoption of VR for medical training?

vi. What could be the solutions to overcome the challenges to the adoption of VR for medical training?

4.3. Study framework

The theoretical framework adopted in the study was the UTAUT. It was adopted as the theoretical foundation because it is comprehensive and, according to Venkatesh *et al*. (2003), it accounts for 69 percent of intentions to use a technology when compared to other theories of technology acceptance, for example, TAM, TPB, DOI, MM, MPCU, SCT and TRA. Venkatesh *et al.* (2003) noted that there are four direct determinants of user acceptance and usage behaviour of a technology, namely, performance expectancy, effort expectancy, social influence, and facilitating conditions that are moderated by gender, age, voluntary use and experience. These determinants and moderating variables can be used to determine the likelihood of a technology being adopted (Venkatesh *et al.*, 2003).

Performance expectancy (PE) is defined as the extent to which an individual believes that using a system will help him or her to attain some benefits in his/her job. Effort expectancy (EE) is the extent to which a system is easy to use. Social influence (SI) refers to the degree to which an individual perceives the importance of other people's beliefs regarding the use of a technology. Facilitating conditions (FC) refer to the existence of factors such as organisational and technical infrastructure to support the use of a system (Venkatesh *et al*., 2003).

4.4. Research philosophy

The first layer of the Research Onion framework is the research philosophy (Saunders *et al*., 2009). The research philosophy refers to the set of beliefs concerning the nature of the phenomena being investigated (Bryman, 2012). May (2011) noted that the choice of the research philosophy is defined by the type of problem under investigation. Flick (2011) added that the assumptions delineated in the research philosophy provide the justification for how the research will be undertaken. Research philosophies differ based on the goals of the research and on the most appropriate method that should be used to achieve those goals (Goddard and Melville, 2004).

According to Hürlimann (2019), there are two main research philosophies that can inform the research process, namely, positivism and interpretivism. Bryman (2012) stated that positivism is anchored in the assumption that reality exists independently of the aspect being studied. Newman, Benz and Ridenour (1998) posited that positivism claims that the meaning of the phenomenon under investigation is consistent among the respondents. Bryman (2012) stated that positivism may include statistical or quantitative methods, while interpretivism may include humanistic qualitative methods.

Thanh and Thanh (2015) noted that interpretivism suggests that the inherent meaning of the social phenomena is created by each observer or group. In this way, a researcher should not assume that what is observed during the data collection phase is interpreted in the same manner by all the respondents (Thanh and Thanh, 2015). Similarly, Hürlimann (2019) noted that the interpretivism approach suggests that researchers need to examine the differences in the respondents' understanding of the concept being investigated rather than assuming that all the respondents feel the same way.

A research philosophy provides the justification for the research methodology that is undertaken in a study and should, therefore, be informed by the nature of the phenomena being observed (Thanh and Thanh, 2015; Hürlimann, 2019). In this study the interpretivism philosophy was used to determine the respondents' perceptions of the usefulness of VR in medical training; the effort required to use VR for medical training; the social influence on the adoption of VR for medical training; the perceived facilitating conditions for the adoption of VR for medical training; and, lastly, the challenges associated with adopting VR for medical training in the context of South African higher education.

4.5. Research approaches

4.5.1. Deductive approach

The deductive approach is best suited to contexts where a research project is concerned with examining whether the observed phenomena fit within the expected results (Wiles, Crow and Pain, 2011). Similarly, Silverman (2013) stated that the deductive approach develops hypotheses based on a pre-existing theory and thereafter formulates the research approach to test it. Snieder and Larner (2009) added that the deductive approach may, therefore, be considered appropriate for positivism which permits the formulation of hypotheses and the statistical testing of expected results at a defined significance level. However, Saunders *et al*. (2009) noted that a deductive stance may also be used with the interpretive approach and in such cases, the expectations informed by pre-existing research would be formulated using research questions rather than hypotheses. The deductive approach often tests an existing theory (Kothari, 2004).

4.5.2. Inductive approach

Bell, Bryman and Harley (2018) stated that the inductive approach focuses on the creation of new theories and ideas from the collected data. In the inductive approach, observations are the starting point for the researcher, and thereafter they are thoroughly searched to uncover patterns (Beiske, 2007). Flick (2011) mentioned that in the inductive approach there is no initial framework that informs the data collection process. The research focus can, therefore, be formulated after the data has been collected (Flick, 2011). Bell *et al.* (2018) stated that the inductive method is more commonly used in qualitative research, where the absence of a theory informing the research process may help reduce the potential for researcher's bias during the data collection stage. Flick (2011) noted that in an inductive approach, interviews can be conducted to investigate specific phenomena and thereafter data may be examined to deduce patterns within the respondents' answers. Similarly, Bell *et al.* (2018) noted that this approach may also be used effectively within the positivist methodology where the data is analysed initially, and significant patterns are used to formulate a theory.

The deductive research approach was used in this study. The UTAUT, developed by Venkatesh *et al.* (2003), was used as a guide for the formulation of the research questions, objectives and interview questions. Data was analysed and results were compared with the existing literature on the adoption of VR for medical training purposes. Appendix 1 depicts the alignment of the research objectives, questions and the interview questions with the UTAUT framework.

4.6. Research strategies

According to Saunders *et al*. (2009), a research strategy depicts how the researcher intends to carry out the study and there is an array of research strategies. These strategies can be classified as experimental research, action research, case study research, grounded theory research, survey research, and archival research.

Experimental research refers to a research strategy that examines the results of an experiment against the expected results (Saunders *et al*., 2009). This type of research strategy usually involves the use of a relatively limited number of factors and the relationship between the factors is examined and evaluated against the expected research outcomes (Saunders *et al*., 2009). Zeng, Pope, Lee and Gao (2018, p. 6) noted that the "amount of variability" in the data is often captured in experimental research design. The authors further noted that it is often possible to enhance the accuracy of the study by increasing the sample size.

Action research is defined as a practical approach to a specific research problem within a community of practice (Bryman, 2012). Wiles *et al*. (2011) stated that it involves reflective practice, which is a systematic process by which the professional experience of a medical practitioner can be assessed. This form of research is common in occupations such as teaching or nursing, where the practitioner can assess ways in which they can improve their professional approach and understanding of, for example, a medical condition (Wiles *et al*., 2011). Jenkins (2017) stated that research that is done on or with participants is considered action research. Hence, the research is designed, conducted and integrated by the participants in the study. Action research is an iterative process (similar to grounded theory research) in which researchers investigate an identified problem to discover a solution within an acceptable ethical framework (Jenkins, 2017). For instance, researchers might investigate approaches to obesity prevention via surveys or interviews conducted in local churches, community centres, and/or schools. Hence, in this way, action research aids in making the results of obesity research more generalisable (Jenkins, 2017).

Case study research involves the assessment of a single unit of study to establish its key features and deduce generalisations (Bryman, 2012). Bryman (2012) added that this form of research is effective in financial research, such as comparing the experiences of two companies or comparing the effect of investments in different contexts over a period. Quinlan, Babin, Carr and Griffin (2019) noted that case study research is also used in the sciences field, for example, social and life sciences. A case study is a research methodology entailing an up-close, in-depth and detailed investigation of a subject of study, and its related contextual conditions (Quinlan *et al.*, 2019).

Grounded theory research entails the use of a qualitative method and an inductive approach in which patterns are derived from the data as a pre-condition for a study (May, 2011). Bryman (2012) stated that a study that uses grounded theory begins with the collection of data which may become the foundation for emerging theories. Similarly, Glaser (1978) stated that the focus of data collection in grounded theory should be on how relevant the data is to the study. The analysis and creation of theories occur after data has been collected (Flick, 2011). Grounded theory is commonly used in social science disciplines (Bryman, 2012). Holton and Walsh (2017) noted that grounded theory is a structured research methodology which is not associated with any philosophical standpoint. Grounded theory helps depict an integrated theoretical explanation of a pattern of social behaviour while being primarily focused on discovering new theories. In addition, the data analysed using grounded theory does not necessitate interpretation or co-creation by researchers (Holton and Walsh, 2017).

Smith-MacDonald, Reay, Raffin-Bouchal and Sinclair (2019) stated that grounded theory is the most structured and well-used qualitative research methodology in the medical field. Smith-MacDonald *et al.* (2019) also stated that a theory grounded in, and created from, a patient's medical portfolio is more likely to be successful in achieving the desired medical change, with the least negative consequences when compared to a theory which is not derived from patients. Additionally, Jenkins (2017) noted that the main focus of grounded theory is to investigate social phenomena in order to create a deeper understanding that is derived from a systematic analysis of the study data. Grounded theory is appropriate when the study of social interactions and/or experiences intends to describe a process, but not to test or validate an existing theory (Jenkins, 2017). In addition, the main features of grounded theory are its iterative study design, theoretical (purposive) sampling, and system of analysis (Jenkins, 2017).

An iterative study design entails a cycle of simultaneous data collection and analysis, where analysis informs the next cycle of data collection (Lingard *et al.*, 2008). Theoretical (purposive) sampling is where the sample is not set at the outset of the study but is instead selected purposefully as the analysis of data proceeds. Hence, participants are chosen to confirm or contest an emerging theory (Lingard *et al.*, 2008). Survey research refers to the collection of information that is obtained by asking participants research-related questions and can be done face-to-face, on paper by means of a questionnaire, telephonically or online by means of online forms (for example, Google Forms). Surveys normally use interviews or questionnaires as data collection methods (Bell *et al.*, 2018). Wagner, Mendez, Felderer, Graziotin and Kalinowski (2019) stated that surveys enable researchers to obtain large amounts of data that can be analysed for regularities, statistical averages and patterns. It is a common method in statistical research, which is focused on discovering causal relationships between variables. There are different types of surveys such as exploratory, descriptive and explanatory surveys (Wagner *et al.*, 2019). Explorative surveys are generally used as a foundation to investigate issues such as theory constructs not being predicted upfront and instead discovered as the research progresses (Wagner *et al.* 2019). Descriptive surveys are done to develop statements and/or claims or assumptions about a population. Statements based on the social characteristics of a population, for example, education, training, profession and location, can be used to investigate how these characteristics could be related to an individual's behavioural patterns and/or attitude toward technology adoption. In this example, the focus is on finding what correlations exist that influence technology adoption (Wagner *et al.* 2019). Wagner *et al.* (2019) further noted that explanatory surveys focus on deriving explanatory statements about a population (for example, why certain techniques are utilised in specific contexts).

An archival research strategy can be used in a research study that is solely based on existing data, also referred to as secondary data (Flick, 2011). Flick (2011) stated that this form of research may involve a systematic literature review, where patterns in existing research are examined. Archival research may also refer to historical research, whereby a body of secondary data resources is analysed to address specific research problems (Flick, 2011). Similarly, Heng, Wagner, Barnes and Guarana (2018) stated that the archival research design consists of examining historical data which is stored for purposes apart from purposes for academic research. Heng *et al.* (2018) believed that studies based on the archival research design have many benefits, including an increased generalisability. However, archival research design may also have disadvantages that could subsequently result in researchers concluding on misleading inferences based on false results (Heng *et al.*, 2018). In addition, Heng *et al*. (2018) noted that one of the main features of archival research is the nature of data which entails using pre-existing research (also referred to as secondary data) as part of a study.

4.7. Research choices

4.7.1. Quantitative research method

Quantitative research focuses on gathering numerical data and generalising it across groups of people to explain a particular phenomenon. Goddard and Melville (2004) noted that there are various statistical standards to examine the validity of the quantitative approach, such as the number of respondents that are required to establish a statistically significant result. Similarly, May (2011) stated that quantitative methods can be used in cases where there are many potential respondents, and/or the data can be effectively analysed using statistical tests. Similarly, Rajasekar, Philominathan and Chinnathambi (2013) stated that the quantitative method is used when the data can be statistically analysed. Although this research method is informed by the positivist philosophy, it can be used to investigate a wide range of social phenomena, including feelings, beliefs and opinions (Goddard and Melville, 2004). Bhattacherjee (2012) noted that quantitative research methodology often refers to the systematic investigation of a phenomenon through statistical and mathematical analysis as well as the processing and analysis of numerical data. Similarly, Basias and Pollalis (2018) stated that quantitative research generally entails the systematic and statistical examination of a problem through the processing of numerical data while Braun *et al*. (2019) noted that quantitative research data is often obtained and analysed in a numerical or statistical form. Basias and Pollalis (2018) added that the process of examining a problem through the use of numbers in quantitative research provides a fundamental link between empirical observation and mathematical expression of quantitative relations.

It is essential to analyse and process a large quantity of data to verify or test a theory (Bhattacherjee, 2012). Similarly, Basias and Pollalis (2018) noted that quantitative research is used to analyse and process a large quantity of data to validate and test a theory. Furthermore, the quantitative approach simplifies the processing of a large amount of data (Basias and Pollalis, 2018). Braun *et al.* (2019) also pointed out that quantitative research methodology assists with the processing, summarising and analysing of large quantities of data.

Bhattacherjee (2012) stated that quantitative research entails the correlation with experiments, the testing of hypotheses related to the phenomena, the use of advanced statistical tools, and the use of questionnaires. Basias and Pollalis (2018) noted that quantitative research is effectively done via questionnaires or surveys containing close-ended and/or open-ended questions generally in the form of short answers (Basias and Pollalis, 2018). Bhattacherjee (2012) added that quantitative research is also used when there is uncertainty related to the theories under examination and that statistical tools are used to conduct an analysis. Basias and Pollalis (2018) stated that quantitative research enables comparison of data through the use of empirical valuation indicators and tools. In quantitative research, data processing is typically performed using distinctive statistical tools and software (Braun *et al.*, 2019).

Some advantages of quantitative research include obtaining a result that is numerical (quantitative) thereby preventing a study from being influenced by personal feelings or opinions in considering and representing research and facts (Basias and Pollalis, 2018). Similarly, Braun *et al.* (2019) noted that the result of a quantitative study is numerical and is, therefore, often considered to be more objective (fact-based, measurable and observable).

4.7.2. Qualitative research method

The qualitative approach is deduced from the interpretivism paradigm (Bryman, 2011). The qualitative approach is used when data pertaining to a phenomenon is meant to be collected subjectively and, therefore, cannot be measured empirically (Rajasekar *et al.*, 2013). Similarly, Bryman (2011) stated that the aim of a study based on the qualitative approach is to investigate the respondents' understanding of the phenomena being examined. Rajasekar *et al*. (2013) indicated that the qualitative approach is used when the researcher wants to gain an in-depth understanding of the phenomena being investigated. The qualitative approach requires the researcher to avoid imposing his or her own perceptions about the social phenomena being investigated onto the respondents (Bryman, 2011). It can, therefore, be concluded that the qualitative approach, unlike the quantitative approach, is used for examining the significance of the social phenomena, rather than identifying a causal relationship between established variables (Yvonne Feilzer, 2010).

Basias and Pollalis (2018) noted that qualitative methodology helps to deal with phenomena by analysing participants' experiences, behaviours and social relations. Qualitative research methodology often provides answers to research questions through a word-based research approach (Basias and Pollalis, 2018). Similarly, Braun *et al.* (2019) pointed out that qualitative research is defined as an arrangement of explanatory techniques that describe, decode and translate concepts instead of measuring the frequency of certain phenomena in society. Basias and Pollalis (2018) noted that qualitative methodology assists researchers to understand the nature and complexity of the phenomenon being investigated hence enabling research in relatively new areas. The proponents of qualitative research claim that the quality of recording, comprehending and analysing a phenomenon is significantly reduced when the texts are quantified (Basias and Pollalis, 2018).

Braun *et al*. (2019) noted that qualitative methodologies challenge the researcher to interpret the data and to draw the conclusion based on his or her observation. A researcher who follows a qualitative research approach observes, interviews, summarises, describes, analyses and interprets the phenomena being investigated. The main advantage of qualitative methodology is that it supports the in-depth study of the problem being investigated (Braun *et al*. 2019). Qualitative research methodology uses flexible questionnaires (that is, open-ended questionnaires) or interviews for an in-depth understanding of the problem. During interviews, audio recordings from the session are converted to text for easier interpretation (Basias and Pollalis, 2018). Similarly, Braun *et al*. (2019) noted that qualitative research methodology assists with an in-depth investigation of the phenomena being investigated via the use of interviews. Hence, this study used a qualitative approach to gain an in-depth understanding of the potential adoption of VR for medical training from the perspective of a South African higher education institution.

4.7.3. Differences between quantitative and qualitative research methodology

The choice of a quantitative or/and qualitative research methodology is informed by the research aim, objectives, the nature of the study and the research questions. Table 4.1 describes the differences in quantitative and qualitative research methodologies to enable researchers to better understand these aspects and thereby inform their decision to adopt one or both of these methodologies.

Qualitative research	*Quantitative research*
Qualitative research methodology includes an interpretation of techniques that aim to describe and decode phenomena instead of measuring the frequency of phenomena in society.	Quantitative research methodology refers to the systematic, empirical examination of phenomena via statistical and mathematical analysis and the processing and analysis of numerical data.
There is often uncertainty about the assumptions under investigation because the interpretation of participants' responses based on the researcher's understanding and is, therefore, subjective.	There is no uncertainty about the assumptions under investigation because the interpretation of participants' responses is done using empirical means.
Qualitative research methodology obtains information via interviews which enable an in-depth understanding of the phenomena being investigated.	Quantitative research methodology obtains information via large volumes of questionnaires which are interpreted using statistical tools.

Table 4. 1. Comparison of qualitative and quantitative research methodologies

Source: Braun *et al.* (2019)

4.7.4. Mixed-method approach

The mixed-method approach uses both qualitative and quantitative approaches and can be portrayed as using both open and closed-ended questions in interviews and questionnaires to answer the research questions (Bell *et al*., 2018). One advantage of using a mixed-method approach is that it allows one of the method's weaknesses to be offset by the other method's strengths. As noted above, this study used a qualitative approach to gain an in-depth understanding of the potential adoption of VR for medical training at a South African educational institution.

4.8. Time-horizons

Time-horizon refers to the timeframe within which a project is expected to be completed (Saunders *et al*., 2009). Two types of time-horizons are specified within the Research Onion, that is, cross-sectional and longitudinal time frameworks (Bryman, 2012). Flick (2011) noted that in the cross-sectional time-horizon, data is collected within a single, specified timeframe. In contrast, in a longitudinal time-horizon, data is collected repeatedly over an extended period of time and is used when examining change over time which can be an important component of a research study (Goddard and Melville, 2004). Similarly, Bryman (2012) noted that the longitudinal time-horizon can be used to evaluate change and development within a phenomenon. Goddard and Melville (2004) stated that the longitudinal time-horizon allows for the establishment of some control over the variables being studied. The time-horizon selected should not be dependent on a specific research approach or methodology (Saunders *et al*., 2009). This study adhered to the cross-sectional time-horizon as data was collected within one specific timeframe.

4.9. Data collection

4.9.1. Study site and target population

The physical location where the data is collected is referred to as the study site. In the context of this study, data was collected from the UKZN College of Health Sciences at the Westville Campus in Durban. The College consists of four schools: the School of Health Sciences; the School of Clinical Medicine; the School of Nursing and Public Health; and the School of Laboratory Medicine and Medical Sciences. In January 2019, the College had 6 242 students, 642 staff members (academic and non-academic) and 63 postdoctoral fellows (UKZN, 2019). Data was collected from the School of Laboratory Medicine and Medical Sciences. This School was chosen (instead of one of the other schools) because it is located on the same campus where the researcher was based at the time of data collection. Hence, it was convenient for the researcher to collect data from the School. The description of the School (obtained from the UKZN website) indicated that it focuses on anatomy and physiology, and inpatient and outpatient care for terminally ill patients in its syllabus. The School has 55 academic staff members of which 12 were selected as participants. The participants were or had been, in the healthcare industry as practising doctors and they were also academics in that they were employed by UKZN and were teaching at the Medical School. Therefore, based on their medical and teaching experience (as well as other criteria - see below), they were considered best-suited to provide responses that would contribute to answering the research questions.

4.9.2. Sampling techniques

Sampling techniques aid in the choice of an appropriate sample size for a study (Bryman, 2012). There are several accepted techniques that can be used such as probability and non-probability sampling techniques.

4.9.2.1. Probability sampling techniques

Bryman (2012) stated that probability sampling is a process that affords potential respondents with equal chances of being selected to be part of a study. There are several different types of probability sampling techniques such as random, stratified, cluster, systematic and multi-stage sampling.

In simple random sampling, individuals within a larger population are chosen unsystematically (Bryman, 2012). However, Neuman and Kreuger (2003) stated that this can result in random distribution, which may lead to data being skewed. For example, a random sample may result in more males than females being represented in a sample, or an unequal distribution across ages (Neuman and Kreuger, 2003). A systematic random sample is obtained from the population by choosing a random starting point and subsequently selecting respondents based on a certain interval. The interval is calculated by dividing the entire population size by the desired sample size (Flick, 2011). For example, if a local hospital requires a sample of 500 volunteers from a population of 5000 people, the hospital can select every 10th person from the population to get a systematic random sample (Flick, 2011). Similarly, Lynn (2019) stated that systematic sampling is generally used because it is relatively easy to implement, and it can be used to govern the dispersal of a sample across a combination of variables.

A stratified sample may be used to ensure that the sample respondents reflect the significant characteristics of the population, such as making sure that the demographic characteristics of age and gender are reflected in the sample (Newman, Benz and Ridenour, 1998). For instance, a researcher divides a sample of adults according to age into subgroups such as 18-29, 30-39, 40-49, 50-59 and so on (Flick, 2011). Jing, Tian and Huang (2015) stated that stratified sampling consists of datasets which are grouped into similar categories or subsets known as strata, with a common set of data being selected from each stratum. Similarly, Zhao, Liang and Dang (2019) pointed out that stratified sampling is commonly conducted in two steps. The first step entails dividing the dataset into groups known strata, and the second step deals with randomly sampling within each stratum to select commonly occurring subgroups. The authors) found that combining clustered sampling with stratified sampling outperform the results obtained from using random sampling only. However, stratified sampling has higher estimation efficiency and better clustering quality when compared to the other probability sampling techniques such as cluster, simple random and systematic random sampling (Zhao *et al*., 2019).

Cluster sampling entails dividing the population into groups and, thereafter, randomly selecting the sample from those groups (Neuman and Kreuger, 2003). A researcher, for instance, may investigate the academic performance of high school students in England. The researcher can thereafter divide the population of England into various clusters (in this case, in terms of cities). The researcher can subsequently select a sample from each cluster, depending on the research objectives, through simple or systematic random sampling (Neuman and Kreuger, 2003).

Flick (2011) stated that multistage sampling requires the researcher to divide the population into categories to make sampling easier and it generally uses a combination of other probability sampling techniques.

4.9.2.2. Non-probability sampling techniques

Bryman (2012) noted that non-probability sampling is based on the researcher's subjective judgement. There are several types of non-probability sampling techniques such as convenience, consecutive, purposive and snowball sampling (Bryman, 2012).

In convenience sampling, data is collected from a population of individuals who are conveniently accessible to the researcher (Bryman, 2012).

Bhattacherjee (2012) stated that consecutive sampling is similar to convenience sampling except that it requires using all available respondents as part of the sample. This sampling technique ensures that the researcher has the opportunity to work with multiple samples to gain better insights into a phenomenon.

Kohler, Kreuter and Stuart (2019) noted that snowball sampling is generally used with a small population size. In this instance, the researcher requests the initial respondent to identify another potential respondent.

Purposive sampling is a type of non-probability sampling whereby respondents are chosen to be part of the sample based on the researchers' judgement of the respondents' knowledge of a subject under investigation (Kohler *et al*., 2019).

The purposive sampling technique was used in this study to determine the potential adoption of VR for medical training from lecturers who teach and/or practice medicine. The reason for adopting this sampling technique was to identify and select respondents who could potentially have knowledge of the use of VR for medical training.

4.9.3. Sample size

The sample size represents the selected number of respondents in a study from the overall population (Newman, Benz and Ridenour, 1998). Bryman (2012) noted that in quantitative research, the size of a sample is essential in determining the reliability of the study's results. A sample size that is less than thirty will tend to produce results that are skewed (Bryman, 2012). Hence, generally, reliable results are obtained from large sample sizes (Flick, 2011). However, in qualitative research, the size of the sample is less important, and the concept of representativeness is not a strong indication of the validity of qualitative research (Flick, 2011).

According to Creswell and Miller (2000), qualitative research generally requires a smaller sample size than quantitative research. Similarly, some researchers have stated that qualitative research is in-depth and, therefore, the sample required for the analysis of the data is generally small and selective (Cormack 1991; Carr, 1994).

4.9.4. Sampling process

The researcher used the UKZN website to obtain a list of staff members from the School of Laboratory Medicine and Medical Science on the Westville Campus. The staff list was screened and staff who did not fit into the inclusion criteria were excluded from participating in the study. As stated, the study used the purposive sampling method to choose the participants. To obtain a purposive sample, the researcher was particularly interested in academic staff members who had taught medicine or those whose research focused on medical education or the use of technologies in medical practices. Of the 55 academic staff members in the School, 12 participants were selected using the inclusion criteria above. Of the 12 participants, four professors were interviewed because all of them had taught medicine and had conducted research on the use of technologies in the medical field. Three senior lecturers were selected because they were teaching medicine and also conducted research on medical education. Five lecturers were selected as they were currently teaching medicine. In addition, all the selected participants were or had been, general medical practitioners.

4.9.5. Data types

There are two main types of data, namely, primary data and secondary data.

4.9.5.1. Primary data

Primary data is derived from first-hand sources (Saunders *et al*., 2009). This can be historical first-hand sources or data derived from a survey or interview (Bryman, 2012). Similarly, Glaser and Strauss (1967) showed that data could be collected from primary sources such as participants in a study. Flick (2011) noted that data derived from a collection of statistics by a researcher can constitute primary data. Therefore, primary data is best defined as data that is analysed as itself, rather than through the analysis of other data. This study collected first-hand (or primary) data from the respondents.

4.9.5.2. Secondary data

Glaser and Strauss (1967) stated that secondary data consists of academic documents, surveys, books and articles and that it assists the researcher to understand the phenomena being investigated. However, Newman, Benz and Ridenour (1998) were of the view that secondary data is derived from the opinions of other researchers. For example, the conclusions of a research article can be considered as secondary data because they comprise information that has already been processed by another researcher (Newman *et al*., 1998). Kothari (2004) added that results that emanate from a statistical analysis of data collected from a close-ended questionnaire can constitute secondary data. The most effective distinction between the two types of data (primary and secondary) is based on how the data is used, rather than the inherent characteristic of the data itself (Flick, 2011). For instance, newspapers may be used as both primary and secondary sources for data, depending on whether the reporter was physically present during the incident or not (Flick, 2011).

4.9.6. Data collection methods

The data collection method depends on the research methodology used in a study (Bhattacherjee, 2012). In addition, the data collection method used in a study influences the study's overall reliability and validity (Saunders *et al*., 2009). There are three types of interviews, that is, structured, semi-structured and unstructured. In structured interviews, the questions are asked in a standardised manner and follow an order where respondents are asked the same questions while in unstructured interviews the respondents are asked different questions in a non-standardised manner (Saunders, Lewis, Thornhill and Bristow, 2015). This study used semi-structured interviews to collect data from the respondents because they are more flexible than structured interviews. In this regard, semi-structured interviews are 'informal' and can be used to probe respondents for additional information. Semi-structured interviews are also systematic when compared to unstructured interviews (Saunders *et al.*, 2015).

4.9.7. Data collection process

Interviews were arranged based on the respondents' availability. Interview questions were formulated and were used as a guide during the interviews. Responses were recorded using an audio recorder and were later transcribed, verbatim, to a disc. The transcribed documents were then sent to the relevant participants for validation.

Dworkin (2012) stated that obtaining repetitive information will indicate the attainment of saturation because adding more respondents to the study does not result in additional perceptions or information. Authors have stated that data saturation is reached when there is adequate information to duplicate the study (Walker, 2012; O'Reilly and Parker, 2013); when one can no longer obtain additional or new information (Guest, Bunce and Johnson, 2006); and when further coding or categorising of data into themes is no longer possible (Guest *et al.*, 2006). Guest *et al*. (2006) further noted that data saturation may be attained after six interviews depending on the sample size. However, Dibley (2011) and Burmeister and Aitken (2012) have stated that it may be best to think of data in terms of richness and thickness rather than by the size of the sample. According to Fusch and Ness (2015), the simplest way to differentiate between rich and thick data is to think of 'rich' as the quality of data obtained and 'thick' as the quantity of data obtained. Simply stated, thick data is a large amount of data and rich data is data from which detailed information can be extracted to answer the research questions (Fusch and Ness, 2015). Creswell and Miller (2000) pointed out that thin data lacks detail and simply reports facts and statements with no thorough explanation of the findings, while thick data provides more detailed findings.

Regarding this study, the researcher interviewed all 12 academic staff targeted and by the twelfth interview it was realised that saturation had been reached, that is, respondents 10, 11 and 12 provided similar information as previous interviewees. Thus, no new information could be derived from their responses.

4.10. Data analysis

Thematic data analysis was used to gain in-depth knowledge from the collected data (Braun and Clarke, 2006). Stake (1995) and Yin (2003) recognised the importance of effectively organising data. The advantage of using a database to accomplish the organisation of data is that the data is available for independent examination and analysis later (Stake, 1995; Yin, 2003). Baxter and Jack (2008) stated that a database improves the reliability of a study because it enables the researcher to organise data sources like documents, interview materials, photographs and audio files which can be stored in the database for subsequent easy access and retrieval. In this study, the tool Listen N' Write was used to transcribe the audio files and the qualitative data analysis tool, NVivo, was used to analyse the collected data by coding the data into themes, analysing the themes and interpreting them in the light of the available literature.

Figure 4.2 depicts an example of the process used to analyse data. However, this figure is an excerpt from only one respondent. Responses from each respondent were transcribed and imported into the Nvivo software. Thereafter, the researcher created nodes based on the most commonly occurring information (themes). The interviewees' responses were assessed to determine the themes that aligned with the UTAUT framework and sub-themes were derived from these. As depicted in the example portrayed in Figure 4.2, the respondent's answer was mapped to the construct of the UTAUT framework (performance expectancy). This was noted when the respondent stated that VR adheres to ethical standards (refer to Figure 4.2 for the full response).

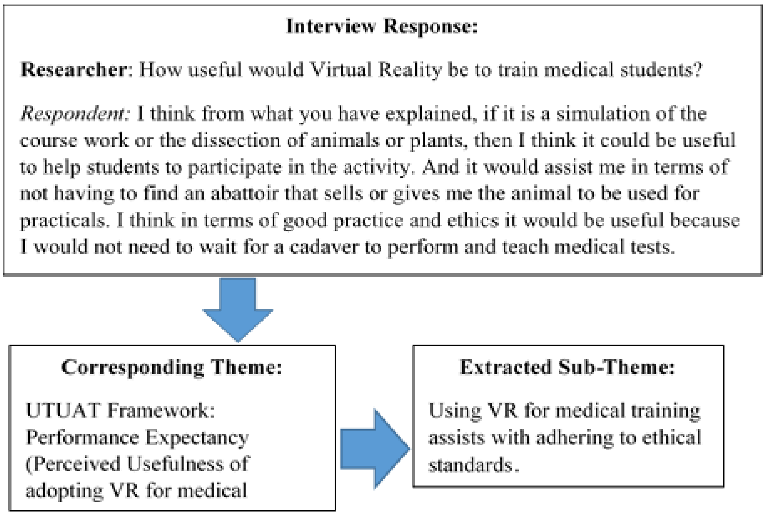

Figure 4. 2. Excerpt of the data analysis process (using one response)

4.11. Data quality control

Data quality control consists of ensuring the validity and reliability of the data. Several frameworks have been developed to assess the trustworthiness of qualitative data (Guba, 1981; Lincoln and Guba, 1985, Guba and Lincoln, 1994). Guba and Lincoln (1994) proposed four criteria for determining the ‘correctness’ of qualitative research compared to quantitative research, as depicted in Table 4.2 below.

Traditional criteria (quantitative)	*Alternative criteria (qualitative)*
Internal validity	Credibility
External validity	Transferability
Reliability	Dependability
Objectivity	Confirmability

Table 4. 2. Quantitative data vs qualitative data control

Source: Guba and Lincoln (1994)

According to Patton (2005), the credibility criterion determines whether the results of the qualitative research are credible from the perspective of the respondents. Some researchers noted that the use of multiple data sources is a strategy that can enhance data credibility (Patton, 1990; Yin, 2003; Baxter and Jack, 2008). Baxter and Jack (2008) stated that these data sources may include documentation, archived records, interviews, physical artefacts and observations. The process of reviewing multiple data sources to enhance the validity of the study is referred to as triangulation. Creswell and Miller (2000) stated that triangulation is a systematic process of sorting data to find common themes or categories by eliminating overlapping areas. The authors further stated that triangulation is a valid method for assessing the quality of a study because researchers rely on multiple forms of evidence rather than a single incident or data source in the study (Creswell and Miller, 2000). Baxter and Jack (2008) pointed out that during data collection and analysis, researchers may also incorporate a process of member checking, where the researchers' understanding of the data (participants' responses) is shared with the respondents. This could contribute new or additional perspectives about the study. In this study, the respondents assisted with the credibility of the results by verifying the information that they provided to the researcher. In this instance, the researcher emailed the transcribed copies of the interviews to the respondents for them to validate the transcription.

Transferability refers to the degree to which the results of qualitative research can be generalised or transferred to other settings (Brantlinger, Jimenez, Klingner, Pugach and Richardson, 2005). In this study, the researcher enhanced transferability by thoroughly describing the research context and the assumptions that were central to the research.

The qualitative stance on dependability refers to whether the research can describe the changes that occur in the setting and how the changes affected the way the research was conducted (Golafshani, 2003). The researcher aimed at enhancing dependability by recording any changes that occurred during the data collection process that would have affected the study. These changes and their effects are explained in the limitations section of the dissertation below.

According to Krefting (1991), during the analysis stage, the consistency of the findings or the dependability of the data can be enhanced by having multiple researchers independently code a set of data and thereafter meet to provide consensus on the emerging codes. In a similar vein, Baxter and Jack (2008) noted that researchers may also choose to implement a process of double coding whereby a set of data is coded, and thereafter the researcher re-codes the same data set and compares the results. However, in this study, due to time constraints, it was not possible to double code.

According to Golafshani (2003), confirmability may be defined as the degree to which the results could be confirmed by others. There were various strategies that the researcher used to enhance confirmability. For example, the researcher documented the procedures used for checking and re-checking the data throughout the study and by both recording the interview and writing down the responses from the respondents. Golafshani (2003) stated that a data audit should be used to identify the potential for bias or distortion of the results. If bias or distortion are found, this should be reported as a limitation of the study (Golafshani, 2003). At the end of this study, the researcher conducted a data audit to examine the data collection procedures by, as noted above, emailing the transcribed documents to the respondents to confirm the information they provided. The data audit revealed that the collected data was not distorted.

4.12. Ethical considerations

According to Gregory (2003), ethical considerations ensure that the researcher's objective is not solely focused on collecting data from the respondents but that it also considers the respondent's safety and dignity. In the context of this study, the researcher applied for ethical clearance from the UKZN and it was approved (reference number: HSS/0679/018M) on 21 June 2019 (refer to Appendix 1: Ethical Clearance Letter) before data collection commenced.

Confidentiality, as an ethical consideration, was adhered to in the study. Thus, personal information such as the names of the interviewed staff members (who had consented to participate in this study) was kept confidential by allocating codes (numbers 1-12) to their responses and names were not used in the reporting and discussing of the findings. Interviews were recorded using a voice recorder after obtaining consent from the participants to do so. To help ensure the validity of the research, a data audit was conducted. In terms of the audit, the audio files were transcribed, and the transcribed files were stored in computer folders. Folders were named after each respondent to ensure that each respondent received his or her own responses. Once the audit verification was completed, the researcher deleted the respondent's names from the documents and re-named the documents with codes that had been assigned to the respondents during the data collection phase. These codes were written down manually when the interviews were being conducted (for example, Mr X, Interview 1: 26/12/2019). In the analysis phase, transcribed documents were imported into Nvivo and the names of those documents remained coded.

4.13. Conclusion of Chapter four

This chapter discussed the methodology adopted in the study using the Research Onion Framework. The chapter identified and explained the research philosophy, approach and strategy adopted in the study. It further explained the research choice, time-horizon and the data collection and analysis procedures followed in the study.

The following chapter presents and discusses the results of the data analysis phase.

CHAPTER FIVE: FINDINGS AND DISCUSSION

5.1. Introduction

Lune and Berg (2017) stated that the research questions should be tied in with the findings and presented as such. Similarly, Tracy (2019) stated that a researcher should be able recognise the patterns or common ideas that emerge from the data to classify it as findings. These patterns should be aligned with the research questions (Tracy, 2019). Hennink, Hutter, and Bailey (2020) added that one major challenge in qualitative research is the presentation of findings because the results are often confused. As a suggestion, Hennink *et al.* (2020) noted that researchers should focus on the research questions when presenting their findings.

This chapter discusses the results of the study based on the participant's commonly stated ideas.

5.2. Designation of respondents

Table 5.1 depicts the designation of the 12 interviewees. Four were professors, three were senior lecturers and the remaining five had the rank of lecturer. These academics were chosen because they are experts in their fields. Their research focused on medical education and/or the integration of technology in medicine. The interviewees were or had been, practicing doctors and were currently employed in the School of Laboratory Medicine and Medical Science at the UKZN Westville Campus in the city of Durban in South Africa. The interviewees were assigned numbers (according to scheduled appointments) to maintain their confidentiality.

Respondent number	Designation	Total Number of Publications	Publications on medical education and/or technology integration
1	Senior lecturer	15	10
2	Lecturer	10	7
3	Professor	9	4
4	Senior lecturer	15	7
5	Professor	13	5
6	Lecturer	3	2
7	Senior lecturer	33	11
8	Professor	15	5
9	Professor	24	15
10	Lecturer	4	4
11	Lecturer	6	3
12	Lecturer	5	2

Table 5. 1. Designation of respondents and publications made

5.3. Answering the research questions

5.3.1 Research question 1: What is the perceived usefulness of using VR for medical training?

VR is beneficial from an ethical perspective

Some respondents indicated that VR would be beneficial from an ethical perspective. In this instance, respondent 1 stated: "*VR would be beneficial from an ethical perspective because students would not be required to use human cadavers to conduct tests and diagnoses*". Respondent 2 added: "*…in terms of good practice and ethics, VR would be useful because students would not need to wait for a cadaver to perform medical tests to investigate the results"*. Similarly, respondent 3 stated that "*Medical students will be able to improve their skills by practicing medicine using virtual reality instead of practicing on a real person because they do not need to wait for a real-life patient to display the symptoms required for medical examination"*. Several authors have also noted that the use of VR for medical training purposes addresses some ethical concerns because students do not need to train using real-life patients (Freina and Ott, 2015; Nickel *et al*., 2015; Ruthenbeck and Reynolds, 2015).

Thomsen *et al*. (2017) stated that the use of VR for medical training adheres to ethical practices because students can practice diagnostic and therapeutic interventions at any time without having to wait for a real-life patient to display specific symptoms. However, Lazarus *et al*. (2019) found that although technology such as VR for medical training is ethically beneficial, it is simply a tool used to support training and should not replace dissections using human and animal cadavers. Similarly, Alblas *et al.* (2018) cited the President of the Anatomical Society who was of the opinion that using a human or animal cadaver helps medical students develop their emotional and interpersonal skills which computer graphics cannot assist them with; hence, technologies such as VR should not replace human or animal dissections but should rather complement them.

In South Africa, medical interns or residents (post-graduate students) are required to participate in community initiatives at various local public hospitals (Dos Santos, 2019). Alblas *et al.* (2018) noted that medical students in South Africa often use a real-life patient for training on how to diagnose and treat illnesses. Residents need to wait for patients to display full-blown symptoms before they start the diagnosis process because diagnosing on the basis of a few partial symptoms can lead to misdiagnosis and incorrect treatment (Alblas *et al.*, 2018). Waiting for a patient to display full-blown symptoms can be time-consuming. Instead of students waiting for real-life patients to display full-blown symptoms, VR can be used to practice diagnosing various symptoms. This can be much safer than practicing on humans that are alive. Pelargos *et al.* (2017) noted the importance of developing and adopting advanced technologies such as VR to increase residents' exposure to surgical procedures and to decrease the risk associated with using real-life patients during training sessions. Similarly, Hu *et al*. (2019) pointed out that using VR for medical training warrants patient safety.

Guedes *et al.* (2019) revealed in their study that VR could be used to provide practical training for a resident (medical student) trainee under the supervision and guidance of an experienced surgeon, thereby minimising the risk of negative outcomes. The resident could be trained using a VR simulator prior to surgery, thus giving the resident increased surgical experience without exposing patients (Guedes *et al.*, 2019).

In South Africa, residents utilise human cadavers to practice surgical procedures (Sheikh, Barry, Gutierrez, Cryan and O'Keeffe, 2016). This implies the need for a continuous supply of dead human bodies to train surgeons. However, this is not always the case. In 2011, for instance, there was a shortage of human cadavers that could be used for training purposes (Dardagan, 2011, p. 12). People are generally reluctant to donate their bodies or those of their relatives due to cultural or religious reasons. The UKZN had to appeal to the community to voluntarily donate their bodies for medical experiment (after death). A common practice is to use dead bodies that have not been claimed by relatives and hence recorded as unidentified individuals (these unidentified individuals are commonly referred to as Jane or John Doe) (Sheikh *et al.*, 2016). However, according to Sheikh *et al.* (2016), dissecting a human body requires consent and it is unethical if consent from the relevant people is not given. In the case of a Jane or John Doe, it is, therefore, technically unethical to dissect the deceased body if consent has not been granted. One way of avoiding this practice is to use a virtual patient for practicing surgical procedures instead of dissecting an unclaimed human body without the family's consent (Sheikh *et al.*, 2016; Alblas *et al.*, 2018; Popoola *et al.*, 2020).

VR provides a safe environment for training

Respondent 6 commented that VR could be used to prepare students for critical medical interventions without putting the patient's or the student's life in danger. The respondent further stated: "*VR could be used to train students to identify the correct treatment in cases where there are accidents or multiple casualties".* In this regard, Salam *et al.* (2016) noted that VR is utilised in simulation-based education to train students to become medical professionals by creating a safe environment in which students can practice medical procedures. Similarly, Al Kuwari (2018) stated that VR provides a danger-free environment to practice medical procedures. Hence, in the context of South Africa, as alluded to by respondent 6, VR can create a safe environment for medical training.

VR provides a suitable environment to practice procedures that are seldom performed in real-life and improves student's decision-making

According to Thomsen *et al*. (2017), virtual environments allow students to safely practice rare procedures and diagnostic interventions that are often only read about in textbooks. In a similar vein, Hu *et al*. (2019) noted that VR creates procedures that are seldom seen in real-life. The practicing of rare diagnoses subsequently enables students to improve their knowledge and general decision-making skills (Thomsen *et al*., 2017; Hu *et al*., 2019). Sweeney (2012) noted that simulation-based training can improve students' knowledge, decision-making, and surgical skills. Respondent 6 stated that VR allows students to experience the *"tense"* real-world clinical environment that requires immediate responses, analysis and decision-making (especially when managing critically ill patients). The respondent noted: "*VR provides a good and safe practice environment for aspects that are highly technical but are seldom performed by doctors but need to be well-known by them".* The respondent went on to state: "*....an example of a procedure that is seldom performed but needs to be well-known is cricothyrotomy. This procedure involves making an incision into a specific area of the patient's neck to insert a plastic tube through a thin membrane in the trachea. This procedure requires speed and accuracy and can be life-saving if it is performed correctly but deadly if it is not performed correctly hence a quick analysis and decision about the area of incision need to be taken".*

VR allows students to make errors and learn from them

Respondent 3 stated: *"virtual reality also allows medical students to make mistakes and learn from it without the risk of harming real patients".* Similarly, respondent 10 pointed out that VR enables students to make errors which they can "*undo*" in the simulated environment when compared to a real-life situation. Tun *et al.* (2015) stated that VR mannequins, such as model-driven and instructor-driven VR mannequin systems, may be used to teach basic sciences such as pharmacology and physiology and could also be used to teach complex medical management of a patient case, including drug administration, cardiopulmonary resuscitation, endotracheal intubation, tracheostomy, and insertion of chest tubes. VR, therefore, allows students to practice procedures, make errors and learn from those errors to ensure competency in the real-world. In the context of South African medical training, Popoola *et al.* (2020) noted that dissecting a human cadaver to practice surgical skills requires precision because an incorrect dissection cannot be undone, unlike using a virtual patient where errors can be made and reversed. The process of making errors and being able to see the outcome thereof results in learning and knowledge retention (Popoola *et al.,* 2020).

VR helps students to gain real-life exposure

Respondent 4 stated that VR can assist students to gain real-life exposure: "*Students can practice diagnosis and treatment of patients with common diseases. Students, for instance, can prepare for how it would be in a hospital environment".* Similarly, both Issenberg *et al*. (1999) and Pulijala *et al.* (2017) noted that an effective VR simulation would expose students to life-like situations in the virtual environment. Yule *et al.* (2006) pointed out that surgeons need to learn how to perform surgical procedures in a VR simulated environment before entering the OR. They noted that VR simulations offer the best training for novice learners such as recently qualified nurses, surgical technicians, medical students, and anaesthesia and surgery residents (Yule *et al.*, 2006).

Respondent 3 mentioned that medical students can benefit from using VR by repeatedly practicing medical procedures which will reduce the prospects of "*misdiagnosing patients"*. Similarly, respondent 8 stated that "*VR could be helpful for students who need to practice procedures that require repetition to perfect. In cardiology, for instance, it would be useful for teaching cardiopulmonary resuscitation (CPR) in a more realistic environment".* Respondent 4 pointed out that a virtual environment could be used to continuously practice medical procedures to gain experience and knowledge. Similarly, Pelargos *et al*. (2017) stated that a virtual environment that mimics the real environment could be used to train students and surgeons to prepare them for the real-world. Zhang *et al*. (2019) noted that currently in the USA, VR and motion-sensing devices are used for immersive and interactive training as well as physical exercise. Some VR systems capture user movements to inform sensory stimuli displayed to the user via the head-mounted display (HMD) to create an illusion of being immersed in the VR environment, therefore resulting in user interaction. In South Africa, some senior doctors allow residents to assist with the treatment of patients while others only allow residents to observe the medical procedures without active engagement (information obtained from respondents 9, 10, 11 and 12).

Based on this information provided by the respondents about their training experiences, the researcher was able to deduce that because the manner of teaching and training varies amongst senior doctors, the residents would be trained differently. Cecil *et al*. (2017) stated that residents initially observe the surgeon performing the surgery and subsequently, after some time, would gradually progress to assisting in performing surgeries. Similarly, Hu *et al*., (2019) noted that residents undergo surgical training and acquire surgical skills by observing the surgeon in the OR prior to assisting in surgery. Therefore, some residents may have had adequate practical exposure to treating patients while some residents may not have had such exposure. It is, therefore, important to have common training standards. In this regard, Sheikh *et al.* (2016) stated that it is necessary to standardise medical training. The authors pointed out that by exposing students to the same medical virtual environments will ensure that all students gain the same knowledge and experience to prepare them for the real-world.

VR is used to mentally prepare students to face critical emergency situations

Respondent 4 stated: *"In terms of the trauma cases, where you have patients who have suffered from severe illnesses or accidents and require extensive support, virtual reality will help to mentally prepare students for that situation. It will allow them to gain practical knowledge that they would need to deal with the emergency".* Greci *et al.* (2013), in their study using a virtual hospital combined with artificial intelligence (AI), found that students displayed improved medical emergency knowledge because the AI-VR system allowed them to repeatedly practice medical examination and decision-making in a controlled environment. Additionally, students were able to see the outcomes of their decisions in real-time and were able to experience a life-like emergency environment to prepare them for the real-world (Greci *et al*., 2013). Similarly, Ingrassia *et al*. (2014) stated that emergency medical (EM) personnel train using simulations which allow them to gain exposure to disaster situations and this subsequently prepares them to deal with both physical and emotional stresses.

As reported above, respondent 6 mentioned that VR allows students to experience the "*tense*" real-world clinical environment. Hu *et al.*, (2019) pointed to VR enhancing the ability to learn through experience. Smith *et al.* (2015) found that VR simulators could be integrated with sophisticated life-like mannequins. These VR mannequins are used for respiratory, cardiovascular, and pharmacological modelling of drugs to mimic a real-life stressful situation (Smith *et al*., 2015). However, Roy *et al*. (2006) found that although VR simulations enhanced the learning of medical procedures, it was expensive to adopt on a wide scale and, therefore, could only be used to train a relatively small number of students.

VR assists students to learn about anatomy in a realistic setting

Respondent 7 stated: *"VR can be used to assist medical students to learn anatomy and physiology".* Erolin, Lamb, Soames and Wilkinson (2016) pointed to a VR system called Anatomic VisualizeR that contains several 3D anatomic models and allows students to virtually dissect the models. A similar virtual anatomy project, 3D Human Atlas, was developed in Japan to assess students understanding of human anatomy (Mazziotta *et al.*, 2001). Respondent 7 further stated: *"Simulations of dissections can be used by medical students to revise their anatomy…the way in which the organs and muscles work inside the human body can also be shown through VR simulations".* Hu *et al*. (2019) used a VR system combined with an advanced tracking system to display a patient's anatomy and surgical plans within an operation theatre in real-time. Results from the study indicated that using VR with tracking systems shortened operation times and improved efficiency (Hu *et al*., 2019). Respondent 10 stated that VR would be useful because students can gain experience with conducting physical examinations of the patient's body in the virtual environment. Similarly, Estai and Bunt (2016) indicated that VR systems that are based on anatomy allow students to gain experience and receive real-time feedback.

Moro, Štromberga, Raikos and Stirling (2017) and Murgitroyd, Madurska, Gonzalez and Watson (2015) noted that anatomy is generally taught at the beginning of a medical course and that it is taught using lectures, which include PowerPoint presentations, oral demonstrations of concepts using 2D images, multimedia resources such as video materials, and dissections using human cadavers. In South Africa, medical students are given a time limit to practice dissections. Consequently, human cadavers are only available to students for practice at specific scheduled times (Codd and Choudhury, 2011; Murgitroyd *et al*., 2015). This means that students only have a restricted time frame in which they can learn anatomy effectively from a human cadaver.

Students are also expected to utilise supplementary study materials, such as lecture slides and textbooks, to enhance their knowledge of anatomy (Messier, Wilcox, Dawson-Elli, Diaz and Linte, 2016). Thus, using VR for anatomical dissections at South African educational institutions will enhance learning about anatomy because students will have access to practical learning in 3D at any time needed. Similarly, Moro *et al.* (2017) noted that students may have difficulty learning from 2D anatomical images found in textbooks because some aspects are easier to comprehend in 3D. Hence, VR immersive environments can assist students to learn and understand medical concepts better than using a textbook. VR also assists by reducing the mental effort required when learning new anatomical aspects (Küçük, Kapakin and Göktaş, 2016).

VR caters for different learning styles

Respondent 7 indicated that VR is useful because it caters for various learning styles and, therefore, provides customised learning experiences. The respondent further stated: "*Virtual reality medical simulations deliver a tailored learning experience that can be standardised and can cater to different learning styles in ways that cannot be matched by traditional teaching. These simulations also facilitate self-directed learning*". Halili (2019) in a similar vein, stated that technology can become a powerful learning tool if it is customised to suit the various learning needs of students. From a South African perspective, there is a lack of research on the use of VR to enhance student learning outcomes (Azer and Azer, 2016). Moro *et al.* (2017) noted that despite the potential of using VR for medical training, its successful integration in the South African medical training curricula is affected by a lack of research on the adoption of VR for medical training purposes. There is, therefore, a lack of adequate evidence to demonstrate VR's effectiveness in South African healthcare training.

VR allows students to continuously practice medical aspects at their own pace

According to Respondent 7: *"VR allows students to repeat specific medical scenarios that enable them to address skill deficiencies and to develop the required skills at their own pace"*. Ziv, Wolpe, Small and Glick (2006) would concur. The authors noted that VR simulations allow students to practice clinical skills at their own pace and also allow them to repeat medical procedures, when needed, to gain adequate confidence and skills proficiency. Similarly, Piromchai, Avery, Laopaiboon, Kennedy and O'Leary (2015) stated that VR-enabled medical tasks can be created on-demand to enable skills proficiency.

VR assists with the development of communication skills

Respondent 1 noted: *"…VR can assist with interpersonal skills such as interacting and communicating with patients".* A study conducted by Yule *et al*. (2006) on the acquisition of non-technical skills required for surgery, found that VR could become a valuable, standardised method of improving communication among surgical teams as well as improving patient safety. Similarly, Rabkin (2002) stated that a VR simulator can assist students to develop medical skills, including communication skills, prior to interacting with a real-life patient. Hu *et al*. (2019) stressed that communication between doctors and patients is also vital. However, the authors point out that in most medical situations there is a lack of communication between patients and doctors because patients (and their families) lack understanding of medical jargon and hence lack understanding of the medical procedures (Hu *et al*., 2019). VR can, therefore, promote communication between those with insight and knowledge (doctors) and those seeking understanding (patients and their families). Patients and their families will have more understanding of the operation process if medical professionals use VR to simulate the operation during the pre-operative conversation phase with the patient (Hu *et al*., 2019).

VR assists with a transfer of knowledge and skills to the real-world

Respondent 9 detailed: *"In some areas, such as conformal radiotherapy and stereotactic neurosurgery, treatment is not possible without pre-operative planning and practice with the aid of a computer and/or simulation. VR, therefore, has a substantial impact on the success and safety of surgery because it enables medical professionals to practice the surgery before entering the operating room".* Aziz (2018) noted that surgeons perform non-invasive remote surgery, surgical pre-operative planning, surgical preparation and practice, image-guided surgery and surgery simulation using a virtual surgery console. Referring to pre-operative planning specifically, Yule *et al*. (2006) stated that it is important in ensuring that medical professionals are prepared for surgical operations. Hu *et al*. (2019) noted that pre-operative planning is a difficult task which requires knowledge and rational thinking to decrease complications during surgery. It allows for a transfer of knowledge and skills acquired in the virtual surgical environment to the real-world. Respondent 9 also mentioned that doing pre-preparation for surgery using VR could allow for a transfer of knowledge from the VR environment to the OR. According to Sweeney (2012), VR simulation-based training can facilitate a transfer of knowledge and skills to a real-life setting if it is effectively adopted.

Potkonjak *et al*. (2016) noted that VR provides real-time feedback on decisions, actions and questions which assists students to learn and successfully retain the information and skills acquired. This could subsequently lead to a transfer of knowledge and skills to the real-world (Potkonjak *et al.,* 2016). Bing *et al*. (2019) found that residents who were assigned to VR training to perform a radical abdominal hysterectomy (RAH) (a surgical procedure for the treatment of early-stage cervical cancer) made fewer errors, performed the procedure faster, and required approximately half the time to reach an intermediate skill level of a skilled surgeon when compared to residents assigned to standard training. The authors also pointed out that the acquisition of knowledge and skills from VR training could result in a transfer of knowledge and skills to the real-world (Bing *et al.,* 2019).

VR promotes teamwork and collaboration

Respondent 4 noted that VR promotes teamwork and collaboration among students. According to the respondent, operating rooms (ORs) are one of the intense-pressure environments in a healthcare facility and a breakdown in communication during surgery can result in adverse outcomes for patients. Similarly, Moline (1995) noted that VR could be used to enhance the way medical professionals (for example, surgeons, therapists and residents) plan for medical procedures before a surgical operation. Similarly, Hu *et al.* (2019) stated that surgeons, or residents training to be surgeons, can utilise VR pre-operative patient simulations to determine the optimal surgical procedural method. The authors believe that preoperative surgical planning using VR provides more realistic predictions for surgical results (Hu *et al*., 2019).

Yule *et al.* (2006) noted that several ORs utilise a surgical safety checklist of questions for each team member to answer before a procedure begins so that each member is aware of, and is prepared for, his or her role during surgery. The goal of the checklist is to avoid errors and to improve patient safety during the surgery. However, training students on this aspect, called the surgical time-out, can be difficult. VR could, therefore, be utilised to ensure that students are fully aware of their responsibilities as a team prior to performing surgical operations (Yule *et al.*, 2006). The researcher deduced that the checklist is a crucial traditional method of preparing for surgery and that using VR for doing so would be a more effective method to prepare students for surgical operations. The VR-enabled method would subsequently lead to students learning about teamwork and collaboration. Similarly, Rabkin (2002) stated that a VR simulator can assist students to develop medical skills, including teamwork, collaboration, and communication skills, prior to interacting with a real-life patient.

In the context of this study and in terms of the first research question, the researcher deduced from the above responses and the literature that VR, if adopted for medical training in the South African context, could enhance students' knowledge and skills acquisition. This could subsequently improve healthcare in South Africa because students would be adequately prepared for real-life medical situations and, as a result, would be competent medical professionals. In addition, the tasks that medical professionals perform would be much easier to execute if they are trained continuously in them (Seretse *et al.*, 2018). Hence, VR, by providing an immersive environment for medical training, would subsequently make medical professionals' jobs simpler as it would enable them to repeatedly practice medical procedures. Additionally, based on the responses, perceived usefulness of VR positively influences the decision to adopt it for medical training.

5.3.2 Research question 2: What is the perceived effort required to use VR for medical training?

When respondents were asked if they would find VR systems for medical training easy to use, mixed responses were received. Respondent 1 stated that VR systems would initially be difficult to use for medical training because newer technologies take time to become accustomed to. Similarly, respondent 6 stated: *"I would find it difficult because I have not used it before".* In contrast, respondent 3 noted that it would be easy to use and understand because they had used VR previously for entertainment purposes. Respondent 2 observed: *"It will be difficult to use initially because no-one likes to learn a new technology when he or she is already comfortable with the currently used technology".* With the exception of four respondents (1, 4, 8 and 11) all the remaining respondents indicated that VR would be easy to use if training and workshops were provided to both students and lecturers. According to respondent 10: "*For instance, if I was told to use it for my module and the university provides training to assist me to learn about it, then I would be excited to try something new*". Respondent 11 stated that VR would be easy to use and understand given that a manual or a guide that explicitly details how to use the VR system would be provided to both staff and students to enable them to learn about the new technology.

The researcher deduced that from a South African perspective, the degree of ease related to using and understanding VR is dependent on factors such as the extent of the adoption by educational institutions as well as the extent of training provided to users. Training should be guided by expert users and training manuals provided for basic and advanced use. However, Seretse *et al.* (2018) noted that although staff require training programs to acquire skills, they are often not properly guided and provided with adequate time and realistic deadlines to focus on completing the training successfully. Training should, therefore, be combined with active mentorship to ensure that the users of a system are able to utilise and comprehend it after the training session (Seretse *et al.*, 2018).

Seretse *et al.* (2018) emphasised the importance of South African educational institutions providing adequate support to simplify the adoption of VR for medical training. He postulated that support is not only about providing training and manuals to staff members but also about reducing their negative perceptions of a new technology, especially with older staff members and changing the staff's attitude toward using the technology. The researcher deduced that the level of support from the South African educational institutions would determine whether the users (academic staff, students and medical professionals) found using and understanding the VR system easy or not. Hence, facilitating conditions and effort expectancy can positively influence the behavioural intention to adopt and use VR for medical training.

5.3.3 Research Question 3: What are the social factors that can influence the adoption of VR for medical training?

A majority of the participants (2, 3, 6, 8, 9, 10, 11 and 12) stated that the integration of VR in medical training can be influenced by doctors who are currently exploring opportunities that utilise VR in various aspects of the medical industry. Laaki, Miche, and Tammi (2019) noted that people are often empowered and influenced by trends and norms in society. In terms of VR, people (academics, students and medical professionals) would be empowered and influenced by other people who are using it for medical tasks and who are conforming to trends that relate to it, such as using VR to perform surgery remotely (Laaki *et al*., 2019).

Respondent 9 narrated a story about the current use of VR in the medical industry: *"Dr Shafi Ahmed is trying to curb the global shortage of trained surgeons. Dr Ahmed wants to be able to train thousands of surgeons simultaneously using virtual reality. The doctor used Google Glass to stream a surgical training session… I believe that guys like Dr Ahmed are shaping our future of how we go about providing medical expertise in terms of training and treatment for patients".* The researcher believes that the respondent was influenced by Dr Ahmed's work because most of his responses to the questions asked concerned Dr Ahmed's work. The researcher was able to further deduce from respondents 8, 9 and 10 that they would most likely adopt VR for medical training if they are aware of other doctors who are using VR in their work. This conclusion was deduced from the respondents' comments such as *"Dr Spiegel is a pioneer of VR in the medical industry. He began using wearable technology like biosensors to assist his patients as well as to improve healthcare for everyone…admire and aspire to be like him" (respondent 8)* and *"Doctors like Dr Ahmed are shaping the future of the medical industry and I want to be a contributing part of that future"* (respondent 9). The researcher also deduced that doctors and medical professionals who are investigating the use of VR in the medical field could influence the adoption of VR for medical training. Likewise, respondent 12 noted that students would most likely be influenced to use the VR training system if previous medical students (alumni), who are now qualified doctors, use or support the use of VR systems for training.

Social influence (SI) may be referred to as the degree to which an individual perceives the importance of other people's beliefs regarding the use of a technology (Venkatesh *et al*., 2003). As pointed to above, the researcher deduced from the responses that the respondents would be influenced by other medical professionals who are currently using VR and that the respondents were most likely to adopt VR for medical training based on the degree of influence from those medical professionals. Doctors who utilise VR in medicine, not only for training but also for other aspects in the medical field such as remote surgery, are shaping the future of healthcare (Laaki *et al*., 2019). Remote surgery is done effectively even though the surgeon is not in close proximity to the patient. The simulated medical procedure in the virtual environment is transmitted to a robotic instrument that mimics the surgeon's actions (Aziz, 2018). Surgeons can execute non-invasive remote surgery, surgical pre-operative planning, surgical preparation and practice, image-guided surgery and surgery simulation using a virtual surgery console (Aziz, 2018). Sheikh *et al.* (2016) stated that there are several uses of VR in anatomy and that medical professionals make variable use of VR based on influential people such as senior doctors and surgeons who are currently using it for medical purposes.

5.3.4 Research question 4: What are the facilitating conditions for the adoption of VR for medical training?

Respondents suggested various ways in which VR could be successfully adopted. A majority of the respondents (excluding respondents 1, 4, 8 and 11) agreed that *"...training and workshops on VR use should be provided to both students and lecturers*". Respondent 11 stated that a manual or a guide that explicitly details how to use the VR system should be provided to both staff and students to enable them to learn about the new technology. The respondents also noted that there are financial and infrastructural impediments that could hinder the adoption of VR for medical training. Some of these suggestions were noted under the 'ease of use' section (research question 2) because although these aspects are considered to be facilitating conditions, during the interviews the respondents mentioned them to substantiate their responses to research question 2.

5.3.5 Research question 5: What are the challenges to the adoption of VR for medical training?

Financial implications

Most of the respondents (apart from respondents 4, 7 and 9) commented on the VR adoption challenges from infrastructural and financial perspectives. Respondents 3, 4 and 12 mentioned that there will be an increase in costs for the organisation with regard to maintaining VR devices. Respondent 4 stated: "*Maintaining the devices, like our labs are costly, so if you have this new VR device it's going to add to costs and then what happens to the maintenance of the devices?"* Respondent 3, on the other hand, voiced concern about the use of VR at local public hospitals: *"Financial assistance is important because this kind of advanced technology will be expensive. Public hospitals are currently undergoing financial constraints and cannot afford many medical and surgical equipment required for daily running hence the use of virtual reality will not be prioritised".*

Similarly, Maran and Glavin (2003) noted that due to their complexity, VR systems are very expensive, specifically because of the purchasing, operational and maintenance costs and, therefore, the systems are often located in specialist or private medical facilities. Respondent 12 raised concerns that the University will need to evaluate the costs that will be incurred as a result of introducing VR in medical training stating: "*Aspects such as whether students would need to purchase their own devices or if the university would provide the devices, should be considered. Furthermore, how would that affect the* *fees payable by students?"* Respondent 8, also referring to students, noted: *"Most student's fees are funded by bursaries and financial aid schemes which may not allocate funding to this resource (VR)".* Respondent 9 also agreed that funding the adoption of VR would be an issue. The respondent raised an important reason for the financial issues: *"Many of the companies producing VR content like VR systems and programs are start-ups in South Africa ... Money and funding for such projects in terms of development, research and other marketing costs are not at the forefront".* Similarly, Mbarika (2004) and Monakise (2019) pointed out that most African countries cannot afford the advanced technological solutions such as VR and, therefore, its adoption for medical training remains slow in resource-limited countries.

Respondent 9, providing the example of immunotherapy and VR, explained: *"Based on medical research immunotherapy involving T-cells that express chimeric antigen receptors (these are receptor proteins that have been engineered to give T cells the ability to target a specific protein) have shown promising results in the treatment of leukaemia and lymphoma (types of blood cancer). This therapy along with technologies such as VR depict changes we can anticipate in the practice of medicine in the near future. However, despite the benefits of immunotherapy and virtual reality, there are significant challenges for its introduction into the healthcare sector in South Africa including:*

- *(i) that engineering chimeric antigen receptors are technologically demanding, and their manufacture is resource-intensive;*
- *(ii) that the regulatory system is underdeveloped and is likely to be challenged by ethical, legal and social requirements that accompany these new therapies and technologies (VR, AI);*
- *(iii) that costs are likely to be unaffordable, at least initially, and before economies of scale take effect".*

Notwithstanding the challenges, Hamza-Lup, Bogdan, Popovici and Costea (2019) stated that the benefits of using certain VR systems, for example, the *VSOne* system, include a reduction in the time and the cost of training. Additionally, Kim, Chun, Kim and Park (2011) noted that when compared with traditional symptom-management interventions in cancer treatment, VR-based interventions such as VR-based cognitive training can allow cancer patients to learn. This is due to VR-based interventions offering real-time feedback on patient performance which allows the difficulty level of the treatment to be adjusted to suit the patient's learning needs.

Resistance to change

Resistance to change was a challenge that respondents 4, 6, 7, 11 and 12 believed needed to be addressed from an organisational perspective. Respondent 12 stated the following as a challenge to the adoption of VR for medical training: *"Getting older staff to accept using newer technologies… changing to* *newer technologies will be an issue*". Tun *et al.* (2015) stated that the medical industry has not fully adopted VR for simulation-based training for various reasons, including cost, the lack of significant proof of effect and resistance to change. Additionally, Bangert and Doktor (2002) noted that a new IT system such as VR has implications that affect the organisation in terms of the organisational culture and its capacity to learn and adapt to the new technology. In developing countries, factors such as inadequate organisational structures, policies and politics can influence the organisation's ability to adopt and implement VR for medical training (Sood *et al*., 2008).

The researcher noted that the transition from old technologies such as projectors and 2D computer systems to more advanced systems such as 3D interactive and immersive systems like VR can sometimes cause resistance to change because lecturers are accustomed to the old technologies. Lecturers have had adequate exposure to, and experience with, using old technologies when compared to their exposure and experience with using VR. The researcher deduced from the responses that it is sometimes difficult for lecturers to transition from physically demonstrating a dissection of a cadaver to using a simulated 'patient' to do so. Firstly, they are accustomed to the hands-on approach of demonstrating a dissection using a human cadaver and secondly, they may refuse to switch to using a simulated environment because the VR device and environment would need to be learnt first (lecturers would need to familiarise themselves with the VR system first before using it to teach and train students).

Respondents 10, 11 and 12 focused on PowerPoint as a commonly used ICT tool and contrasted it with VR to depict their inclination to adopt or not adopt VR. These respondents perceived PowerPoint as a tool that could be used in conjunction with virtual environments. Respondent 11 explained that PowerPoint could be used to teach the theoretical sections of the coursework and VR could be used to teach the application sections, such as dissections and surgery. Respondent 8 noted: *"VR would be a suitable replacement for the videos screened prior to dissecting a cadaver. This is because videos do not allow students to fully conceptualise the subject material".* However, respondent 12 opposed replacing videos. The video referred to by the respondent is one that details the process of a dissection, especially explaining the process(es) that would occur once the video was completed. The respondent explained that they would be uncomfortable teaching an aspect of dissection if a video was not played at the beginning of the class. This further shows the respondents' mixed responses pertaining to whether they would switch completely to VR or have it as an additional tool to support the technology currently used for training.

Lack of knowledge of using VR

A few of the respondents (respondents 1, 8, 9 and 10) were well-versed with technological trends and were keen to try out newer technologies in the medical field such as VR. However, respondents 2, 3, 6 and 12 appeared to have conflicting perceptions of adopting VR (as an advanced technology). This was deduced from comments such as: *"I have heard of VR being used for gaming, but I was unaware of its medical uses and the research behind it"*; *"I understand why we would use VR but most patients cannot use simple technologies so then how would they use VR for therapy and rehabilitation?";* and *"Knowledge of how to use the technology would be an issue because not everyone would be able to fully utilise the technology and understand how it works".* The researcher believes that these respondents are reluctant to adopt VR for medical training partially because they lack adequate knowledge of it. As Govender and Mars (2018) point out, teachers should have adequate experience in and knowledge of VR to support the education and training of students.

A majority of respondents (except for respondents 1, 8, 9 and 10) when asked about their experience of using VR, declared that they had never experienced VR immersion. Hence, for them, it would be difficult to comprehend such an experience. Pelargos *et al.* (2017) made the point that VR systems require adequate knowledge and technical skills to effectively use them for medical training.

Respondent 3 generalised that students may also not be familiar with advanced technologies such as VR because some of them come to university from rural areas with limited exposure to technology. In this regard, Dhai (2018) noted that the student's lack of knowledge can be related to a lack of infrastructure at South African educational institutions. The lack of infrastructure, including skilled educators, subsequently causes a lack of exposure to new technologies and a lack of knowledge thereof (Dhai, 2018). Similarly, Buliva (2018) noted that educators who are required to teach courses remotely are not sufficiently trained to teach in virtual and technological environments, and some educators often lack adequate knowledge and experience to do so.

Regarding the use of VR for rehabilitation and therapy, Fishkin, Fishkin, Leli, Katz and Snyder (2011) observed that a lack of technological proficiency can become a problem when a patient is more technologically skilled than the therapist. The lack of technological knowledge on the part of the therapist may affect the treatment of the patient. For instance, a patient may be compelled to assist a therapist through a technical malfunction during the treatment. The patient may thus spend more time addressing technical problems of the VR system and less time on being treated. It is, therefore, very important that medical professionals have a thorough understanding of the virtual system being used to ensure that patients receive adequate treatment to recover from an illness (Fishkin *et al.,* 2011). Shuvo *et al*. (2015) noted that acquiring adequately trained personnel who have the capability to successfully administer medical treatments and address technical system difficulties is crucial but challenging. Govender and Mars (2018) stated that in South Africa there is a lack of personnel with sufficient technological knowledge to facilitate the training of healthcare professionals. This would be an impediment for the successful adoption of VR.

According to Ohei, Brink, and Abiodun (2019), developed countries have invested heavily in ICT integration in medical education and made it possible for medical students to have access to the latest updates in the medical field. On the other hand, developing countries are lagging because of several economic, social, and infrastructural limitations (Ohei *et al.,* 2019). Additionally, IT knowledge and computer skills among medical undergraduates and medical professionals are higher in developed countries compared to developing countries (Ohei *et al.,* 2019). This is mainly due to infrastructural limitations in developing countries such as the limited availability of computers and Internet connections (Ohei *et al.,* 2019). In Sri Lanka, for example, IT-based components are not included in the medical curricula of most medical schools, and experiences with IT-based activities in these medical schools are limited (Ghosh, 2017). It is a similar situation for most developing countries like South Africa. Furthermore, IT-related publications from those countries are limited (Ghosh, 2017).

Inability to differentiate simulated environments from the real-world

Respondent 3 expressed concern that students may treat real-life patients like virtual patients because the VR training system will coach students to react and behave in a specific way to attain a specific outcome. Subsequently, once their behaviour becomes routine it may lead to students developing a *"cold"* and routine attitude towards real patients. The respondent believed that students who attended university from rural (non-privileged) schools that had limited or no access to technology, were most likely to perceive the VR training as a standard manner of treating patients and, therefore, were more likely to treat real-life patients as they would patients in a virtual environment. Respondent 8 opined: *"The successful implementation of the VR technology will depend on the attitude of students and staff".*

Griffiths (2000) raised the issue of addiction to VR, stating that it is a disadvantage that becomes a problem when students can no longer differentiate between reality and VR. Similarly, Dhai (2018) observed that users can often confuse the real-world with the virtual environment and that the confusion is irrespective of the previous technological exposure that the user experienced.

Lack of haptic feedback

Respondent 8 raised the issue of haptic feedback: "*…various simulators have been tested and have shown clear benefits for medical training. However, while graphical realism is high, realistic haptic feedback and interactive tissues are limited for many simulators*". Smith *et al.* (2015) stated that training devices such as VR devices that have haptic feedback mechanisms tend to improve skills acquired in the virtual environment and may, therefore, lead to a transfer of training to the real-world. Torkington, Smith, Reest and Darzi (2000) noted that the MIST-VR simulator has no haptic interface, meaning that there is no feedback from the instruments and/or objects when it makes contact which simply translates to its inefficiency to maintain an immersive 'feel' in the VR environment. Similarly, McGrath *et al*. (2018) stated that haptic feedback allows residents to 'feel' a physical object and to manipulate it in a realistic manner and that without such feedback residents would not be aware of the amount of force they are applying to a scalpel or the tissue resistance they would normally encounter during a surgical procedure. Providing haptic feedback is thus a major factor influencing the adoption of VR for medical training.

5.3.6 Research question 6: How can VR be adopted for medical training purposes?

Solutions to overcome the challenges

Performing a cost-benefit analysis before the adoption of VR

Respondents 4, 9, 11 and 12 recommended that South African educational institutions should consider performing a cost-benefit analysis to assess the financial feasibility of adopting VR for medical training. Comments such as *"We need to first look at whether it can be used to teach medicine and how effective would it be?"* and *"Does the benefit derived from adopting VR for medical training outweigh the cost of it?"*, indicated that respondents believed that VR should only be adopted for medical training if the benefits of using it outweigh the cost of its purchase and maintenance. Similarly, Beck *et al*. (2007) noted that the benefits derived from using VR systems must outweigh the cost of their purchase or development to ensure that effective outcomes are attained when using them for training, treatment and therapy. Respondent 12 suggested that randomised studies on the adoption of VR for medical training should be provided to show evidence of VR's benefits and thus enable its wide-scale adoption by healthcare professionals. Similarly, De Rosis and Nuti (2018) stated that focus should be on actionable research, management aspects, and scalability of VR when gathering evidence and assessing its adoption.

According to Harrison (2018), there must be positive outcomes for all stakeholders for change to be accepted. Patients need to see improvements in the way they access healthcare and medical professionals' workloads need to be reduced where necessary (Harrison, 2018). This statement re-iterates that the benefits of using VR should be evident to all users for it to be accepted (Harrison, 2018). The researcher thus believes that there must be an effective transition from old methods of training (for example, human cadavers and training boxes) to newer methods of training using VR. A clear depiction of the positive outcomes of using VR for medical training is needed for it to be successfully adopted by South African educational institutions.

Forming partnerships with VR companies and seeking sponsorships or donations from alumni

Respondent 3 suggested that the University should liaise with VR companies to enable them to *"get a contract to acquire cost-effective devices".* Elliman *et al*. (2016) noted that the Google Cardboard VR device is cost-effective and has limited hardware restrictions, therefore making it easier for students and other users to access healthcare training. The Google Cardboard Kit (T) is another cost-effective solution to mitigate the cost of purchasing VR hardware (Buliva, 2018). These cost-effective devices and systems make the adoption of VR for medical training a possibility (Elliman *et al*., 2016). Similarly, Buliva (2018) noted that these cost-effective devices can subsequently result in the adoption of VR for education provided that other factors such as infrastructure and the training of educators are addressed as well.

Most of the respondents, apart from respondents 4 and 7, were of the opinion that in order to deal with the financial constraints of adopting VR for medical training, the University could seek funding from sponsorships or donations from former students (alumni) who are now qualified medical professionals. In addition, respondent 6 stated: *"VR can decrease the operational cost of a physical training facility and it can allow students and medical personnel to train remotely without the additional costs".* The respondent mentioned that VR enables remote training to occur which would result in the University saving costs. Buliva (2018) noted that countries in sub-Saharan Africa can form partnerships with established VR providers in developed countries to learn from them and facilitate the transfer of technology.

Increasing national budget allocated to healthcare

Respondent 9 suggested that governments from developing countries should increase their budgets allocated to clinical simulation centres. Respondents 7, 8, 9 and 10 voiced that the South African government should actively participate in the wide-scale adoption of advanced technologies, such as VR for medical training, by South African educational institutions. Respondents 8 and 9 believed that the government would be able to allocate funds for new educational developments. Respondent 9 expressed further: *"If the government allocates more funds to advanced technologies for training medical professionals, this could subsequently result in a decrease in poorly skilled medical professionals. Additionally, national investment should be made into finding novel and innovative ways to introduce therapies such as immunotherapy and technologies such as VR into South Africa sooner rather than later to ensure that South African patients are not excluded from these exciting global initiatives".*

Ohei *et al.* (2019) supported the idea of the government getting involved in making healthcare available and accessible to everyone. Similarly, De Rosis and Nuti (2018) stated that financing of initiatives affecting healthcare, for example, VR, should come from the national government. Buliva (2018) suggested that if VR were to be successfully combined into the curricula of educational institutions in sub-Saharan Africa, national policies would need to be adjusted to accommodate students using the technology. De Rosis and Nuti (2018) added that to promote sustainable long-term investment in VR, the government needed to integrate policies and scale up current infrastructure by including technological innovation in the healthcare strategy and in its healthcare financing models.

Respondent 8 mentioned: "*Local students that are being trained abroad require a lot of money which the government could put to better use*". Dhai (2018) noted that while the South African government spends millions sending students to train abroad, it lacks the funds required to purchase medical equipment such as wheelchairs (Dhai, 2018). Dhai (2018) further noted the crucial need for government to support the adoption of VR for medical training in South Africa. The author argued that once the country had the necessary resources to train local students, there would be no need for these students to travel abroad to study. This would prevent money from flowing out of the country and may provide an opportunity for international students to come to South Africa to study. Both would have a positive impact on the South African economy (Dhai, 2018).

Implementing a gradual adoption process

As a solution to the issue of unwillingness to change, respondents 4, 6, 7 and 8 recommended that the VR system needed to be gradually introduced to users (staff and students). According to Ohei *et al.* (2019), people become resistant to change because of a lack of support to facilitate the change. Respondent 3 mentioned that students need to be properly educated on the use of VR because "*they must be aware of the difference between using the VR technology and treating a real person".* Users (staff and students) of VR systems can only be properly educated on them if the process of adoption is not rushed. The researcher, therefore, believes that to prevent resistance to change, the University needs to implement proper procedures and support facilities for the adoption of VR for medical training. A gradual adoption process needs to be pursued to allow staff and students to get used to the new technology (VR). Similarly, Zhao, Pugh, Sheldon and Byers (2002) noted that instead of implementing a new technology using a radical approach, that is, on a large scale, the adoption of a new technology should be done using an evolutionary approach, that is, in small increments. Thus, by adopting small progressive steps that are manageable, users (medical professionals, staff and residents) are more likely to experience less frustration and more success with using the virtual environment (Zhao *et al.*, 2002).

Introducing an effective change management process

Ohei *et al.* (2019) noted that several South African institutions invest in IT skills development when it is too late. Ohei *et al.* (2019) further noted that negative environments are created at the workplace when training is rushed or when staff feel pressurised to learn about a new technology. As a suggestion for preventing negative environments from occurring, respondents 5, 7 and 9 stated that change management and education should be at the forefront of the adoption of VR for medical training. Respondent 9 stated: "*Universities should empower the staff to the extent that they are excited about gaining new skills"*. As part of the change management approach, Ohei *et al.* (2019) suggested that universities can implement skills training using unconventional methods such as dividing staff members into teams and allocating VR tasks to them to complete. Ohei *et al.* (2019) further suggested that universities can use a rewards approach (such as a points-based system: points 1-4 ranging from bad to good or a status system: winners, runners-up, and losers) instead of enforcing deadlines. This is one way to train staff members without making them feel pressurised to learn about VR. The idea is to make staff members goal-driven and to motivate them to learn more about VR (Ohei *et al.*, 2019).

Solutions to overcome a lack of haptic feedback

Respondent 10 stated that the VR system would be easy to use *"... if the design is user friendly and it provides feedback to assist users, hence making the VR simulation real-lik*e". Respondent 9 noted: *"Haptic feedback is especially important with the rehabilitation of patients suffering from mobility-related illnesses that require stimulation of the senses. For instance, the position of an amputated arm is tracked by 3D sensors in the VR environment or movement of fingers are tracked by the VR motion-sensing gloves. A lack of haptic feedback would prevent patients from feeling the rehabilitation".* The respondent spoke about creating a life-like VR environment that provides feedback to patients.

To overcome a lack of haptic feedback, VR environments should be designed to closely resemble the real-world environment (McGrath *et al*., 2018). Ali, DeMaria, Kaplan and Mowery (2002) found that VR simulations that are developed with life-like interfaces are easy to use and understand. Ahlberg *et al.* (2002) found that there was no transfer of training and skill acquisition from the VR environment to the real-world because the interface of the VR environment was difficult to understand and caused usability constraints. The researcher deduced that the VR system interface and overall design should be simple to understand for a novice user. Ananda and Suman (2016) noted that Google Cardboard is a VR device that is designed in a way that makes it easier for all users (novices and experts) to utilise it because it uses a smartphone device and hence decreases the complexity of having a separate computing device that it runs off (Ananda and Suman, 2016).

Solutions to overcome the lack of knowledge about using VR

Respondent 12 suggested that training should be provided in at least three different languages (English, IsiZulu and Afrikaans) to ensure the successful adoption of VR for medical training. The respondent further suggested: *"There are a few unused venues available at the Medical School Campus which could be used to create different VR rooms, each used for different aspects of VR training".* There is a need to assist local educators and medical trainers with the ability to fully use the VR systems (Buliva, 2018). Ohei *et al.* (2019) argued that a lack of knowledge of VR systems at institutions can be addressed by implementing developmental training programs that combine formal education and unstructured learning. To address the lack of knowledge at educational institutions requires strategic planning and a comprehensive organisational strategy that prioritises skills development. Formalising training sessions will ensure that existing skills are assessed, and new skills are gained to prevent obstacles in the learning process (Ohei *et al.,* 2019).

In the context of this study, UTAUT's facilitating conditions (FC) could refer to the factors and resources at UKZN that the respondents believe should be present to support the adoption of VR. In this regard, the respondents highlighted various challenges that should be addressed for the successful adoption of VR for medical training. The proposed solutions could be seen as the pre-conditions for the adoption of VR for medical training. However, the mentioned challenges are not exhaustive and hence further research should be conducted on the potential challenges to the adoption of VR for medical training as well as the solutions to overcome them. For example, VR uses Internet connectivity and, therefore, educational institutions should be able to have access to the devices required for the adoption of VR as well as access to a high-speed network (broadband) infrastructure (Ma, Jain and Anderson, 2014). Although South Africa has recently implemented fibre optic cables for Internet connectivity, it has not been done on a wide scale with the result that some places in South Africa still experience slow Internet speed. Slow Internet speed along with high data costs can be challenges that affect the adoption of VR for immersive medical training at South African educational institutions, and specifically in situations where students require real-time feedback and where analytics on training statistics and course completion tracking are done as students train (Guo *et al*. 2020). According to Dhai (2018), crucial aspects such as proper maintenance of public hospitals, availability of hospital equipment such as life-support machines and other crucial machinery, and spaces available at medical universities for the enrolment of students, will need to be assessed to reach a decision about adopting VR for medical training in South Africa.

5.4. Conclusion of Chapter five

This chapter discussed the interviewees' responses in relation to the research questions, the reviewed literature and the theoretical framework. Most of the respondents perceived VR to be useful for medical training. In addition, most respondents perceived that using VR will be easy, provided that there are adequate interventions in the form of formal and informal training. Moreover, the academic staff members insinuated that they are, or could be influenced by their peers to adopt VR for medical training. The chapter further discussed the challenges and the proposed solutions to the adoption of VR for medical training.

The following chapter is the final one of the dissertation. It provides a summary, conclusions, recommendations, and suggestions for further research.

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1. Introduction

This chapter summarises the study, provides conclusions and recommendations stemming from the findings and discussion, and suggestions for further research.

6.2. Summary of the study

VR is a new concept in South Africa and, therefore, limited literature exists from a South African educational perspective. This study aimed at identifying the determinants of the adoption of VR for medical training, the challenges to doing so, and the proposed solutions to overcome these challenges.

Various studies have highlighted the possibilities and benefits associated with using VR for medical training as indicated in the literature review (Chapter two). However, the literature review revealed that research on the adoption of VR for medical training in South Africa is scarce. Mbarika (2004) and Monakise (2019) stated that most African countries, which can be referred to as resource-limited countries, cannot afford advanced technological solutions such as VR and, therefore, its adoption for medical training remains slow. This study investigated the determinants of, and the challenges to, the adoption of VR for medical training in the South African educational context. Using the Unified Theory of Acceptance and Use of Technology (UTAUT) as a framework, the study investigated the perceived usefulness of VR to train medical students, the ease of use of the technology, social influence towards the adoption of the technology for medical training, and the facilitating conditions for its adoption. Interviews were held with 12 academic staff members from the School of Laboratory Medicine and Medical Sciences at the Westville Campus of the UKZN. The interviewees were chosen using a purposive sampling strategy and all were or had been practising doctors who also taught at the University.

Findings depicted in Chapter 5 revealed that from the interviewees' (respondents) point of view, the use of VR simulations for training medical students is useful because it provides a safe training environment to practice dangerous or risky medical procedures. In addition, VR simulations expose students and other users to emergency situations. The simulations are beneficial from an ethical perspective and they enable students to make errors and learn from them, thus promoting skills development. VR simulations also accommodate students with different learning needs, assist students to learn about anatomy in a realistic setting and enable a transfer of knowledge and skills to the real-world. The interviewees mentioned that due to the evolving nature of technology, there is a need for adequate training to ensure that VR is perceived to be easy to use. Interviewees also mentioned that medical professionals, who are already using or investigating the use of VR, could motivate their peers to incorporate the technology in their teaching portfolio. They further mentioned that there is a need to implement an effective change management process to gradually phase in VR for medical training. In terms of the challenges, the interviewees expressed their concerns about the infrastructural and financial capabilities of the institution and the South African higher education sector to adopt VR. However, these are not an exhaustive list of challenges and, therefore, further research should be conducted to identify additional challenges and factors that hinder the adoption of VR for medical training. Further studies should also focus on practical solutions to overcome the identified challenges.

6.3. Conclusion

The researcher believes that the adoption of VR for medical training will be assessed based on its feasibility (cost-benefit analysis) and the infrastructure needed to do so. Pepper, Alessandrini, Pope, Van Staden and Green (2019) noted that antiretroviral therapy (ART) for HIV in South Africa can be used as an illustration. It makes sense from both a clinical and an economic perspective to provide ART because everyone suffering from HIV stands to benefit. Hence, gene therapy (similar to immunotherapy mentioned by respondent 9) for HIV subsequently resulting in a cure would be plausible if the once-off cost of the HIV gene therapy were less than the lifetime cost of current HIV treatment. Pepper *et al*. (2019) noted that the current cost of HIV gene therapy in South Africa would significantly outweigh the cost of lifetime ART for HIV (bearing in mind that the cost of anticipated medical complications and the costs to society are more difficult to define). Using the above analogy, the researcher believes that the adoption of VR for medical training is not currently advisable from a health economics perspective because the infrastructure, equipment and manufacturing costs are likely to be unaffordable. However, respondent 9 mentioned that cost reductions are likely to occur in the future as advanced technologies such as VR are refined and adapted to local settings and that economies of scale are likely to result in significant cost reductions.

According to the World Bank, South Africa has the highest Gini coefficient globally, which reflects large inequalities in individual or household incomes. This inequality is clearly visible in the healthcare sector, where more than 50 percent of total annual health expenditure in the country is in the private health sector (serving less than 20 percent of the population), while less than 50 percent is in the public health sector (serving more than 80 percent of the population) (Lee, Noh and Khim, 2020). Mehl *et al*. (2018) stated that several advanced technologies are available in the private sector but not in the public sector because of challenges such as financial constraints. It is, therefore, possible that innovative technologies such as VR may enter the South African market initially through the private sector. Although, public sector patients may not initially benefit from VR, by being able to demonstrate its efficacy, the South African government may be persuaded to provide the necessary funding for it to be used for the rehabilitation of patients from public hospitals.

This state of affairs raises the question whether South Africa should refrain from participation and simply be a bystander in the development of rapidly evolving and highly efficacious, albeit costly, technologies (Mehl *et al*., 2018). However, Leong (2019, p. 4) noted that the "evidence of the relative efficacy and effectiveness of technology (including medical devices and advanced technological medical systems) would be assessed against the current standard of care". A related aspect in the NHI Bill states that "The Benefits Advisory Committee must determine and review detailed and cost-effective treatment guidelines that take into account the emergence of new technologies" (Leong, 2019, p. 8). This simply means that there is a possibility for technologies such as VR to be adopted in the healthcare industry provided that they are cost-effective when compared to currently used treatment methods. Hence, it is possible for VR to be adopted for medical training in South Africa. However, the researcher believes that VR could also be adopted under the government's 10-point plan which includes the integration of new technologies into the South African healthcare industry. Non-adoption of VR would be due to the cost of implementation and the priorities of the DoH.

6.4. Recommendations

Hennink *et al.* (2020) noted that the recommendations need to be well supported by the findings of the study. Generally, the challenges identified by the study serve as a foundation for further research and hence need to be listed in the recommendations section (Hennink *et al.,* 2020). Furthermore, the listed recommendations should be reasonable and contextually relevant (Hennink *et al.,* 2020). Similarly, Bush and Amechi (2020) noted that the recommendations section should focus on describing the implementation of an innovation to provide practical suggestions to not only address the impediments found in the study but should also guide further research to strive to attain optimum service delivery in any given context.

Based on this study, respondents suggested a gradual approach to VR adoption, combined with fundraising, requests for financial assistance, and forming partnerships with UKZN's alumni. However, the researcher believes that although financial assistance from government, alumni, and relevant partners is crucial, a business case for the adoption of VR should first be drawn up. The business case should specify, among other vital aspects, the functionality of VR required for medical training (immersive e.g. Patient Simulators or non-immersive e.g. Second Life), budgeted costs and target markets. This will enable stakeholders to make informative decisions about estimated costs associated with purchasing and maintaining a VR system for medical training. Similarly, De Rosis and Nuti (2018) stated that focus should be on actionable research, management aspects, and scalability of VR when gathering evidence and assessing its adoption.

Furthermore, some respondents indicated that a lack of knowledge of VR would become an issue because *"not everyone would be able to understand how to fully utilise the technology"* (participants 2, 3, 6 and 12). Similarly, Govender and Mars (2018) point out, teachers should have adequate experience in and knowledge of VR to support the education and training of students. To surmount the challenge of a lack of knowledge, respondent 12 suggested that training should be provided in at least three different languages (English, IsiZulu and Afrikaans) to ensure the successful adoption of VR for medical training. Similarly, the researcher believes that tailoring VR training and instruction manuals to be in South African languages will assist with exploring the full potential of VR because it will become easier to understand how to use the technology, provided its instruction manual is in vernacular. Buliva (2018) noted that there is a need to assist local educators and medical trainers with the ability to fully use the VR systems. Similarly, Ohei *et al.* (2019) argued that a lack of knowledge of VR systems at institutions can be addressed by implementing developmental training programs that combine formal education and unstructured learning.

Resistance to change was another identified challenge from a South African educational context. Tun *et al.* (2015) stated that the medical industry has not fully adopted VR for simulation-based training for various reasons, including cost, the lack of significant proof of effect and resistance to change. The respondents indicated that the South African educational institutions should adopt a hybrid approach, combining the use of existing technologies such as PowerPoint and multimedia in conjunction with new ones such as VR. Although the researcher agrees with the suggestions of the participants to surmount the challenge of resistance to change, the researcher also believes that because of the major differences between using VR and using traditional teaching methods (PowerPoint and multimedia), educators will encounter a learning curve when trying to use the technology and hence focus should be given to training and teaching educators on how to use VR to try to reduce their resistance in terms of adopting VR for medical training.

Similarly, Datta-Paulin and Salt (2019) found that the participants from their study were reluctant to try new techniques of training such as VR because they preferred the old training techniques. Mazurek *et al*. (2019) also found that older users (senior medical professionals) were more likely to be reluctant to use VR for medical purposes because they were accustomed to traditional training methods. Both Datta-Paulin and Salt (2019) and Mazurek *et al*. (2019) emphasised the need to teach users (educators, medical professionals, students) how to use a new technology to enable a smooth transition from using traditional technologies to using advanced ones such as VR.

In addition, UKZN (and any other institution that wishes to adopt VR for medical training) should engage its academic staff on the need to move to VR systems and to create a pathway for their adoption. Regarding the reasoning to migrate to using VR systems, the researcher believes that educational institutions should explain to users (medical professionals and academic staff) about how VR can be used not only as a teaching and learning tool but also about how it could be used to enhance healthcare for South Africans. Additionally, the costs and benefit(s) obtained from using VR should be explicitly depicted to ensure that users (medical professionals and academic staff) are fully aware of the pros and cons of adoption. This will spark debate among users (medical professionals and academic staff) and will prompt users to provide alternative suggestions to assist with the adoption of VR for medical training. Harrison (2018) noted that there must be positive outcomes for all stakeholders for change to be accepted.

6.5. Limitations of the study and suggestions for further research

The researcher acknowledges that not all the determinants and challenges to the adoption of VR in medical training were investigated because of time constraints. Thus, the researcher suggests a further in-depth investigation of additional factors that may influence the adoption of VR in the South African higher education sector. Further studies should adopt a more robust theoretical and methodological approach and should endeavour to capture stakeholders' perceptions on a large scale, that is, from more than one educational institution. According to Lopreiato and Sawyer (2015), the adoption of VR for medical training is influenced by changes in the standards of medical training, which focus on incorporating sophisticated technologies within traditional training methods. Further studies should be conducted to assess the possibility of adopting VR in the South African education sector in terms of the prevailing infrastructure, the financial implications for the educational institutions, as well as the educational policies put in place by the government that dictate the rules for technology adoption in the sector. Finally, further studies should investigate the integration of technologies such as IoMT, AI and VR to enhance eHealth.

REFERENCES

Abbasi, M. S. (2011). *Culture, demography and individuals' technology acceptance behaviour: A PLS based structural evaluation of an extended model of technology acceptance in South-Asian country context*. (Unpublished doctoral thesis), Brunel University, England.

Abubakar, F. M., and Ahmad, H. B. (2013). The moderating effect of technology awareness on the relationship between UTAUT constructs and behavioural intention to use technology: A conceptual paper. *Australian Journal of Business and Management Research, 3*(2), 14-23.

Adams, H., Shinn, J., Morrel, W.G., Noble, J. and Bodenheimer, B. (2019). Development and evaluation of an immersive virtual reality system for medical imaging of the ear. In B. Fei and C.A. Linte (Eds.), *Medical Imaging 2019: Image-Guided Procedures, Robotic Interventions, and Modeling*, 10951, 14 June. San Diego, California: International Society for Optics and Photonics.

Afkhami, M. (2012). *Leading to choices: a leadership training handbook for women*. Maryland, U.S.A: Development and Peace (WLP), 11-153. ISBN 0-9710922-0-6.

Aggelidis, V.P. and Chatzoglou, P.D. (2009). Using a modified technology acceptance model in hospitals. *International Journal of Medical Informatics*, *78*(2), 115-126.

Ahlberg, G, Heikkinen T, Iselius L., Leijonmarck, C.E, Rutqvist J. and Arvidsson D. (2002). Does training in a virtual reality simulator improve surgical performance? *Surgical Endoscopy*, *16*(1), 126-129.

Ajzen, I. (1985). From intentions to actions: a theory of planned behaviour. In J. Kuhl and J. Beckman (Eds.) *Action control: From cognition to behaviour* (pp. 11-39). Berlin, Heidelberg: Springer.

Ajzen, I. (1989). Attitude structure and behavior. In A.R. Pratkanis, S.J. Breckler and A.G. Greenwald (Eds.), *Attitude structure and function* (pp. 241-274). Hilldsdale, New Jersey: Lawrence Erlbaum Associates, Inc.

Ajzen, I. (1991). The Theory of Planned Behaviour. *Organisational Behaviour and Human Decision Processes*, *50*(2), 179-211.

Ajzen, I., and Fishbein, M. (1977). Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychological Bulletin*, 84(5), 888.

Ajzen, I., and Madden, T. J. (1986). Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psychology*, 22(5), 453-474.

Alblas, A., Greyling, L. M., and Geldenhuys, E.M. (2018). Composition of the Kirsten skeletal collection at Stellenbosch University. *South African Journal of Science*, *114*(1-2), 1-6.

Al-Gahtani, S.S., Hubona, G. S., and Wang, J. (2007). Information technology (IT) in Saudi Arabia: Culture and the acceptance and use of IT. *Information and Management*, 44(8), 681-691.

Ali, M.R., DeMaria, E.J., Kaplan., B. and Mowery, Y. (2002). Training the novice in laparoscopy. *Surgical Endoscopy, 16,* 1732-1736. doi: 10.1007/ s00464-002-8850-6

Alkhwaldi, A.F.A., and Kamala, M.A. (2017). Why do users accept innovative technologies? A critical review of models and theories of technology acceptance in the information system literature. *Journal of Multidisciplinary Engineering Science and Technology (JMEST), 4*(8), 7962-7971.

Al Kuwari, K. M. (2018). Simulation-based medical education. *Bahrain Medical Bulletin, 158*(5914), 1-2.

Al-Rajhi, M., Liu, K., and Nakata, K. (2010). A conceptual model for acceptance of information systems: An organizational semiotic perspective. *Proceedings of the Americas Conference on Information Systems* (p. 348). Lima, Peru. Retrieved from https://aisel.aisnet.org/amcis2010/348**.**

Ananda, B.R. and Suman, D. (2016). Smartphone based virtual reality systems in classroom teaching: A study on the effects of the learning outcome. *8th IEEE International Conference on Technology for Education* (pp. 68-71). Mumbai, India: Indian Institute of Technology Bombay.

Anderson, E.W. and Sullivan, M.W. (1993). The antecedents and consequences of customer satisfaction for firms. *Marketing Science, 12*(2), 125-143. https://doi.org/10.1287/mksc.12.2.125.

Anderson, E.W., Fornell, C. and Lehmann, D.R. (1994). Customer satisfaction, market share, and profitability: Findings from Sweden. *Journal of Marketing*, *58*(3), 53. https://doi.org/10.2307/1252310.

Andreatta, P. B., Maslowski, E., Petty, S., Shim, W., Marsh, M., Hall, T., . . . Frankel, J. (2010). Virtual reality triage training provides a viable solution for disaster-preparedness. *Academic Emergency Medicine*, *17*(8), 870-876.

Arning, K., and Ziefle, M. (2007). Understanding age differences in PDA acceptance and performance. *Computers in Human Behavior*, *23*(6), 2904-2927. https://doi.org/10.1016/j.chb.2006.06.005.

Asano, T., Yano, H., and Iwata, H. (1997). Basic technology of simulation system for laparoscopic surgery in virtual environment with force display. *Studies in Health Technology and Informatics, 39*, 207-215.

Atkinson, J.W. (1964). *An introduction to motivation*. Oxford, England: Van Nostrand.

Attuquayefio, S. and Addo, H. (2014). Review of studies with UTAUT as conceptual framework. *European Scientific Journal*, *10*(8), 249-258.

Azer, S.A. and Azer S. (2016). 3D anatomy models and impact on learning: A review of the quality of the literature. *Health Professions Education*, *2*(2), 80-98.

Aziz, H.A. (2018). Virtual reality programs applications in healthcare. *Journal of Health and Medical Informatics*, *9*(1), 1-3.

Baby, B., Srivastav, V. K., Singh, R., Suri, A., and Banerjee, S. (2016). *Neuro-endo-activity-tracker: An automatic activity detection application for neuro-endo-trainer: Neuro-endo-activity-tracker.* In the International Conference on Advances in Computing, Communications, and Informatics (ICACCI) (pp. 987-993), Jaipur, India: IEEE, doi: 10.1109/ICACCI.2016.7732173.

Bajaj, A., and Nidumolu. S. R. (1998). A feedback model to understand information system usage. *Information and Management*, *33*(4), 213-224. https://doi.org/10.1016/S0378-7206(98)00026-3.

Bandura, A. (1986). *Social foundations of thought and action.* Englewood Cliffs, NJ.: Prentice Hall.

Bandyopadhyay, K. and Bandyopadhyay, S. (2010). User acceptance of information technology across cultures. *International Journal of Intercultural Information Management*, *2*(3), 218-231.

Banerjee, D., Cronan, T.P. and Jones, T.W. (1998). Modelling IT ethics: A study of situational ethics. *MIS Quarterly*, *22*(1), 31-60.

Bangert, D. and Doktor, R. (2002). Telemedicine as an IS implementation problem: comparison of dynamics in the USA and India. *International Journal of Healthcare Technology and Management*, *4*(6), 525-541.

Banszki, F., Beilby, J., Quail, M., Allen, P., Brundage, S. and Spitalnick, J. (2018). A clinical educator's experience using a virtual patient to teach communication and interpersonal skills. *Australasian Journal of Educational Technology*, *34*(3), 60-73.

Basias, N. and Pollalis, Y. (2018). Quantitative and qualitative research in business and technology: Justifying a suitable research methodology. *Review of Integrative Business and Economics Research, 7,* 91-105.

Baxter, P. and Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *Qualitative Report*, *13*(4), 544-559.

Beck, J. G., Palyo, S. A., Winer, E. H., Schwagler, B. E., and Ang, E. J. (2007). Virtual reality exposure therapy for PTSD symptoms after a road accident: An uncontrolled case series. *Behavior Therapy*, *38*(1), 39-48.

Beiske, B. (2007). *Research methods. Uses and limitations of questionnaires, interviews, and case studies*. Manchester: Manchester School of Management Generic Research.

Bell, D., Gachuhi, N. and Assefi, N. (2018). Perspective piece. Dynamic clinical algorithms: Digital technology can transform healthcare decision-making. *American Journal of Tropical Medicine and Hygiene*, *98*(1), 9-14. doi: 10.4269/ajtmh.17-0477

Bell, E., Bryman, A., and Harley, B. (2018). *Business research methods*. Oxford: Oxford University Press.

Bertsch, T.G., McKeirnan, K.C., Frazier, K., VanVoorhis, L., Shin, S. and Le, K. (2019). Supervising pharmacists' opinions about pharmacy technicians as immunizers. *Journal of the American Pharmacists Association*, *59*(4), 527-532.

Bhattacherjee, A. (2012). *Social science research: Principles, methods, and practices.* Textbooks Collection. Book 3. Retrieved from https://scholarcommons.usf.edu/oa_textbooks/3.

Bian, Q. and Forsythe, S. (2012). Purchase intention for luxury brands: A cross cultural comparison. *Journal of Business Research*, *65*(10), 1443-1451. https://doi.org/10.1016/j.jbusres.2011.10.010

Bickmore, T.W., Pfeifer, L.M. and Jack, B.W. (2009). Taking the time to care: empowering low health literacy hospital patients with virtual nurse agents. In CHI '09: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1265-1274). New York, USA: ACM.

Biemans, M., Swaak, J., Hettinga, M. and Schuurman, J.G. (2005). Involvement matters: the proper involvement of users and behavioural theories in the design of a medical teleconferencing application. In *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work* (pp. 304-312). Florida, USA: ACM.

Bing, E.G., Parham, G.P., Cuevas, A., Fisher, B., Skinner, J., Mwanahamuntu, M. and Sullivan, R. (2019). Using low-cost virtual reality simulation to build surgical capacity for cervical cancer treatment. *Journal of Global Oncology, 5,* 1-7.

Bloom, D., Canning, D. and Chan, K. (2006). *Higher Education and Economic Development in Africa*. (Human Development Sector, Africa Region). [Washington, DC: World Bank].

Boian, R.A., Sharma, C., Han, C., Burdea, G., Merians, A., Adamovich, S., Recce, M., Poizner, H. (2002). Virtual reality-based post-stroke hand rehabilitation. *Studies in Health Technology and Informatics*, *85,* 64-70.

Bracq, M.S., Michinov, E., Arnaldi, B., Caillaud, B., Gibaud, B., Gouranton, V. and Jannin, P. (2019). Learning procedural skills with a virtual reality simulator: An acceptability study. *Nurse Education Today*, *79,* 153-160.

Brantlinger, E., Jimenez, R., Klingner, J., Pugach, M. and Richardson, V. (2005). Qualitative studies in special education. *Exceptional Children, 71*(2), 195-207.

Braun, A., Trivedi, D. P., Dickinson, A., Hamilton, L., Goodman, C., Gage, H., . . . Manthorpe, J. (2019). Managing behavioural and psychological symptoms in community dwelling older people with dementia: 2. A systematic review of qualitative studies. *Dementia*, *18*(7-8), 2950-2970.

Braun, V., and Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Brooks, B.M., McNeil, J.E., Rose, F.D., Greenwood, R.J., Attree, E.A., and Leadbetter, A.G. (1999). Route learning in a case of amnesia: A preliminary investigation into the efficacy of training in a virtual environment. *Neuropsychological Rehabilitation*, *9*, 63-76.

Brown, S. A., and Venkatesh, V. (2005). A model of adoption of technology in the household: A baseline model test and extension incorporating household life cycle. *Management Information Systems Quarterly*, *29*(3), 11.

Bruner, G.C. and Kumar, A. (2005). Explaining consumer acceptance of handheld Internet devices. *Journal of Business Research*, *58*(5), 553-558. https://doi.org/10.1016/j.jbusres.2003.08.002.

Bryman, A. (2011). Research methods in the study of leadership. In *the SAGE handbook of leadership*, (pp.15-28). London: Sage. Retrieved from http://www.elfhs.ssru.ac.th/pokkrong_ma/pluginfile.php/50/block_html/content/The%20SAGE%20Handbook%20of%20Leadership.pdf#page=54.

Bryman, A. (2012). Sampling in qualitative research. *Social Research Methods*, *4*, 415-429.

Buck, G.H. (1991). Development of simulators in medical education, *Gesnerus*, *48*, 7-28.

Buliva, N. (2018). Virtual reality and knowledge rediscovery in sub-Sahara Africa: A review of literature. In *International Conference on Innovative Technologies and Learning* (pp. 36-47). Portoroz, Slovenia: Springer.

Burdea, G. (2002). KeyNote Address: Virtual Rehabilitation-Benefits and Challenges. CAIP Center, Rutgers University. Retrieved from http://ti.rutgers.edu/publications/papers/2002_vrmhr_burdea.pdf.

Burdea, G., Popescu, V., Hentz, V. and Colbert, K. (2000). Virtual reality-based orthopedic tele-rehabilitation. *IEEE Transactions on Rehabilitation Engineering*, *8*(3), 429-432.

Burger, R. and Christian, C. (2018). Access to health care in post-apartheid South Africa: Availability, affordability, acceptability. *Health Economics, Policy and Law*, *15*(1), 1-13.

Burmeister E. and Aitken, L.M. (2012). Sample size: How many is enough? *Australian Critical Care*, *25*, 271-274. doi: 10.1016/ j. aucc.2012.07.002

Bush, A. A., and Amechi, M. (2020). QUALITATIVE RESEARCH IN PHARMACY EDUCATION. *American Journal of Pharmaceutical Education*, *84*(3), 7129.

Carr L.T. (1994). The strengths and weaknesses of quantitative and qualitative research: What method for nursing? *Journal of Advanced Nursing*, *20*, 716-721.

Casso, G., Schoettker, P., Savoldelli, G. L., Azzola, A., and Cassina, T. (2019). Development and initial evaluation of a novel, ultraportable, virtual reality bronchoscopy simulator: the computer airway simulation system. *Anesthesia and Analgesia*, *129*(5), 1258-1264.

Cecil, J., Gupta, A., Pirela-Cruz, M. and Ramanathan, P. (2017). A cyber training framework for orthopedic surgery. *Cogent Medicine*, *4*(1), 1419792.

Cecil, J., Xavier-Cecil, A. and Gupta, A. (2017). Foundational elements of next generation cyber physical and IoT frameworks for distributed collaboration. In *13th IEEE Conference on Automation Science and Engineering (CASE),* (pp. 789-794). Xian, China: IEEE.

Chang, F.H., Chang, C. and Cheng, Y.W. (2012). Planned behavior theory factors influencing employers' willingness to hire people with mental illness, *Chinese Journal of Mental Health*, *25*(1), 73-104.

Chao, L.F., Huang, H. P., Ni, L.F., Tsai, C.L. and Huang, T.Y. (2017). Construction and application of innovative education technology strategies in nursing, *Journal of Nursing*, *64*(6), 26-33.

Chau, P.Y.K. and Lai, V.S.K. (2003). An empirical investigation of the determinants of user acceptance of internet banking. *Journal of Organizational Computing and Electronic Commerce*, *13*(2), 123-145. https://doi.org/10.1207/S15327744JOCE1302_3.

Chaudhry, A., Sutton, C., Wood, J., Stone, R. and McCloy, R. (1999). Learning rate for laproscopic surgical skills on MIST VR, a virtual reality simulator: quality of human-computer interface. *Annals of the Royal College of Surgeons of England*, *81*(4), 281-286.

Chen, C.J. (2006). The design, development and evaluation of a virtual reality-based learning environment. *Australasian Journal of Educational Technology*, *22*(1), 39-63.

Chiu, C.M., and Wang, E.T. (2008). Understanding Web-based learning continuance intention: The role of subjective task value. *Information and Management*, *45*(3), 194-201. https://doi.org/10.1016/j.im.2008.02.003

Choi, Y.K. and Totten, J.W. (2012). Self-construal's role in mobile TV acceptance: Extension of TAM across cultures. *Journal of Business Research*, *65*(11), 1525-1533. https://doi.org/10.1016/j.jbusres.2011.02.036.

Chopra V, Gesink BJ, De Jong J, Bovill JG, Spierdijk J, Brand R. (1994). Does training on an anaesthesia simulator lead to an improvement in performance? *British Journal of Anaesthesia*, *73*, 293-297.

Chung, J.E., Park, N., Wang, H., Fulk, J. and McLaughlin, M.L. (2010). Age differences in perceptions of online community participation among non-users: An extension of the technology acceptance model. *Computers in Human Behavior*, *26*(6), 1674-1684. https://doi.org/10.1016/j.chb.2010.06.016.

Clarke, R. (1999). *A primer in diffusion of innovations theory*. Chapman, Australia: Xamax Consultancy. Retrieved from http://www.rogerclarke.com/SOS/InnDiff.html.

Codd, A.M. and Choudhury, B. (2011). Virtual reality anatomy: Is it comparable with traditional methods in the teaching of human forearm musculoskeletal anatomy? *Anatomical Sciences Education*, *4*,119-125.

Colley, A. and Comber, C. (2003). Age and gender differences in computer use and attitudes among secondary school students: What has changed? *Educational Research*, *45*(2), 155-165.

Compeau, D.R. and Higgins, C.A. (1995). Computer self-efficacy: Development of a measure and initial test. *MIS Quarterly,* June, 189-211.

Compeau, L.D., Grewal, D. and Monroe, K.B. (1998). Role of prior affect and sensory cues on consumers' affective and cognitive responses and overall perceptions of quality. *Journal of Business Research*, *42*(3), 295-308. https://doi.org/10.1016/S0148-2963(97)00126-4.

Cooper, J.B. and Taqueti, V.R. (2004). A brief history of the development of mannequin simulators for clinical education and training. *Quality and Safety in Health Care*, 13(Suppl 1), i11-i18. doi: 10.1136/qshc.009886.

Cormack, D.F.S. (1991). *The research process in nursing*. (2nd ed.). Oxford: Blackwell Scientific.

Coss, D.L. (2009), Individual's intention to use self-diagnostic medical support systems. In *Southern Association for Information Systems 2009 Proceedings* (pp. 1-6). Retrieved from https://aisel.aisnet.org/sais2009/9

Creswell, J.W. and Miller, D.L. (2000). Determining validity in qualitative inquiry. *Theory into Practice*, *39*(3), 124-130. doi: 10.1207/s15430421tip39032

Cronan, T.P., Leonard, L.N.K. and Kreie, J. (2005). An empirical validation of perceived importance and behavior intention in IT ethics. *Journal of Business Ethics, 56,* 231-238.

Cronin, J.J., Brady, M.K. and Hult, G.T.M. (2000). Assessing the effects of quality, value, and customer satisfaction on consumer behavioral intentions in service environments. *Journal of Retailing*, 76(2), 193-218.

Czaja, S.J., Charness, N., Fisk, A.D., Hertzog, C., Nair, S.N., Rogers, W.A. and Sharit, J. (2006). Factors predicting the use of technology: Findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychology and Aging*, *21*(2), 333-352.

Dadayan, L. and Ferro, E. (2005). When technology meets the mind: A comparative study of the technology acceptance model. In *International Conference on Electronic Government* (pp. 137-144). Berlin: Springer.

Dahlgren, L., Emmelin, M. and Winkvist, A. (2004). *Qualitative Methodology for International Public Health*. Umea: Umea International School of Public Health, Epidemiology and Public Health Sciences, Umea University. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:umu:diva-13785

Dalcher, I. and Shine, J. (2003). Extending the new technology acceptance model to measure the end user information systems satisfaction in a mandatory environment: A bank's treasure. *Technology Analysis and Strategic Management*, *15*(4), 441-455.

Dardagan, G. (2011). Medical School appeals for bodies as cadaver shortage hits training. *Mercury* (Durban). Retrieved from https://www.pressreader.com/south-africa/the-mercury-south-africa/20110223/284679023541283

Dascal, J., Reid, M., Ishak, W.W., Spiegel, B., Recacho, J., Rosen, B. and Danovitch, I. (2017). Virtual reality and medical inpatients: a systematic review of randomized, controlled trials. *Innovations in Clinical Neuroscience*, *14*(1-2), 14.

Datta-Paulin, L. and Salt, S. (2019). 13 Assessing the impact of a one-day advanced communication skills course for qualified and unqualified nurses in a hospice setting. *BMJ of Supportive and Palliative Care*, *9*(Supp 1), A14.

Davis, F.D. (1985). *A technology acceptance model for empirically testing new end-user information systems: Theory and results*. Cambridge: Massachusetts Institute of Technology,

Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*, 319-340.

Davis, F.D., Bagozzi, R.P. and Warshaw, P.R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, *35*(8), 982-1003.

Davis, F.D., Bagozzi, R.P. and Warshaw, P.R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology*, *22*(14), 1111-1132.

De Rosis, S. and Nuti, S. (2018). Public strategies for improving eHealth integration and long-term sustainability in public health care systems: Findings from an Italian case study. *International Journal of Health Planning and Management*, *33*(1), e131-e152.

De Villiers, M.R., Blitz, J. and Couper, I. (2017). Decentralized training for medical students: Toward a South African consensus. *African Journal of Primary Healthcare and Family Medicine*, *9*(1): a1449. Retrieved from: https://www.DOI.org/10.4102/phcfm. v9i.1449.

Dearing, J.W. and Cox, J.G. (2018). Diffusion of innovations theory, principles, and practice. *Health Affairs*, *37*(2), 183-190.

Deci, E.L. and Ryan, R.M. (1985). *Intrinsic motivation and self-determination in human Behavior*. New York: Plenum Press.

Deci, E.L., and Ryan, R.M. (1987). The support of autonomy and the control of behavior. *Journal of Personality and Social Psychology*, *53*(6), 1024-1037.

Dhai, A. (2018). Healthcare in crisis: A shameful disrespect of our Constitution. *South African Journal of Bioethics and Law, 11*(1), 8-10.

Diaz, M. C. and Loraas, T. (2010). Learning new uses of technology while on an audit engagement: Contextualizing general models to advance pragmatic understanding. *International Journal of Accounting Information Systems*, *11*(1), 61-77.

Dibley, L. (2011). Analysing narrative data using McCormack's Lenses. *Nurse Researcher*, *18*(3), 13-19.

Dishaw, M. T. and Strong, D. M. (1999). Extending the technology acceptance model with task technology fit constructs. *Journal of Information and Management, 36*(1), 9-21.

Dos Santos, L.M. (2019). Rural Public Health Workforce Training and Development: The Performance of an Undergraduate Internship Programme in a Rural Hospital and Healthcare Centre. *International Journal of Environmental Research and Public Health, 16*(7), 1259.

Doyle, D.J. and Arellano R. (1995). The virtual anaesthesiology training simulation system (Editorial). *Canadian Journal of Anesthesia*, *42*, 267-73.

Ducey, A.J. and Coovert, M.D. (2016). Predicting tablet computer use: An extended Technology Acceptance Model for physicians. *Health Policy and Technology*, *5*(3), 268-284.

Dwivedi, Y.K., Papazafeiropoulo, A., Parker, C.M. and Castleman, T. (2009). Small firm e-business adoption: a critical analysis of theory. *Journal of Enterprise Information Management*, 22(1), 167-182.

Dwivedi, Y. K., Rana, N. P., Jeyaraj, A., Clement, M., and Williams, M. D. (2019). Re-examining the unified theory of acceptance and use of technology (UTAUT): Towards a revised theoretical model. *Information Systems Frontiers, 21*(3), 719-734.

Dworkin, S.L. (2012). *Sample size policy for qualitative studies using in-depth interviews.* Heidelberg: Springer.

Eisenhardt, K.M. and Graebner, M.E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal, 50*(1), 25-32.

Eisenhardt, M. (1991). Conceptual frameworks for research circa 1991: Ideas from a cultural anthropologist; implications for mathematics education rese. *Proceedings of the 13th Annual Meeting* (pp. 1-11), Blacksburg, Virginia: Robert Underhill. Retrieved from https://nepc.colorado.edu/sites/default/files/Eisenhart_ConceptualFrameworksforResearch.pdf.

Elliman, J., Loizou, M. and Loizides, F. (2016). Virtual reality simulation training for student nurse education. Paper presented at the 2016 *8th International Conference on Games and Virtual Worlds for Serious Applications* (VS-Games) (pp. 1-2). Barcelona, Spain: IEEE. doi: 10.1109/VS-GAMES.2016.7590377.

Ellis, R.D. and Allaire, J.C. (1999). Modeling computer interest in older adults: The role of age, education, computer knowledge, and computer anxiety. *Human Factors, 41*(3), 345-355.

Erolin, C., Lamb, C., Soames, R. and Wilkinson, C. (2016). Does virtual haptic dissection improve student learning? A multi-year comparative study. Paper presented at the *Medicine Meets Virtual Reality Conference* (pp. 110-117). Los Angeles, CA.: NextMed.

Estai, M. and Bunt, S. (2016). Best teaching practices in anatomy education: A critical review. *Annals of Anatomy-Anatomischer Anzeiger, 208*, 151-157.

Ewy, G.A., Felner, J.M., Juul, D., Mayer, J.W., Sajid, A.W. and Waugh, R.A. (1987). Test of a cardiology patient simulator with students in fourth-year electives. *Journal of Medical Education*, 62(9), 738-743.

Falck, O., Mang, C. and Woessmann, L. (2018). Virtually no effect? Different uses of classroom computers and their effect on student achievement. *Oxford Bulletin of Economics and Statistics, 80*(1), 1-38.

Fejzic, N., Seric-Haracic, S, and Mehmedbasic, Z. (2019). From white coat and gumboots to virtual reality and digitalisation: where is veterinary medicine now? Paper presented at the *IOP Conference Series: Earth and Environmental Science*, 333(1), p. 012009. Bristol: IOP Publishing.

Fetscherin, M. and Lattemann, C. (2008). User acceptance of virtual worlds. *Journal of Electronic Commerce Research*, *9*(3), 231.

Fischer, M. (2018). Decoding sustainability in the healthcare system. Teaching students how to problematize complex concepts. *Journal on Innovation and Sustainability*, *9*(3), 149-159.

Fischer, M. and Heinrichs, H. (2018). Dimensions, dialectic, discourse. Three political perspectives on the sustainability of the German healthcare system. *International Journal of Environmental Research and Public Health, 15*(7), 1526.

Fishbein, M. (1963). An investigation of the relationships between beliefs about an object and the attitude toward that object. *Human Relations, 16*(3), 233-239.

Fishbein, M. and Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research. 5,* 177-189. New York: Elsevier Science. Retrieved from https://philarchive.org/archive/FISBAI

Fishbein, M. and Ajzen, I. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ.: Prentice-Hall.

Fishkin, R., Fishkin, L., Leli, U., Katz, B. and Snyder, E. (2011). Psychodynamic treatment, training, and supervision using internet-based technologies. *Journal of the American Academy of Psychoanalysis and Dynamic Psychiatry*, 39(1), 155-168.

Fleischman, A.R. and Murray, T.H. (1983). Ethics committees for infants Doe? *Hastings Center Report,* 13(6), 5-9.

Flick, U. (2011). Mixing methods, triangulation, and integrated research: Challenges for qualitative research in a world of crisis. In N.K. Denzin and M.D. Giardina (Eds.). *Qualitative inquiry and global crisis* (pp. 132-152). Walnut Cree, CA: Left Coast Press.

Foa, E.B. and Kozak, M. J. (1986). Emotional processing of fear: exposure to corrective information. *Psychological Bulletin, 99*(1), 20.

Forchuk, C. and Roberts, J. (1993). How to critique qualitative research articles. *Canadian Journal of Nursing Research Archive, 25*(4), 47-56.

Fornell, C. (1992). A national customer satisfaction barometer: The Swedish experience. *Journal of Marketing, 56*(1), 6-21.

Francis, J.J., Eccles, M P., Johnston, M., Whitty, P., Grimshaw, J.M., Kaner, E.F., . . . Walker, A. (2008). Explaining the effects of an intervention designed to promote evidence-based diabetes care: a theory-based process evaluation of a pragmatic cluster randomised controlled trial. *Implementation Science, 3*(1), 50.

Freeman, K.M., Thompson, S.F., Allely, E.B., Sobel, A.L., Stansfield, S.A. and Pugh, W.M. (2001). A virtual reality patient simulation system for teaching emergency response skills to US Navy medical providers. *Prehospital and Disaster Medicine, 16*(1), 3-8.

Freina, L. and Ott, M. (2015). A literature review on immersive virtual reality in education: state of the art and perspectives. Paper presented at *The International Scientific Conference eLearning and Software for Education.*

Fridhi, A., Benzarti, F., Frihida, A., and Amiri, H. (2018). Application of Virtual Reality and Augmented Reality in Psychiatry and Neuropsychology, in Particular in the Case of Autistic Spectrum Disorder (ASD). *Neurophysiology, 50*(3), 222-228.

Friederici, N. (2018). Hope and hype in Africa’s digital economy: The rise of innovation hubs. In M. Graham (Ed.), *Digital economies at global margins* (pp. 193-222). Cambridge: MIT Press.

Friedl, R., Preisack, M., Schefer, M., Klas, W., Tremper, J., Rose, T., . . . Guilliard, P. (2000). CardioOp: an integrated approach to teleteaching in cardiac surgery. *Studies in Health Technology and Informatics, 70*, 76-82.

Friedrich, M. (2002). Practice makes perfect. *Jama*, *288*(22), 2808-2812.

Fuertes Muñoz, G., Mollineda, R. A., Gallardo Casero, J., and Pla, F. (2019). A RGBD-Based interactive system for gaming-driven rehabilitation of upper limbs. *Sensors, 19*(16), 3478.

Fulton, J. (2017). *Digital natives: The millennial workforce's intention to adopt bring your own device.* Capella University, Minneapolis, Minnesota. (Doctoral dissertation, Capella University). Ann Arbor, Michigan: Proquest. 1-24.

Fung, J., Malouin, F., McFadyen, B., Comeau, F., Lamontagne, A., Chapdelaine, S., . . . Richards, C. (2004). Locomotor rehabilitation in a complex virtual environment. Paper presented at the *26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 2(1), 4859-4861.

Fusch, P.I. and Ness, L.R. (2015). Are we there yet? Data saturation in qualitative research. *Qualitative Report*, *20*(9), 1408.

Gaba, D.M. and De Anda, A. (1988). A comprehensive anesthesia simulation environment re-creating the operating room for research and training. *Anesthesiology: Journal of the American Society of Anesthesiologists*, *69*(3), 387-394.

Gaba, D.M., Howard, S.K., Fish, K.J., Smith, B.E. and Sowb, Y.A. (2001). Simulation-based training in anesthesia crisis resource management (ACRM): a decade of experience. *Simulation and Gaming, 32*(2), 175-193.

Gaede, B. (2018). Decentralised clinical training of health professionals will expand the training platform and enhance the competencies of graduates. *South African Medical Journal*, *108*(6), 451-452.

Gallagher, A.G., Richie, K., McClure, N. and McGuigan, J. (2001). Objective psychomotor skills assessment of experienced, junior, and novice laparoscopists with virtual reality. *World Journal of Surgery*, *25*(11), 1478-1483.

Gambhir, S., Narkeesh, A. and Arunmozhi, R. (2017). Role of virtual reality in cognitive rehabilitation-a review. *International Journal of Therapies and Rehabilitation Research*, *6*(2), 125.

Gao, T.T., Rohm, A.J., Sultan, F. and Pagani, M. (2013). Consumers un-tethered: A three-market empirical study of consumers' mobile marketing acceptance. *Journal of Business Research*, *66*(12), 2536-2544.

Garner, R. and Scott, G.M. (2013). *Doing qualitative research: designs, methods, and techniques*. Upper Saddle River, NJ.: Pearson.

Gaskin, P.R., Owens, S.E., Talner, N.S., Sanders, S.P., and Li, J S. (2000). Clinical auscultation skills in pediatric residents. *Pediatrics, 105*(6), 1184-1187.

Ghosh, S.K. (2017). Cadaveric dissection as an educational tool for anatomical sciences in the 21st century. *Anatomical Sciences Education, 10*(3), 286-299.

Glanz, K., Rizzo, A.S. and Graap, K. (2003). Virtual reality for psychotherapy: Current reality and future possibilities. *Psychotherapy: Theory, Research, Practice, Training, 40*(1-2), 55.

Glaser, B.G. (1978). *Theoretical sensitivity*. Mill Valley, CA: Sociology Press.

Glaser, B.G. and Strauss, A.L. (1967). *Discovery of grounded theory*. Mill Valley, CA: Sociology Press.

Glegg, S.M., Tatla, S.K, and Holsti, L. (2014). The GestureTek virtual reality system in rehabilitation: a scoping review. *Disability and Rehabilitation: Assistive Technology, 9*(2), 89-111.

Goddard, W. and Melville, S. (2004). *Research methodology: An introduction*. Cape Town: Juta.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research.*Qualitative Report, 8*(4), 597-607.

Gordon, J.A., Oriol, N.E. and Cooper, J.B. (2004). Bringing good teaching cases “to life”: a simulator-based medical education service. *Academic Medicine*, *79*(1), 23-27.

Gordon, M.S. (1974). Cardiology patient simulator: development of an animated manikin to teach cardiovascular disease. *American Journal of Cardiology, 34*(3), 350-355.

Gordon, M.S., Ewy, G., Felner, J., Forker, A., Gessner, I., McGuire, C., . . . Waugh, R. (1980). Teaching bedside cardiologic examination skills using 'Harvey', the cardiology patient simulator. *Medical Clinics of North America, 64*(2), 305-313.

Gorey, T.F. (1997). Training in minimally invasive therapy and its impact on traditional surgical education. *Irish Medical Journal, 166,* 1-2.

Gorman, P.J., Lieser, J., Murray, W., Haluck, R., and Krummel, T.M. (1999). Evaluation of skill acquisition using a force feedback, virtual reality based surgical trainer. Paper presented at the *7th Conference on Medicine Meets Virtual Reality* (pp. 121-123), Amsterdam, Netherlands: IOS Press.

Gorman, P.J., Meier, A.H., Rawn, C. and Krummel, T.M. (2000). The future of medical education is no longer blood and guts, it is bits and bytes. *American Journal of Surgery*, *180*(5), 353-356.

Govender, S. and Mars, M. (2018). The perspectives of South African academics within the disciplines of health sciences regarding telehealth and its potential inclusion in student training. *African Journal of Health Professions Education*, *10*(1), 38-43.

Grantcharov, T.P., Kristiansen, V.B., Bendix, J., Bardram, L., Rosenberg, J., and Funch-Jensen, P. (2004). Randomized clinical trial of virtual reality simulation for laparoscopic skills training. *British Journal of Surgery*, *91*(2), 146-150.

Grbich, C. (1998). *Qualitative research in health: An introduction*. Newbury Park,CA.: Sage.

Greci, L.S., Ramloll, R., Hurst, S., Garman, K., Beedasy, J., Pieper, E.B., . . . Agha, Z. (2013). vTrain: A novel curriculum for patient surge training in a multi-user virtual environment (MUVE). *Prehospital and Disaster Medicine*, *28*(3), 215-222.

Greenhalgh, T. and Taylor, R. (1997). How to read a paper: papers that go beyond numbers (qualitative research). *British Medical Journal*, *315*(7110), 740-743.

Gregory, I. (2003). *Ethics in research.* London: A&C Black.

Griffiths, M. (2000). Does Internet and computer "addiction" exist? Some case study evidence. *CyberPsychology and Behavior*, *3*(2), 211-218.

Guba, E.G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *ECTJ*, *29*(2), 75.

Guba, E.L. and Lincoln, Y. (1994). Competing paradigms in qualitative research. In N.K. Denzin and Y.S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks, CA.: Sage.

Guedes, H.G., Ferreira, Z.M.C.C., de Sousa Leao, L.R., Montero, E.F.S., Otoch, J.P. and de Almeida Artifon, E. L. (2019). Virtual reality simulator versus box-trainer to teach minimally invasive procedures: A meta-analysis. *International Journal of Surgery*, *61*, 60-68.

Guest, G., Bunce, A. and Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods, 18*(1), 59-82.

Gunawardana, K. and Ekanayaka, S. (2009). An empirical study of the factors that impact medical representatives' attitude toward the intention to use m-learning for career development. *Sasin Journal of Management*, *15*(1), 1-26.

Guo, Y., Mao, L., Zhang, G., Chen, Z., Pei, X. and Xu, X.G. (2020). *Conceptual design and preliminary results of a VR-based radiation safety training system for interventional radiologists* (pp. 1-5). Retrieved from https://arxiv.org/ftp/arxiv/papers/2001/2001.04839.pdf.

Guri-Rosenblit, S., Šebková, H. and Teichler, U. (2007). Massification and diversity of higher education systems: Interplay of complex dimensions. *Higher Education Policy, 20*(4), 373-389.

Ha, S. and Stoel, L. (2009). Consumer e-shopping acceptance: Antecedents in a technology acceptance model. *Journal of Business Research*, *62*(5), 565-571.

Hadley, M., Mullen, L.A., Dickerson, L. and Harvey, S.C. (2018). Assessment and improvement strategies for a breast cancer early detection program in rural South Africa. *Journal of Global Oncology*, *4*, 1-12.

Hagger, M.S. (2019). The Reasoned Action Approach and the theories of Reasoned Action and Planned Behavior. In D.S. Dunn (Ed.), *Oxford Bibliographies in Psychology* (pp. 1-29). New York: Oxford University Press.

Haldar, S., Mishra, S. R., Khelifi, M., Pollack, A. H., and Pratt, W. (2019). *Beyond the patient portal: supporting needs of hospitalized patients.* Paper presented at the Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Glasgow, Scotland. NY: Association for Computing Machinery, *366*, 1-14.

Haleem, A., Javaid, M. and Khan, I.H. (2019). Internet of things (IoT) applications in orthopaedics. *Journal of Clinical Orthopaedics and Trauma.* doi: https://doi.org/10.1016/ j.jcot.2019.07.003.

Halili, S. H. (2019). Technological advancements in education 4.0. *The Online Journal of Distance Education and E-Learning, 7*(1), 63-69.

Hamilton, E.C., Scott, D.J., Fleming, J., Rege, R.V., Laycock, R., Bergen, P.C., . . . Jones, D. (2002). Comparison of video trainer and virtual reality training systems on acquisition of laparoscopic skills. *Surgical Endoscopy and Other Interventional Techniques, 16*(3), 406-411.

Hamza-Lup, F.G., Bogdan, C.M., Popovici, D.M., and Costea, O.D. (2019). *A survey of visuo-haptic simulation in surgical training* (pp.1-6). Retrieved from https://arxiv.org/ftp/arxiv/papers/1903/1903.03272.pdf.

Hamza-Lup, F.G., Rolland, J.P., and Hughes, C. (2018). A distributed augmented reality system for medical training and simulation, *Journal of Energy, Simulation-Training, Ocean Engineering and Instrumentation: Research Papers of the Link Foundation Fellows*, *4*, 213-235. Retrieved from https://arxiv.org/abs/1811.12815

Han, D.I.D., Tom Dieck, M.C., and Jung, T. (2019). Augmented Reality Smart Glasses (ARSG) visitor adoption in cultural tourism. *Leisure Studies, 38*(5), 618-633.

Harrison, A.W. and Rainer Jr, R.K. (1992). The influence of individual differences on skill in end-user computing. *Journal of Management Information Systems*, *9*(1), 93-111.

Harrison, A., Derwent, G., Enticknap, A., Rose, F. and Attree, E. (2002). The role of virtual reality technology in the assessment and training of inexperienced powered wheelchair users. *Disability and Rehabilitation*, 24(11-12), 599-606.

Harrison, C.J. (2018). Digital consultations-overcoming cultural resistance to change. *BMJ,* (Online), 362. DOI:10.1136/bmj.k2824.

Heng, Y.T., Wagner, D.T., Barnes, C.M. and Guarana, C.L. (2018). Archival research: Expanding the methodological toolkit in social psychology. *Journal of Experimental Social Psychology*, *78*, 14-22.

Hennink, M., Hutter, I., and Bailey, A. (2020). *Qualitative research methods*. Thousand Oaks, California: SAGE Publications Limited, *2,* 1-376.

Hoffman, H.G. (2004). Virtual-reality therapy. *Scientific American, 291*(2), 58-65.

Hoffman, H., Murray, M., Curlee, R. and Fritchle, A. (2001). Anatomic visualizeR: teaching and learning anatomy with virtual reality. *Information Technologies in Medicine*, 1, 205-218.

Holden, M.K., and Dyar, T. (2002). Virtual environment training – a new tool for meurorehabilitation? *Neurology Report, 26*(2), 62-71.

Holden, M.K. and Todorov, E. (2002). Use of virtual environments in motor learning and rehabilitation. Department of Brain and Cognitive Sciences, In K.M. Stanney (Ed.), *Handbook of virtual environments: design, implementation, and applications* (pp. 999-1026). Hillsdale, NJ.: Lawrence Elbraum Associates.

Holden, M.K., Dyar, T.A., Schwamm, L. and Bizzi, E. (2005). Virtual-environment-based telerehabilitation in patients with stroke. *Presence: Teleoperators and Virtual Environments*, *14*(2), 214-233.

Holton, J.A. and Walsh, I. (2017). *Evaluating classic grounded theory*. In J. Holton and I. Walsh, (Eds.), *Classic grounded theory: Applications with qualitative and quantitative data* (pp. 152-158). Thousand Oaks, CA.: Sage.

Honda, A., Ryan, M., van Niekerk, R. and McIntyre, D. (2015). Improving the public health sector in South Africa: eliciting public preferences using a discrete choice experiment. *Health Policy and Planning, 30*(5), 600-611.

Hsu, C. and Lu, H.P. (2004). Why do people play online games? An extended TAM with social influences and flow experience. *Information & Management, 417*, 853-868.

Hu, H., Shao, Z., Ye, L. and Jin, H. (2019). Application of mixed reality technology in surgery. *International Journal of Clinical Experimental Medicine*, *12*(4), 3107-3113.

Huang, L., Lu, M.T. and Wong, B.K. (2003). The impact of power distance on email acceptance: Evidence from the PRC. *Journal of Computer Information Systems*, *44*(1), 93-101.

Huang, X. (2018). *Using a disruption framework to analysis the feasibility of virtual reality in medical use* (pp.1-48). Retrieved from https://aaltodoc.aalto.fi/bitstream/handle/123456789/30100/master_Huang_Xing_2018.pdf?sequence=1&isAllowed=y.

Hürlimann, C. (2019). Research philosophy and ethics. In *Valuation of renewable energy investment*s (pp. 111-126). Wiesbaden, Germany: Springer Gabler. Retrieved from https://link.springer.com/chapter/10.1007/978-3-658-27469-6_3.

Hussein, A.F., Burbano-Fernandez, M., Ramírez-González, G., Abdulhay, E. and De Albuquerque, V.H.C. (2018). An automated remote cloud-based heart rate variability monitoring system. *IEEE Access, 6,* 77055-77064.

Hussin, N.H., Jaafar, J. and Downe, A.G. (2011). Assessing educators' acceptance of virtual reality (VR) in the classroom using the Unified Theory of Acceptance and Use of Technology (UTAUT). Paper presented at the *International Visual Informatics Conference* (pp. 216-225). Berlin: Springer.

Hyltander, A., Liljegren, E., Rhodin, P. and Lönroth, H. (2002). The transfer of basic skills learned in a laparoscopic simulator to the operating room. *Surgical Endoscopy and Other Interventional Techniques*, *16*(9), 1324-1328.

Ijsselsteijn, W., Nap, H.H., de Kort, Y. and Poels, K. (2007). Digital game design for elderly users. Paper presented at the *Proceedings of the 2007 Conference on Future Play* (pp. 17-22). https://doi.org/10.1145/1328202.1328206

Imani, S., Bandodkar, A.J., Mohan, A.V., Kumar, R., Yu, S., Wang, J. and Mercier, P.P. (2016). A wearable chemical-electrophysiological hybrid biosensing system for real-time health and fitness monitoring. *Nature Communications*, *7*(1), 1-7.

Ingrassia, P.L., Ragazzoni, L., Carenzo, L., Colombo, D., Gallardo, A. R. and Della Corte, F. (2015). Virtual reality and live simulation: a comparison between two simulation tools for assessing mass casualty triage skills. *European Journal of Emergency Medicine*, *22*(2), 121-127.

Iqbal, T. and El-Gohary, E. (2014). An attempt to understand e-marketing: an information technology prospective. *International Journal of Business and Social Science*, *5*(4), 1-23.

Issenberg, S.B., McGaghie, W.C., Hart, I.R., Mayer, J.W., Felner, J.M., Petrusa, E.R., . . . Gessner, I.H. (1999). Simulation technology for health care professional skills training and assessment. *JAMA, 282*(9), 861-866.

Israel, M., Wang, S., and Marino, M. T. (2016). A multilevel analysis of diverse learners playing life science video games: Interactions between game content, learning disability status, reading proficiency, and gender. *Journal of Research in Science Teaching, 53*(2), 324-345.

Istepanian, R.S., Hu, S., Philip, N.Y. and Sungoor, A. (2011). The potential of Internet of m-health Things “m-IoT” for non-invasive glucose level sensing. Paper presented at the 2011 *Annual International Conference of the IEEE Engineering in Medicine and Biology Society* (pp. 5264-5266). IEEE. doi: 10.1109/IEMBS.2011.6091302.

Jack, D., Boian, R., Merians, A.S., Tremaine, M., Burdea, G.C., Adamovich, S.V., . . . Poizner, H. (2001). Virtual reality-enhanced stroke rehabilitation. *IEEE Transactions on Neural Systems and Rehabilitation Engineering, 9*(3), 308-318.

Jackson, C.M., Chow, S. and Leitch, R.A. (1997). Toward an understanding of the behavioral intention to use an information system. *Decision Sciences, 28*(2), 357-389.

Jang, S.S. and Namkung, Y. (2009). Perceived quality, emotions, and behavioral intentions: Application of an extended Mehrabian–Russell model to restaurants. *Journal of Business Research, 62*(4), 451-460.

Jenkins, H. (2017). *An Exploration of Cognitive Behavioural Therapy Training.* (Doctoral dissertation, Cardiff University). Cardiff University, United Kingdom. 1-141.

Jia, M., Wang, L., Guo, Q., Gu, X. and Xiang, W. (2017). A low complexity detection algorithm for fixed up-link SCMA system in mission critical scenario. *IEEE Internet of Things Journal, 5*(5), 3289-3297.

Jing, L., Tian, K. and Huang, J.Z. (2015). Stratified feature sampling method for ensemble clustering of high dimensional data. *Pattern Recognition, 48*(11), 3688-3702.

Johnson, K., Liszewski, B. and McGuffin, M. (2018). Exploring the use of virtual reality as a supplemental educational tool in traditional first day teaching for patients receiving external beam radiation therapy to the pelvis. *Journal of Medical Imaging and Radiation Sciences*, *49*(2), 1-2.

Jones, T.M. (1991). Ethical decision making by individuals in organizations: An issue-contingent model. *Academy of Management Review, 16*(2), 366-395.

Jong, D. and Wang, T.S. (2009). Student acceptance of web-based learning system. In *Proceedings of theInternational Symposium on Web Information Systems and Applications.* Nanchang, China: WISA.

Kalantari, M., and Rauschnabel, P. (2018). Exploring the early adopters of augmented reality smart glasses: The case of Microsoft HoloLens. In *Augmented reality and virtual reality* (pp. 229-245), Otranto, Italy: Springer.

Kaminski, J. (2011). Diffusion of innovation theory. *Canadian Journal of Nursing Informatics, 6*(2), 1-6.

Karahanna, E., Straub, D. and Chervany, N. (1999). Information technology adoption across time: a cross-sectional comparison of pre-adoption and post-adoption beliefs. *Management Information Systems Quarterly, 23*(2), 183-213.

Keller, C. (2007). *Virtual learning environments in higher education: A study of user acceptance.* (Unpublished doctoral dissertation), Institutionen för Ekonomisk och Industriell Utveckling: Linköping, Sweden.

Khater, A.H.O. (2016). *Customers' acceptance of Internet banking service in Sudan by using Unified Theory of Acceptance and Use of Technology (UTAUT) model*. (Unpublished doctoral dissertation), Sudan University of Science and Technology: Sudan.

Kim, B.R., Chun, M.H., Kim, L.S. and Park, J. (2011). Effect of virtual reality on cognition in stroke patients. *Annals of Rehabilitation Medicine, 35*(4), 450.

Kim, C., Mirusmonov, M. and Lee, I. (2010). An empirical examination of factors influencing the intention to use mobile payment. *Computers in Human Behavior, 26*(3), 310-322.

Kim, J.I. (2005). *Distance-learning receptivity differences between American and Korean graduate students.* (doctoral dissertation), Texas A&M University, Texas.

Kim, S.S., and Malhotra, N.K. (2005). A longitudinal model of continued IS use: An integrative view of four mechanisms underlying postadoption phenomena. *Management Science, 51*(5), 741-755.

Kimel-Naor, S., Gottlieb, A., and Plotnik, M. (2017). The effect of uphill and downhill walking on gait parameters: A self-paced treadmill study. *Journal of biomechanics, 60*, 142-149.

King, W. R., and He, J. (2006). A meta-analysis of the technology acceptance model. *Information & management, 43*(6), 740-755.

Kirby, N. (2019). View on the NHI. *HR Future*, 9, Sept., 47. Retrieved from https://journals.co.za/content/journal/10520/EJC-18e8a21eef

Kizony, R., Katz, N. and Weiss, P.L. (2003). Adapting an immersive virtual reality system for rehabilitation. *Journal of Visualization and Computer Animation, 14*(5), 261-268.

Knafl, K.A., and Breitmayer, B.J. (1991). Triangulation, in qualitative research: issues of conceptual clarity and purpose. In J.M. Morse (Ed.), *Qualitative nursing research: A contemporary dialogue* (pp. 226-239). Newbury Park, CA: Sage.

Koçak, Ö., Yilmaz, R.M., Küçük, S., and Göktaş, Y. (2019). The educational potential of augmented reality technology: Experiences of instructional designers and practitioners. *Journal of Education and Future, 15*, 17-36.

Kodikara, K., Karunaratne, W., and Chandratilake, M. (2019). High fidelity simulation in undergraduate medical curricula: experience of fourth year medical students. *South-East Asian Journal of Medical Education, 13*(2), 2-8.

Kohler, U., Kreuter, F. and Stuart, E.A. (2019). Nonprobability sampling and causal analysis. *Annual Review of Statistics and its Application*, 6, 149-172.

Kothari, C.R. (2004). *Research methodology: Methods and techniques.* New Delhi*:* New Age International.

Kothari, L. G., Shah, K., and Barach, P. (2017). Simulation based medical education in graduate medical education training and assessment programs. *Progress in Pediatric Cardiology, 44(1)*, 33-42.

Krefting, L. (1991). Rigor in qualitative research: The assessment of trustworthiness. *American Journal of Occupational Therapy*, *45*(3), 214-222.

Krijn, M., Emmelkamp, P.M., Olafsson, R.P. and Biemond, R. (2004). Virtual reality exposure therapy of anxiety disorders: A review. *Clinical Psychology Review, 24*(3), 259-281.

Kripanont, N. (2007). *Examining a technology acceptance model of internet usage by academics within Thai business schools.* (Unpublished doctoral dissertation), Victoria University, Australia.

Küçük, S., Kapakin, S. and Göktaş, Y. (2016). Learning anatomy via mobile augmented reality: effects on achievement and cognitive load. *Anatomical Sciences Education*, *9*(5), 411-421.

Kwon, J.H., Powell, J. and Chalmers, A. (2013). How level of realism influences anxiety in virtual reality environments for a job interview. *International Journal of Human-Computer Studies*, *71*(10), 978-987.

Kwon, O., and Wen, Y. (2010). An empirical study of the factors affecting social network service use. *Computers in Human Behavior*, *26*(2), 254-263.

Laaki, H., Miche, Y., and Tammi, K. (2019). Prototyping a digital twin for real time remote control over mobile networks: Application of remote surgery. Piscataway, NJ: IEEE*, 7(1)*, 20325-20336. doi: 10.1109/ACCESS.2019.2897018

Lane, J.L., Slavin, S. and Ziv, A. (2001). Simulation in medical education: A review. *Simulation and Gaming, 32*(3), 297-314.

Laurenza, E., Quintano, M., Schiavone, F. and Vrontis, D. (2018). The effect of digital technologies adoption in healthcare industry: A case-based analysis. *Business Process Management Journal*, 24(5), 1124-1144.

Lavelle, M., Abthorpe, J., Simpson, T., Reedy, G., Little, F. and Banerjee, A. (2018). MBRRACE in simulation: an evaluation of a multi-disciplinary simulation training for medical emergencies in obstetrics (MEmO). *Journal of Obstetrics and Gynaecology, 38*(6), 781-788.

Lazarus, L., Sookrajh, R. and Satyapal, K.S. (2019). Perceptions of South African academic instructors toward the teaching and learning of anatomy. *Folia Morphologica*, 78(4), 871-878.

Lee, K.H., Noh, J. and Khim, J.S. (2020). The Blue Economy and the United Nations' sustainable development goals: Challenges and opportunities. *Environment International, 137*, 105528.

Lee, Y., Kozar, K.A. and Larsen, K.R. (2003). The technology acceptance model: Past, present, and future. *Communications of the Association for Information Systems, 12*(1), 50.

Lee, Y.K., Park, J.H., Chung, N. and Blakeney, A. (2012). A unified perspective on the factors influencing usage intention toward mobile financial services. *Journal of Business Research*, *65*(11), 1590-1599.

Leonard, L.N., Cronan, T.P. and Kreie, J. (2004). What influences IT ethical behavior intentions – planned behavior, reasoned action, perceived importance, or individual characteristics? *Information and Management*, *42*(1), 143-158.

Leong, T. (2019). National Department of Health. Retrieved from https://www.mm3admin.co.za/documents/docmanager/3C53E82B-24F2-49E1-B997-5A35803BE10A/00134970.pdf.

Liao, C.J. and Cho, H.B. (2019). Iceberg Theory-based interview simulation system of mixed reality. *Review of Integrative Business and Economics Research, 8*(3), 61.

Lincoln, Y.S., and Guba, E.G. (1985). *Naturalistic inquiry* (vol. 75). Thousand Oaks, CA.: Sage.

Lingard, L., Albert, M. and Levinson, W. (2008). Grounded theory, mixed methods, and action research. *BMJ, 337*, a567.

Long, V.N. and Hoang, N.A. (2017). Development of IoT based lower limb exoskeleton in rehabilitation. Paper presented at the 2017 *14th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI)* (pp. 824-826). Jeju, South Korea: IEEE. doi: 10.1109/URAI.2017.7992834.

Lopreiato, J. O., and Sawyer, T. (2015). Simulation-based medical education in pediatrics. *Academic Pediatrics*, *15*(2), 134-142.

Losh, S.C. (2004). Gender, educational, and occupational digital gaps 1983-2002. *Social Science Computer Review, 22*(2), 152-166.

Lotzkar, M. and Bottorff, J.L. (2001). An observational study of the development of a nurse-patient relationship. *Clinical Nursing Research, 10*(3), 275-294.

Lu, H., Li, Y., Chen, M., Kim, H. and Serikawa, S. (2018). Brain intelligence: go beyond artificial intelligence. *Mobile Networks and Applications, 23*(2), 368-375.

Lune, H., and Berg, B. L. (2017). *Qualitative research methods for the social sciences*. Harlow, England: Pearson, *9*, 12-251.

Lynn, P. (2019). The advantage and disadvantage of implicitly stratified sampling. *Methods, data, analyses*, 13(2), 14.

Ma, M., Jain, L.C. and Anderson, P. (2014). *Virtual, augmented reality and serious games for healthcare* (Vol. 68). Berlin: Springer.

Maier, C., Laumer, S. and Eckhardt, A. (2011). Technology adoption by elderly people – an empirical analysis of adopters and non-adopters of social networking sites. In *Theory-guided modeling and empiricism in information systems research* (pp. 85-110), Heidelberg: Physica-Verlag.

Manis, K.T. and Choi, D. (2019). The virtual reality hardware acceptance model (VR-HAM): Extending and individuating the technology acceptance model (TAM) for virtual reality hardware. *Journal of Business Research, 100,* 503-513.

Maples-Keller, J. L., Yasinski, C., Manjin, N., and Rothbaum, B. O. (2017). Virtual reality-enhanced extinction of phobias and post-traumatic stress. *Neurotherapeutics, 14*(3), 554-563.

Maran, N.J., and Glavin, R.J. (2003). Low-to high-fidelity simulation – a continuum of medical education? *Medical Education, 37*, 22-28.

Markova, Z., and Yaneva, D. (2020). The Motivation of University Students of International Relations to Learn English. *English Studies at NBU, 6*(1), 5-28.

May, T. (2011). *Social research.* Berkshire, England: McGraw-Hill Education, Open University Press.

Mazurek, J., Kiper, P., Cieślik, B., Rutkowski, S., Mehlich, K., Turolla, A. and Szczepańska-Gieracha, J. (2019). Virtual reality in medicine: a brief overview and future research directions. *Human Movement, 20*(2), 16-22.

Mazziotta, J., Toga, A., Evans, A., Fox, P., Lancaster, J., Zilles, K., . . . Pike, B. (2001). A probabilistic atlas and reference system for the human brain: International Consortium for Brain Mapping (ICBM). *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 356*(1412), 1293-1322.

Mbarika, V.W. (2004). Is telemedicine the panacea for Sub-Saharan Africa's medical nightmare? *Communications of the ACM*, *47*(7), 21-24.

McClelland, D.C. (1973). Testing for competence rather than for “intelligence”. *American Psychologist, 28*(1), 1.

McGrath, J.L., Taekman, J.M., Dev, P., Danforth, D.R., Mohan, D., Kman, N., . . . Lemheney, A. (2018). Using virtual reality simulation environments to assess competence for emergency medicine learners. *Academic Emergency Medicine*, *25*(2), 186-195.

McIntyre, D. (2019). How can we best achieve a universal health system: a public conversation? *South African Health Review, 2019*(1), 17-27.

McLay, R.N., Wood, D.P., Webb-Murphy, J.A., Spira, J.L., Wiederhold, M.D., Pyne, J.M. and Wiederhold, B.K. (2011). A randomized, controlled trial of virtual reality-graded exposure therapy for post-traumatic stress disorder in active duty service members with combat-related post-traumatic stress disorder. *Cyberpsychology, Behavior, and Social Networking, 14*(4), 223-229.

McLean, G., Al-Nabhani, K., and Wilson, A. (2018). Developing a mobile applications customer experience model (MACE)-implications for retailers. *Journal of Business Research, 85*, 325-336.

Mehl, G.L., Tamrat, T., Bhardwaj, S., Blaschke, S. and Labrique, A. (2018). Digital health vision: could MomConnect provide a pragmatic starting point for achieving universal health coverage in South Africa and elsewhere? *BMJ Global Health, 3*(Suppl 2), e000626.

Melenhorst, A.S., Rogers, W.A. and Caylor, E.C. (2001). The use of communication technologies by older adults: exploring the benefits from the user's perspective. In *Proceedings of the human factors and ergonomics society annual meeting*, 45(3), 221-225. Los Angeles, CA: Sage.

Messier, E., Wilcox, J., Dawson-Elli, A., Diaz, G. and Linte, C.A. (2016). An interactive 3D virtual anatomy puzzle for learning and simulation-initial demonstration and evaluation. Paper presented at the *Medicine Meets Virtual Reality Conference,* (pp. 233-240). Amsterdam, Netherlands: IOS Press.

Min, S., So, K.K.F. and Jeong, M. (2019). Consumer adoption of the Uber mobile application: Insights from diffusion of innovation theory and technology acceptance model. *Journal of Travel and Tourism Marketing*, *36*(7), 770-783.

Moline, J. (1995). *Virtual environments for health care* (Vol. 5740). Collingdale, USA: DIANE Publishing, National Institute of Standards and Technology, US Department of Commerce.

Monakise, D. (2019). *Defining a comprehensive telemedicine framework for emerging market healthcare industries.* (Unpublished doctoral dissertation), University of Pretoria, South Africa.

Monroe, K.B. and Petroshius, S.M. (1981). Buyers' perceptions of price: An update of the evidence. *Perspectives in Consumer Behavior, 3(*23), 42.

Moro, C., Štromberga, Z., Raikos, A., and Stirling, A. (2017). The effectiveness of virtual and augmented reality in health sciences and medical anatomy. *Anatomical Sciences Education, 10*(6), 549-559.

Muftah, H. (2013). The investigation of the possible connections between acculturation and the acquisition of a second language on Libyan teenage students. *World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering, 7*(10), 2805-2821.

Mugo, P. M. (2013). *Factors affecting motivation and academic aspirations of Girls and Boys in secondary schools: Laikipia West district, Laikipia County, Kenya.* University of Nairobi. (Doctoral dissertation, University of Nairobi).

Muk, A. and Chung, C. (2015). Applying the technology acceptance model in a two-country study of SMS advertising. *Journal of Business Research*, *68*(1), 1-6.

Murgitroyd, E., Madurska, M., Gonzalez, J. and Watson, A. (2015). 3D digital anatomy modelling–Practical or pretty? *The Surgeon*, *13*(3), 177-180.

Naidoo, M. (2017). An evaluation of the emergency care training workshops in the province of KwaZulu-Natal, South Africa. *African Journal of Primary Health Care and Family Medicine*, *9*(1), 1-6.

Nasri, W. and Charfeddine, L. (2012). Factors affecting the adoption of Internet banking in Tunisia: An integration theory of acceptance model and theory of planned behavior. *Journal of High Technology Management Research*, *23*(1), 1-14.

Neufeld, D.J., Dong, L. and Higgins, C. (2007). Charismatic leadership and user acceptance of information technology. *European Journal of Information Systems*, *16*(4), 494-510.

Neuman, W.L. and Kreuger, L. (2003). *Social work research methods: Qualitative and quantitative approaches*. Boston: Allyn and Bacon.

Newman, I., Benz, C.R. and Ridenour, C. (1998). *Qualitative-quantitative research methodology: Exploring the interactive continuum.* University of Dayton, Ohio: SIU Press.

Ng'ambi, D., Gachago, D., Ivala, E., Bozalek, V. and Watters, K. (2012). Emerging technologies in South African higher education institutions: towards a teaching and learning practice framework. Paper presented at the *International Conference on e-Learning* (p. 354). UK: Academic Conferences International Limited.

Nickel, F., Brzoska, J.A., Gondan, M., Rangnick, H.M., Chu, J., Kenngott, H.G., . . . Müller-Stich, B. P. (2015). Virtual reality training versus blended learning of laparoscopic cholecystectomy: a randomized controlled trial with laparoscopic novices. *Medicine, 94*(20), 1-8.

Nikou, S., Brännback, M. and Widén, G. (2019). The impact of digitalization on literacy: digital immigrants vs. digital natives *Proceedings of the 27th European Conference on Information Systems (ECIS)*, Stockholm and Uppsala, Sweden: ECIS.

Nistor, V.C., Wilson, A., Tamas, S.A. and Radomir, L. (2011). The Romanian high-educated youth market for Internet banking: investigating the drivers of adoption. *Proceedings of the International Conference "Marketing-from Information to Decision"* (pp. 309-336). Babes Bolyai University, Romania. Retrieved from https://www.ceeol.com/search/article-detail?id=259090**.**

Ohei, K. N., Brink, R., and Abiodun, A. (2019). Information and Communication Technology (ICT) graduates and challenges of employability: a conceptual framework for enhancing employment opportunities in South Africa. *Gender and Behaviour, 17(3)*, 13500-13521.

O'Reilly, M. and Parker, N. (2013). 'Unsatisfactory saturation': a critical exploration of the notion of saturated sample sizes in qualitative research. *Qualitative Research, 13*(2), 190-197.

Ogourtsova, T., Archambault, P.S. and Lamontagne, A. (2019). Exploring barriers and facilitators to the clinical use of virtual reality for post-stroke unilateral spatial neglect assessment. *Disability and Rehabilitation, 41*(3), 284-292.

Oh, H., Jeong, M. and Baloglu, S. (2013). Tourists' adoption of self-service technologies at resort hotels. *Journal of Business Research, 66*(6), 692-699.

Omer, T. (2016). Nursing Students' Perceptions of Satisfaction and Self-Confidence with Clinical Simulation Experience. *Journal of Education and Practice, 7*(5), 131-138.

Osanloo, A. and Grant, C. (2016). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your "house". *Administrative Issues Journal: Connecting Education, Practice, and Research, 4*(2), 7.

Ottensmeyer, M.P., Ben-Ur, E. and Salisbury, J.K. (2000). Input and output for surgical simulation: devices to measure tissue properties in vivo and a haptic interface for laparoscopy simulators. *Studies in Health Technology and Informatics, 70*, 236-242.

Pando-Garcia, J., Periañez-Cañadillas, I. and Charterina, J. (2016). Business simulation games with and without supervision: An analysis based on the TAM model. *Journal of Business Research, 69*(5), 1731-1736.

Parsons, T.D., and Rizzo, A.A. (2008). Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis. *Journal of Behaviour Therapy and Experimental Psychiatry, 39*(3), 250-261.

Patton, M.Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Thousand Oaks, CA.: Sage.

Patton, M.Q. (2005). Qualitative research. *Encyclopedia of statistics in behavioral science*. Hoboken, NJ.: John Wiley & Sons.

Pelargos, P.E., Nagasawa, D.T., Lagman, C., Tenn, S., Demos, J.V., Lee, S.J., . . . Ung, N. (2017). Utilizing virtual and augmented reality for educational and clinical enhancements in neurosurgery. *Journal of Clinical Neuroscience, 35*, 1-4.

Pepper, M.S., Alessandrini, M., Pope, A., Van Staden, W. and Green, R.J. (2019). Cell and gene therapies at the forefront of innovative medical care: Implications for South Africa. *South African Medical Journal, 109*(1), 20-22.

Piromchai, P., Avery, A., Laopaiboon, M., Kennedy, G. and O'Leary, S. (2015). Virtual reality training for improving the skills needed for performing surgery of the ear, nose or throat. *Cochrane Database of Systematic Reviews, 9*. Hoboken, NJ.: John Wiley & Sons. Retrieved from https://doi.org/10.1002/14651858.CD010198.pub2.

Piron, L., Cennis, F., Tonins, P. and Dam, M. (2001). Virtual reality as an assessment tool. Paper presented at the *Medicine Meets Virtual Reality, 81*, 386.

Playter, R. and Raibert, M. (1997). A virtual surgery simulator using advanced haptic feedback. *Minimally Invasive Therapy and Allied Technologies, 6*(2), 117-121.

Pope, C., Ziebland, S. and Mays, N. (2000). Qualitative research in health care: Analysing qualitative data. *BMJ, 320*(7227), 114.

Popoola, S. O., Omonisi, A. E., and Odesanmi, W. O. (2020). Sources of Cadaver for Anatomic Sciences in an Evolving Medical Institution. *African Journal of Biomedical Research, 23*(2), 293-296.

Porter, C.E. and Donthu, N. (2006). Using the technology acceptance model to explain how attitudes determine Internet usage: The role of perceived access barriers and demographics. *Journal of Business Research, 59*(9), 999-1007.

Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrović, V.M. and Jovanović, K. (2016). Virtual laboratories for education in science, technology, and engineering: A review. *Computers and Education, 95*, 309-327.

Pouris, A. and Inglesi-Lotz, R. (2014). The contribution of higher education institutions to the South African economy. *South African Journal of Science, 110*(3-4), 01-07.

Quinlan, C., Babin, B., Carr, J. and Griffin, M. (2019). *Business research methods.* 2nd ed. Andover, UK: South Western Cengage.

Rabkin, M. (2002). Patient simulators: Is it real or is it ultraism? *Prospective*, 1(3), 1-19.

Rajasekar, S., Philominathan, P. and Chinnathambi, V. (2013). Research methodology. *Social Research Methods Series*, 5. London: Sage.

Ratten, V. (2013). Cloud computing: A social cognitive perspective of ethics, entrepreneurship, technology marketing, computer self-efficacy and outcome expectancy on behavioural intentions. *Australasian Marketing Journal*, *21*(3), 137-146.

Reed, W., Oughton, J., Ayersman, D., Ervin Jr, J. and Giessler, S. (2002). Computer experience, learning style, and hypermedia navigation. *Computers in Human Behavior*, *16*(6), 609-628.

Reimenschneider, C.K., Leonard, L.N. and Manly, T.S. (2011). Students' ethical decision-making in an information technology context: A theory of planned behavior approach. *Journal of Information Systems Education*, *22*(3), 203.

Reimenschneider, C.K., Manly, T.S. and Leonard, L.N. (2019). Using giving voice to values to improve student academic integrity in information technology contexts. *Journal of Information Systems Education*, *27*(3), 4.

Reznek, M.A., Rawn, C.L., and Krummel, T.M. (2002). Evaluation of the educational effectiveness of a virtual reality intravenous insertion simulator. *Academic Emergency Medicine, 9*(11), 1319-1325.

Riva, G., Wiederhold, B.K. and Molinari, E. (Eds.). (1998). *Virtual environments in clinical psychology and neuroscience: Methods and techniques in advanced patient-therapist interaction* (Vol. 58). Washington, DC: IOS Press.

Rizzo, A.A., Schultheis, M., Kerns, K.A. and Mateer, C. (2004). Analysis of assets for virtual reality applications in neuropsychology. *Neuropsychological Rehabilitation*, *14*(1-2), 207-239.

Robin, D.P., Reidenbach, R.E, and Forrest, P. (1996). The perceived importance of an ethical issue as an influence on the ethical decision-making of ad managers. *Journal of Business Research*, *35*(1), 17-28.

Rodrigues, J.J., Segundo, D.B.D.R., Junqueira, H A., Sabino, M.H., Prince, R.M., Al-Muhtadi, J. and De Albuquerque, V.H.C. (2018). Enabling technologies for the internet of health things. *IEEE Access, 6*, 13129-13141.

Rogers, E M. (1995). *Diffusions of innovations*. 4^{th} ed.New York: Free Press.

Rogers, E.M. (2003). *Diffusion of innovations.* 5th ed. New York: Free Press.

Rogers, E.M. and Shoemaker, F.F. (1971). *Communication of innovations: A cross-cultural approach*. New York: Free Press.

Rosenthal, S., Das, S., Hsueh, P.Y. S., Barker, K., and Chen, C.H. (2020). Efficient goal attainment and engagement in a care manager system using unstructured notes. *Journal of the American Medical Informatics Association (JAMIA) Open, 3*(1), 62-69. Philadelphia: Hanley & Belfus-Elsevier Inc.

Roy, M.J., Sticha, D.L., Kraus, P.L. and Olsen, D.E. (2006). Simulation and virtual reality in medical education and therapy: A protocol. *CyberPsychology and Behavior, 9*(2), 245-247.

Ruthenbeck, G.S., and Reynolds, K.J. (2015). Virtual reality for medical training: the state-of-the-art. *Journal of Simulation, 9*(1), 16-26.

Sager, J.K. and Menon, A. (1994). The role of behavioral intentions in turnover of salespeople. *Journal of Business Research*, *29*(3), 179-188.

Sahay, A. (2016). Peeling Saunder's Research Onion. *Research Gate*, July: 1-5.

Salam, A., Saiboon, I. M., Jaafar, M. J., Hamzah, F. A., Balakrishnian, B., Kamarudin, M. A., . . . Siraz, H. H. (2016). Tutors perception on a training workshop on simulation based medical education. *Bangladesh Journal of Medical Science, 15*(2), 195-200.

Salleh, S.H. (2005). *An examination of factors influencing Bruneian secondary teachers' use of Information and Communication Technology in teaching: A survey exploration.* (Unpublished Doctoral dissertation), University of Southern Queensland, Australia.

Salt, L. and Lopes, R. (2019). Diagnosing employer medical aid contribution changes – the NHI Bill. *MoneyMarketing*, March: 26.

Samaradiwakara, G. and Gunawardena, C. (2014). Comparison of existing technology acceptance theories and models to suggest a well improved theory/model. *International Technical Sciences Journal*, *1*(1), 21-36.

Sandelowski, M. (1986). The problem of rigor in qualitative research. *Advances in Nursing Science,* 8(3), 27-37.

Sandelowski, M. (1993). Rigor or rigor mortis: the problem of rigor in qualitative research. *Advances in Nursing Science, 16*(2), 1-8.

Santamaria, A.F., Serianni, A., Raimondo, P. and De, F. (2016). Smart wearable device for health monitoring in the Internet of Things. In *Proceedings of the Summer Computer Simulation Conference* (p. 36). Montreal, Canada: Society for Computer Simulation International.

Satava, R.M. (1996). Cyber surgeon: Advanced simulation technologies for surgical education. *Bulletin of the American College of Surgeons*, 81, 77-81.

Satava, R.M. and Jones, S.B. (2000). Preparing surgeons for the 21st century: implications of advanced technologies. *Surgical Clinics of North America, 80*(4), 1353-1365.

Saunders, M.N., Lewis, P., Thornhill, A. and Bristow, A. (2015). Understanding research philosophy and approaches to theory development. In: M.N.K. Saunders, P. Lewis and A. Thornhill (Eds.), *Research methods for business students* (pp. 122-161). Harlow: Pearson Education.

Saunders, M., Lewis, P. and Thornhill, A. (2009). Research onion. *Research methods for business students*, London: Pearson Education, Ed., pp. 136-162.

Scalese, R.J., Obeso, V.T., and Issenberg, S.B. (2008). Simulation technology for skills training and competency assessment in medical education. *Journal of General Internal Medicine*, *23*(1), 46-49.

Schaper, L. K., and Pervan, G. P. (2006). Developing a model of technology acceptance within the Australian healthcare sector. *Pacific Asia Conference on Information Systems (PACIS) Proceedings*, 85. Australia. Retrieved from http://aisel.aisnet.org/pacis2006/85.

Schepers, J. and Wetzels, M. (2007). A meta-analysis of the technology acceptance model: Investigating subjective norm and moderation effects. *Information and Management, 44*(1), 90-103.

Sekgweleo, T. and Nemutanzhela, P. (2018). Support for healthcare systems in South Africa healthcare centre. *International Journal of Advances in Management and Economics, 4*(4), 66-72.

Semeraro, F., Ristagno, G., Giulini, G., Gnudi, T., Kayal, J.S., Monesi, A., . . . Scapigliati, A. (2019). Virtual reality cardiopulmonary resuscitation (CPR): Comparison with a standard CPR training mannequin. *Resuscitation*, *135*, 234-235.

Seretse, M., Chukwuere, J., Lubbe, S., and Klopper, R. (2018). Problems around Accessing Information in Rural Communities. *Alternation Journal, 25*(1), 214-244.

Seymour, N.E., Gallagher, A.G., Roman, S.A., O'Brien, M.K., Bansal, V.K., Andersen, D.K. and Satava, R.M. (2002). Virtual reality training improves operating room performance: results of a randomized, double-blinded study. *Annals of Surgery*, *236*(4), 458.

Sharma, A. and Citurs, A. (2004). Incorporating personality into UTAUT: individual differences and user acceptance of IT. *Americas Conference on Information Systems (AMCIS) Proceedings,* p.421, Atlanta, Georgia. Retrieved from https://aisel.aisnet.org/amcis2004/421.

Shay, S. (2017). Educational investment towards the ideal future: South Africa's strategic choices. *South African Journal of Science*, *113*(1-2), 1-6.

Sheikh, A.H., Barry, D.S., Gutierrez, H., Cryan, J.F. and O'Keeffe, G.W. (2016). Cadaveric anatomy in the future of medical education: What is the surgeons view? *Anatomical Sciences Education, 9*(2), 203-208.

Shepard, K.F., Jensen, G.M., Schmoll, B.J., Hack, L.M. and Gwyer, J. (1993). Alternative approaches to research in physical therapy: positivism and phenomenology. *Physical Therapy, 73*(2), 88-97.

Shuvo, T.A., Islam, R., Hossain, S., Evans, J.L., Khatun, F., Ahmed, T., . . . Adams, A.M. (2015). eHealth innovations in LMICs of Africa and Asia: a literature review exploring factors affecting implementation, scale-up, and sustainability. *Health Care, 8*, 9.

Silverman, D. (2013). *Doing qualitative research: A practical handbook*. London: Sage.

Smith-MacDonald, L., Reay, G., Raffin-Bouchal, S. and Sinclair, S. (2019). Patient-oriented research and grounded theory: A case study of how an old method can inform cutting-edge research. *International Journal of Qualitative Methods, 18*, 1-13.

Smith, M. E., Navaratnam, A., Jablenska, L., Dimitriadis, P. A., and Sharma, R. (2015). A randomized controlled trial of simulation-based training for ear, nose, and throat emergencies. *The Laryngoscope, 125*(8), 1816-1821.

Snieder, R. and Larner, K. (2009). *The art of being a scientist: A guide for graduate students and their mentors*. Cambridge: Cambridge University Press.

Sohlberg, M., and Mateer, C. A. (2001). *Cognitive rehabilitation. An integrative neuropsychological approach*. New York: Guilford Publications.

Sood, S.P., Nwabueze, S.N., Mbarika, V.W., Prakash, N., Chatterjee, S., Ray, P. and Mishra, S. (2008). Electronic medical records: A review comparing the challenges in developed and developing countries. In *Proceedings of the 41st Annual Hawaii International Conference on System Sciences* (HICSS), (pp. 248). Hawaii, USA: IEEE.

Speier, C. and Venkatesh, V. (2002). The hidden minefields in the adoption of sales force automation technologies. *Journal of Marketing, 66*(3), 98-111.

Stake, R.E. (1995). The art of case study research. *Handbook of qualitative research, edited by Norman Denzin and Yvonna Lincoln.* Thousand Oaks, CA: Sage.

Steele, E., Grimmer, K., Thomas, B., Mulley, B., Fulton, I. and Hoffman, H. (2003). Virtual reality as a pediatric pain modulation technique: a case study. *CyberPsychology and Behavior, 6*(6), 633-638.

Stone, T.H., Jawahar, I. and Kisamore, J.L. (2009). Using the theory of planned behavior and cheating justifications to predict academic misconduct. *Career Development International*, 14(3), 221-241.

Strickland, E. (2019). IBM Watson, heal thyself: How IBM overpromised and underdelivered on AI health care. *IEEE Spectrum, 56*(4), 24-31.

Suh, B. and Han, I. (2002). Effect of trust on customer acceptance of Internet banking. Electronic *Commerce Research and Applications, 1*(3-4), 247-263.

Suhendra, E.S., Hermana, B., and Sugiharto, T. (2009). Behavioral analysis of information technology acceptance in Indonesia small enterprises. Paper presented at the *Anadolu International Conference in Economics* (pp. 1-13). Eskisehir, Turkey.

Šumak, B., Polancic, G. and Hericko, M. (2010). *An empirical study of virtual learning environment adoption using UTAUT.* Paper presented at the 2010 *Second International Conference on Mobile, Hybrid, and On-line Learning* (pp. 17-22). Saint Maarten, Netherlands: IEEE. doi: 10.1109/eLmL.2010.11.

Sveistrup, H., McComas, J., Thornton, M., Marshall, S., Finestone, H., McCormick, A., . . . Mayhew, A. (2003). Experimental studies of virtual reality-delivered compared to conventional exercise programs for rehabilitation. *CyberPsychology and Behavior, 6*(3), 245-249.

Swart, R., Duys, R. and Hauser, N. (2019). SASS: South African Simulation Survey – a review of simulation-based education. *Southern African Journal of Anaesthesia and Analgesia, 25*(4), 12-20.

Sweeney, J.C., and Soutar, G.N. (2001). Consumer perceived value: The development of a multiple item scale. *Journal of Retailing*, *77*(2), 203-220.

Sweeney, W.B. (2012). Teaching surgery to medical students. *Clinics in Colon and Rectal Surgery, 25*(03), 127-133.

Tashjian, V.C., Mosadeghi, S., Howard, A.R., Lopez, M., Dupuy, T., Reid, M., . . . Robbins, K. (2017). Virtual reality for management of pain in hospitalized patients: results of a controlled trial. *JMIR Mental Health, 4*(1), e9.

Taylor, S. and Todd, P. A. (1995). Understanding information technology usage: A test of competing models. *Information Systems Research, 6*(2), 144-176.

Tendick, F., Downes, M.S., Cavusoglu, M.C., Gantert, W.A. and Way, L.W. (1998). Development of virtual environments for training skills and reducing errors in laparoscopic surgery. Paper presented at the *Surgical-Assist Systems, International Society for Optics and Photonics* (pp. 36-44). San Jose, CA.

Teo, T. and Tan, L. (2012). The theory of planned behavior (TPB) and pre-service teachers' technology acceptance: A validation study using structural equation modeling. *Journal of Technology and Teacher Education*, *20*(1), 89-104.

Thanh, N.C., and Thanh, T. (2015). The interconnection between interpretivist paradigm and qualitative methods in education. *American Journal of Educational Science*, *1*(2), 24-27.

Thompson, R.L., Higgins, C.A., and Howell, J.M. (1991). Personal computing: toward a conceptual model of utilization. *MIS Quarterly, 15*(1), 125-143.

Thompson, R.L., Higgins, C.A. and Howell, J.M. (1994). Influence of experience on personal computer utilization: Testing a conceptual model. *Journal of Management Information Systems, 11*(1), 167-187.

Thomsen, A.S.S., Bach-Holm, D., Kjærbo, H., Højgaard-Olsen, K., Subhi, Y., Saleh, G.M., . . . Konge, L. (2017). Operating room performance improves after proficiency-based virtual reality cataract surgery training. *Ophthalmology*, *124*(4), 524-531.

Torkington, J., Smith, S., Rees, B. and Darzi, A. (2000). The role of simulation in surgical training. *Annals of the Royal College of Surgeons of England*, *82*(2), 88.

Tracy, S. J. (2019). *Qualitative research methods: Collecting evidence, crafting analysis, communicating impact*, Hoboken, NJ: John Wiley & Sons, *2*, 1-432.

Triandis, H.C. (1977). *Interpersonal behavior*. Monterey, CA.: Brooks/Cole Publishing.

Triandis, H.C. (1979). Values, attitudes, and interpersonal behavior. Paper presented at the *Nebraska Symposium on Motivation* (pp. 195-259). Nebraska, USA: University of Nebraska Press.

Tsai, Y.H., Lin, C.P., Chiu, C.K. and Joe, S.W. (2009). Understanding learning behavior using location and prior performance as moderators. *Social Science Journal*, *46*(4), 787-799.

Tseng, C., Lee, Y., Chan, Y., Wu, S. and Chiu, A. (1998). A PC-based surgical simulator. In *Medicine meets virtual reality: Art, science, technology: Healthcare (r) evolution*, 50, 155. Amsterdam: IOS Press.

Tun, J. K., Alinier, G., Tang, J., and Kneebone, R. L. (2015). Redefining simulation fidelity for healthcare education. *Simulation & Gaming*, *46*(2), 159-174.

Van den Berg, J. and Van der Lingen, E. (2019). An empirical study of the factors affecting the adoption of mobile enterprise applications. *South African Journal of Industrial Engineering*, *30*(1), 124-146.

Van Raaij, E.M. and Schepers, J.J. (2008). The acceptance and use of a virtual learning environment in China. *Computers and Education, 50*(3), 838-852.

Vaughan, N., Dubey, V. N., Wainwright, T. W., and Middleton, R. G. (2016). A review of virtual reality-based training simulators for orthopedic surgery. *Medical engineering & physics, 38*(2), 59-71.

Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research, 11*(4), 342-365.

Venkatesh, V. and Davis, F.D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46*(2), 186-204.

Venkatesh, V., Brown, S.A., Maruping, L.M. and Bala, H. (2008). Predicting different conceptualizations of system use: the competing roles of behavioral intention, facilitating conditions, and behavioral expectation. *MIS Quarterly*, 32(3), 483-502.

Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425-478.

Vijayasarathy, L.R. (2004). Predicting consumer intentions to use on-line shopping: The case for an augmented technology acceptance model. *Information and Management*, *41*(6), 747-762.

Wagner, S., Mendez, D., Felderer, M., Graziotin, D. and Kalinowski, M. (2019). *Challenges in survey research* (pp. 1-34). Retrieved from https://arxiv.org/pdf/1908.05899.pdf.

Walker, J.L. (2012). The use of saturation in qualitative research. *Canadian Journal of Cardiovascular Nursing*, *22*(2), 37-41.

Wang, Y., Cui, S., Yang, Y. and Lian, J.A. (2009). Virtual reality mathematic learning module for engineering students. *Technology Interface Journal*, *10*(1), 1-10.

Weghorst, S.J., Sieburg, H.B. and Morgan, K.S. (1996). *Proceedings of the Medicine meets virtual reality Conference: Health Care in the Information Age* (pp. 1-9). San Diego, CA.: IOS Press.

Weghorst, S., Airola, C., Oppenheimer, P., Edmond, C.V., Patience, T., Heskamp, D. and Miller, J. (1998). Validation of the Madigan ESS simulator. *Studies in Health Technology and Informatics, 50*, 399-405.

Weiss, P.L. and Jessel, A.S. (1998). Virtual reality applications to work. *Work, 11*(3), 277-293.

Weiss, P.L., Bialik, P., and Kizony, R. (2003). Virtual reality provides leisure time opportunities for young adults with physical and intellectual disabilities. *CyberPsychology and Behavior*, *6*(3), 335-342.

Westwood, J., Hoffman, H., Stredney, D. and Weghorst, S. (1998). Validation of virtual reality to teach and assess psychomotor skills in laparoscopic surgery: results from randomised controlled studies using the MIST VR laparoscopic simulator. *Medicine Meets Virtual Reality: Art, Science, Technology: Healthcare and Evolution, 124,* 124-130.

Wiederhold, B.K., Jang, D.P., Gevirtz, R.G., Kim, S.I., Kim, I.Y. and Wiederhold, M.D. (2002). The treatment of fear of flying: a controlled study of imaginal and virtual reality graded exposure therapy. *IEEE Transactions on Information Technology in Biomedicine, 6*(3), 218-223.

Wiles, R., Crow, G. and Pain, H. (2011). Innovation in qualitative research methods: A narrative review. *Qualitative Research, 11*(5), 587-604.

Wilson, M., Middlebrook, A., Sutton, C., Stone, R. and McCloy, R. (1997). MIST VR: a virtual reality trainer for laparoscopic surgery assesses performance. *Annals of the Royal College of Surgeons of England, 79*(6), 403.

Witmer, B.G. and Singer, M.J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence, 7*(3), 225-240.

Woolliscroft, J.O., Calhoun, J.G., Tenhaken, J.D. and Judge, R.D. (1987). Harvey: the impact of a cardiovascular teaching simulator on student skill acquisition. *Medical Teacher, 9*(1), 53-57.

World Health Organization. (2003). *Guide to producing national health accounts: With special applications for low-income and middle-income countries*. Geneva: World Health Organization

Xu, B., Da Xu, L., Cai, H., Xie, C., Hu, J. and Bu, F. (2014). Ubiquitous data accessing method in IoT-based information system for emergency medical services. *IEEE Transactions on Industrial Informatics, 10*(2), 1578-1586.

Yang, S. (2013). Understanding undergraduate students' adoption of mobile learning model: A perspective of the extended UTAUT2. *Journal of Convergence Information Technology*, *8*(10), 969.

Yano, H., Kasai, K., Saitou, H. and Iwata, H. (2003). Development of a gait rehabilitation system using a locomotion interface. *Journal of Visualization and Computer Animation*, *14*(5), 243-252.

Yin, R. K. (2003). *Case study research: design and methods*. Thousand Oaks, CA.: Sage.

Yu, W., Wen, L., Zhao, L.-A., Liu, X., Wang, B. and Yang, H. (2019). The applications of virtual reality technology in medical education: a review and mini research. Paper presented at the *Journal of Physics: Conference Series, 1176*(2), 022055. Bristol: IOP Publishing. doi:10.1088/1742-6596/1176/2/022055.

Yule, S., Flin, R., Paterson-Brown, S. and Maran, N. (2006). Non-technical skills for surgeons in the operating room: a review of the literature. *Surgery*, *139*(2), 140-149.

Yvonne Feilzer, M. (2010). Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of Mixed Methods Research, 4*(1), 6-16.

Zacharia, Z. (2003). Beliefs, attitudes, and intentions of science teachers regarding the educational use of computer simulations and inquiry-based experiments in physics. J*ournal of Research in Science Teaching*, *40*(8), 792-823.

Zeithaml, V.A. (1988). Consumer perceptions of price, quality, and value: a means-end model and synthesis of evidence. *Journal of Marketing, 52*(3), 2-22.

Zeng, N., Pope, Z., Lee, J.E. and Gao, Z. (2018). Virtual reality exercise for anxiety and depression: A preliminary review of current research in an emerging field. *Journal of Clinical Medicine*, *7*(3), 42.

Zeng, Y., Zhang, J.E., Cheng, A.S., Cheng, H. and Wefel, J.S. (2019). Meta-analysis of the efficacy of virtual reality–based interventions in cancer-related symptom management. *Integrative Cancer Therapies, 18*, 1534735419871108.

Zhang, Z., and Bickmore, T. (2018). Medical shared decision making with a virtual agent. Paper presented at the Proceedings of the 18th International Conference on Intelligent Virtual Agents, Sydney, Australia. NY: ACM, 113-118. https://doi.org/10.1145/3267851.3267883.

Zhang, M., Park, T. and Biyi, F. (2019). System and apparatus for immersive and interactive machine-based strength training using virtual reality. In: Google Patents. U.S. Patent Application 16/204, 887, filed May 30, 2019.

Zhao, X., Liang, J. and Dang, C. (2019). A stratified sampling-based clustering algorithm for large-scale data. *Knowledge-based Systems*, *163*, 416-428.

Zhao, Y., Pugh, K., Sheldon, S. and Byers, J.L. (2002). Conditions for classroom technology innovations. *Teachers College Record, 104*(3), 482-515.

Zimand, E., Anderson, P., Gershon, J., Graap, K., Hodges, L. and Rothbaum, B. (2002). Virtual reality therapy: Innovative treatment for anxiety disorders. *Primary Psychiatry, 9*(7), 51-54.

Ziv, A., Wolpe, P.R., Small, S. D, and Glick, S. (2006). Simulation-based medical education: an ethical imperative. *Simulation in Healthcare, 1*(4), 252-256.

APPENDICES

Appendix A: Alignment of the theoretical framework with the research objectives and questions; and interview questions

UTAUT CONSTRUCTS	STUDY OBJECTIVES	RESEARCH QUESTIONS	INTERVIEW QUESTIONS
1. Performance Expectancy	1. To identify the determinants of the adoption of Virtual Reality for medical training.	1. What is the perceived usefulness of using Virtual Reality in medical training?	1. How useful would Virtual Reality be in the context of training medical students? a. What is the Information, Communication Technologies (ICTs) - related technologies currently used to train medical students? b. Could you please describe instances whereby Virtual Reality would be a better option for medical training when compared to the existing ICT-related training technologies? If yes or no, Why? Please elaborate. c. Could you please give some examples of how Virtual Reality could be used to train medical students?
2. Effort Expectancy	2. To identify the determinants of the adoption of Virtual Reality for medical training.	2. What is the perceived effort required to use Virtual Reality for medical training?	2. What are your perceptions of ease/difficulty about using Virtual Reality for training medical students? a. Do you think it will easy or difficult for students and staff (lecturers) to use Virtual Reality for medical training? Why do you think that way? b. In your opinion, what could be done to ensure that Virtual Reality technologies are easy to use from the lecturers and students' perspectives?
3. Social Influence	3. To identify the determinants of the adoption of Virtual Reality for medical training	3. What are the social factors that can influence the adoption of Virtual Reality for medical training?	3. Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students? a. Do you perceive any influential people in the society and in the lives of students that could promote the use of Virtual Reality for medical training? Please elaborate. b. How could these people influence the use of Virtual Reality for training medical students?
4. Facilitating Conditions	4. To identify challenges to the adoption of Virtual Reality for medical training. a. To propose potential ways to manage the identified challenges.	4. What are the facilitating conditions for the adoption of Virtual Reality for medical training? a. What are the challenges for the adoption of Virtual Reality for medical training? b. What could be done to overcome challenges associated with the adoption of Virtual Reality for medical training purposes?	4. What are the possible factors that could facilitate the adoption of Virtual Reality for training medical students? a. What, do you perceive, could be the anticipated types (or categories) of challenges to the adoption of Virtual Reality for training medical students? Please elaborate on each challenge category. b. What would you recommend as solutions to surmount the challenges?

Appendix B: Ethical Clearance letter

UNIVERSITY OF KWAZULU-NATAL

INYUVESI YAKWAZULU-NATALI

30 January 2020

Ms Zhane Solomon (214553369)
School of Management, IT & Governance
Pietermaritzburg Campus

Dear Ms Solomon,

Protocol reference number: HSS/0679/018M
New Project Title: The adoption of Virtual Reality for Medical Training in the context of South African higher education

Approval Notification – Amendment Application

This letter serves to notify you that your application and request for an amendment received on 20 January 2020 has now been approved as follows:

•Change in title

Any alterations to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form; Title of the Project, Location of the Study must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

Best wishes for the successful completion of your research protocol.

Yours faithfully

Dr Shamila Naidoo (Chair)

/dd

Cc Supervisor: Dr Patrick Ndayizigamiye and Rushil Raghavjee
Cc Academic Leader Research: Professor Isabel Martins
Cc School Administrator: Ms Debbie Cunynghame

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Appendix C: Letter of professional editing

Athol Leach (Proofreading and Editing)

31 Park Rd
Fisherhaven
Hermanus 7200
Email: atholleach@gmail.com Cell: 0846667799

11 June 2020

To Whom It May Concern

This letter serves to confirm that I have edited the following Master of Commerce (Information Systems and Technology) dissertation:

THE ADOPTION OF VIRTUAL REALITY FOR MEDICAL TRAINING IN THE CONTEXT OF SOUTH AFRICAN HIGHER EDUCATION By Zhane Solomon 214553369

The document was edited in terms of grammar, spelling, punctuation and overall style. In doing so use was made of MS Word's "Track changes" facility thus providing the student with the opportunity to reject or accept each change. Please note that while I have checked for consistency of referencing in terms of format (both in-text and in the list of references), I have not checked the veracity of the sources themselves or that the bibliographic information is complete. Nor have I checked for possible plagiarism.

The tracked document is on file.

Sincerely

Athol Leach

(MIS, Natal)

Appendix D: Interview Transcripts

I 1

Researcher: How useful would Virtual Reality be to train medical students?
Respondent: I think from what you have explained, if it is a simulation of the course work or the dissection of animals or plants, then I think it could be useful to help students to participate in the activity. And it would assist me in terms of not having to find an abattoir that sells or gives me the animal to be used for practicals. I think in terms of good practice and ethics it would be useful because I would not need to wait for a cadaver to perform medical tests.
Researcher: What are the types of training that medical students undergo?
Respondent: Patient relationship training, basically how to handle trauma cases and how to respond to emergency cases. Training in terms of admitting a patient for a certain condition, prescribing medicines, monitoring the patient's vitals and symptoms, and dealing with post-surgery and post-diagnosis. Dealing with the patient's family.

Researcher: How useful, do you think, Virtual Reality could be for the different types of training? *Respondent:* I think it will be useful for practicing diagnosis and treatment of patients with common diseases. Like, students can prepare for how it would be in a hospital.
Researcher: Practice for the real world**?**
Respondent: Exactly… Because it is not easy to be an intern at a hospital. And most of the time, you have to write down notes and have discussions with the head doctor but there aren't situations for you to actually practice treating a real, live, patient.
Researcher: Okay, so you mentioned the different types of training, what benefits do you anticipate from using Virtual Reality for those training… the types of training?
Respondent: In terms of the trauma cases, where you have patients who have suffered from severe illnesses or accidents and require extensive support, I think virtual reality will help to mentally prepare students for that situation. It will provide them with the practical knowledge they need to deal with the situation. Also, I would have liked to have had a dummy environment to continuously practice surgery until I was good at it. I have my own practice and I through many years of studying and interning at hospitals I learnt what it was like to have hands-on experience, and to tell you the truth at times I feel like if I was taught these things earlier than it would have saved me so much of time… because I honestly feel like I have studied for so long and then by the time I enter the market to help people, I am old and want to soon retire. So, if I had exposure to technology such as what you are saying, then perhaps things would be ….. But yeah, so its helps them with gaining experience and knowledge from practicing the work and not just reading about it.

Researcher: What is the Information, Communication Technologies (ICTs) - related technologies currently used to train medical students?
Respondent: ICT utilisation in therapeutic instruction is distinctive among industrialized nations. While developing nations have put intensely in ICT mix in therapeutic training and made it feasible for medicinal understudies to approach the most recent updates in the restorative fields, creating nations that are lagging behind because of number of monetary, social, and infrastructural restrictions. IT information and PC abilities among medical students and doctors are higher in developed nations compared to developed nations, primarily because of financial restrictions, for example, the accessibility of PCs and Internet associations. The university provides us access to laptops and we have labs that have pcs like dell. This allows us to do research from the digital libraries. Also, students can use e-learning sites such as Moodle which you know allows us to share information. Then there is emails and other software such as Dropbox which I sometimes use if I am away and students need to submit group projects.

Researcher: Do you think if you compare the ICTs you mentioned to using VR, would it be a better option for medical training?
Respondent: The virtual reality? Would that be better than emails…

Researcher: Yes, the ICTS…
Respondent: Yes of course it would be better, as I told you I think it will help students to gain experience and knowledge and I feel like the ICTs we are using are very basic compared to something like V... uhm, VR…

Researcher: Could you please give some examples of how Virtual Reality could be used to train medical students?
Respondent: I could use it to teach dissection or anatomy.

Researcher: Okay… Do you think it will be ease/difficulty to use Virtual Reality for training medical students?
Respondent: For whom? Staff or students?

Researcher: Staff?... maybe Both?
Respondent: I would find it difficult because I have not used it before so if I am told to use it without any training then I'll find it difficult. Like if they tell me that I need to use it and then they provide training, then I would be excited to try something new. For students I think they would be okay I mean no one teaches them to use Facebook and twitter so I guess they will be able to use it. But of course, training is necessary.

Researcher: What are the possible factors that could facilitate the adoption of Virtual Reality for training medical students?
Respondent: The university buys the equipment required with no extra costs to students, because I do not think it will be feasible for students to buy the vr equipment because then it will become about whether it is mandatory or optional… is it necessary to pass a module?
Also, maintaining the devices, like our labs are costly, so if you have this new device it's going to add to costs and then what happens to maintenance?

Researcher: Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students?
Respondent: Probably, like if it becomes the next Facebook then students will be keen to use it to study, and also if it is cost-effective.

Researcher: Do you perceive any influential people in the society and in the lives of students that could promote the use of Virtual Reality for medical training?
Respondent: Not too sure about this one, but I guess if the peers are using vr for training then students are most likely to want to use it too. Like I would use something if my friends are using it.

Researcher: What, do you perceive, could be the anticipated types (or categories) of challenges to the adoption of Virtual Reality for training medical students? Please elaborate on each challenge category.
Respondent: The cost of it. The devices, like if it is possible to get it at cost-effective rates. And also getting older staff to accept using newer technologies. So, like changing to newer technologies.

Researcher: What would you recommend as solutions to surmount the challenges?
Respondent: Getting a contract to acquire cost-effective devices. Also, gradually introducing us to it. I would not want to just be told to use the technology. We need to first look at whether it can be used to teach medicine and how effective would it be, before you know…

Researcher: Okay… Thank you so much for your time.
Respondent: No, no it's okay. No problem.

I2

Researcher: How useful would Virtual Reality be to train medical students?
Respondent: Very useful if you think about putting them in an environment which replicates the real-life situation which will give them the skills and experience to actually perform the medical skill in reality.

Researcher: What are the types of training that medical students undergo?
Respondent: Concepts of family medicine, common problems, importance of psychosocial aspects in health and disease, doctor patient relationship, art of family medicine, history taking and examination, record keeping, practice organization and management were the key areas they taught students. They were of the view that three visits, which took place once a week were not sufficient to teach procedural skills, progression of illness and continuity of care adequately.

Researcher: How useful, do you think, Virtual Reality could be for the different types of training?
Respondent: Virtual reality (VR) medical simulations deliver a tailored learning experience that can be standardized and can cater to different learning styles in ways that cannot be matched by traditional teaching. These simulations also facilitate self-directed learning.

Researcher: What benefits do you anticipate from using Virtual Reality for each type of training? Please elaborate on each benefit.
Respondent: Allows trainees to develop skills at their own pace and allow unlimited repetition of specific scenarios that enable them to remedy skills deficiencies in a safe environment. A number of simulators have been validated and have shown clear benefits to medical training. However, while graphical realism is high, realistic haptic feedback and interactive tissues are limited for many simulators

Researcher: What is the Information, Communication Technologies (ICTs) - related technologies currently used to train medical students?
Respondent: Information and communication technology (ICT) has brought many changes in medical education and practice in the last couple of decades. Body scanners: A body scanner sends electromagnetic rays through a patient’s body and sensors detect how much different parts of the body absorb the rays. A computer uses this data to build up an image of the inside of a patient’s body. Body scanners allow doctors to find and treat conditions such as tumours in their early stages when the chances of treating them successfully are much greater. Patient monitoring**:** Computers are used in hospitals to monitor critically ill patients in intensive care units. The patient has sensors attached to him which detect changes in heart rate, pulse rate, blood pressure, breathing and brain activity. If any of this fall below a present level the computer sounds an alarm and alerts the medical staff. The data is also logged and used to analyse the changes in a patient’s condition over a period of time. Organ transplants: Computerised databases are used to help match patients who are waiting for organ transplants such as a new kidney, liver or heart, with suitable organs from donors. Patient records: Computerised databases are used by every hospital in the country to store information about patients. Uses of these databases include: organising the transfer of patients between wards recording the history of a patient’s appointments with a consultant booking outpatient appointments booking ambulances ordering equipment.

Researcher: Could you please describe instances whereby Virtual Reality would be a better option for medical training when compared to the existing ICT-related training technologies? If yes or no, Why? Please elaborate.
Respondent: Yes, when we think about VR, we tend to associate it with the entertainment genre. Although VR indeed set sails to enhance the demanding gamer’s experience, it has also made significant improvements to the lives of people with autism, lazy eye, chronic pain, and other health conditions.

Researcher: Could you please give some examples of how Virtual Reality could be used to train medical students?
Respondent: Can be used to train students who aspire to become surgeons. Shafi Ahmed, in 2016 streamed a cancer surgery in virtual reality that was shot in 360-degree video while he removed a colon tumor from a patient. Ahmed’s philosophy is clear. He says, “Forget one-to-one. My idea is one to many. I want to share knowledge with the masses.” To achieve this, his company Medical Realities is building the world’s first interactive VR training module for surgeons. Brennan Spiegel, a pioneer of VR in healthcare at Cedars-Sinai, has witnessed first-hand the positive impact of using virtual reality with patients for therapeutic treatment. At Cedars-Sinai, Spiegel leads a team that studies how technologies like smartphone apps, VR, wearable biosensors, and social media can improve health outcomes. Spiegel’s team also had success using VR to help men with high blood pressure. Inside of the VR program, users are transported into a kitchen and educated on which types of food contain sodium. The program then brings users inside a human body, where they can see the targeted impact of the sodium intake. Technology doesn’t always *need* to feel like magic, but when it can for a struggling patient or doctor seeking access to training, that’s an extraordinary thing for health care.

Researcher: What are your perceptions of ease/difficulty about using Virtual Reality for training medical students?
Respondent: For me it’s not too difficult to use but I think that even if you find it hard to use, all you need to do is practice with the equipment and then you will become good at it and find it easier to use.

Researcher: Do you think it will easy or difficult for students and staff (lecturers) to use Virtual Reality for medical training? Why do you think that way?
Respondent: It will be difficult at first due to the fact that nobody likes to learn new technology when you are already comfortable with the ICTs you currently use. But once, medical students and professionals use the ICTs more consistently then it will be easier to use and give us an advantage and edge in healthcare.

Researcher: In your opinion, what could be done to ensure that Virtual Reality technologies are easy to use from the lecturers and students' perspectives?
Respondent: I propose that these medical VR's have an easy to read instruction manual which inexplicably explains every detail on how to use the technology so that people who use it can follow the few easy steps to get going.

Researcher: What are the possible factors that could facilitate the adoption of Virtual Reality for training medical students?
Respondent: Systems based on virtual reality offer a unique opportunity for the training of professional surgical skills on a wide scale and in a repeatable manner, in a way similar to the routine training of pilots. In some areas, such as conformal radiotherapy and stereotactic neurosurgery, treatment is not possible without preoperative planning with the aid of a computer. In other areas, such as craniofacial neurosurgery and open neurosurgery, the possibility of planning surgery on a computer screen, trying out different surgical approaches with realistic prediction of the outcome (for example, postoperative appearance of the patient), and planning individualised custom-made implants have substantial impact on the success and safety of the intervention. The rapid adoption of minimally invasive surgical techniques is one of the major driving forces in the development of surgical trainers. The extreme limitations placed on visual and manipulative freedom, including the loss of tactile feedback and the unusual hand-eye coordination, makes extensive specialised training for such interventions necessary. Virtual reality is the technology of choice with the greatest potential for future development, and a rapidly growing number of commercial units is becoming available. Virtual reality-based technology is a new but rapidly growing area in medicine, which will revolutionise health care in the foreseeable future. The impact of this technology is just beginning to be recognised owing to methodological, technical, and manufacturing breakthroughs in the past few years. It must, however, be emphasised that the technology is simply a tool and that the other critical areas of content development and physician-patient relationship must be incorporated into the new systems.

Researcher: Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students?
Respondent: Yes, the influence of other doctors who are currently exploring opportunities through the use of VR in various medical fields can have a social influence which could facilitate the integration of VR's in medical training.

Researcher: Do you perceive any influential people in the society and in the lives of students that could promote the use of Virtual Reality for medical training? Please elaborate.
Respondent: Brennan Spiegel, a pioneer of VR in healthcare at Cedars-Sinai, has witnessed first- hand the positive impact of using virtual reality with patients for therapeutic treatment. Spiegel told the story of a young adult suffering from severe Crohn's disease, which forced him to spend 100 days of the last year in the hospital. The most healing environment he can think of, however, is his grandmother's living room. Spiegel's team was able to place a Samsung 360 camera in the grandmother's living room then give the patient a VR headset to virtually transport him there. The experience nearly brought him to tears and is a perfect example of how VR can make patients in hospital treatment more comfortable. Shafi Ahmed, co-founder of Virtual Medics and Medical Realities, spoke again this year at Exponential Medicine. Last year we wrote about Ahmed's efforts to solve the huge global shortage of trained surgeons: "According to the Lancet commission on global surgery, the surgical workforce would have to double to meet the needs of basic surgical care for the developing world by 2030. Dr. Ahmed imagines being able to train thousands of surgeons simultaneously in virtual reality." With this in mind, Ahmed made a splash back in 2014 when he reached 14,000 surgeons across 100 different countries by using Google Glass to stream a surgical training session. I believe these two guys are shaping our future of how we go about providing medical expertise for training and for patients.

Researcher: How could these people influence the use of Virtual Reality for training medical students?
Respondent: These two guys are already influencing people around the world of how VR can be advantageous for the use of training and practical use also. They did this by streaming to thousands of people worldwide to teach them how to prepare surgery and undertake surgery. Also including, creating relaxed environments for patients.

Researcher: What, do you perceive, could be the anticipated types (or categories) of challenges to the adoption of Virtual Reality for training medical students? Please elaborate on each challenge category.
Respondent: Monetary/Funding - Many of the respondents are start-ups developing AR/VR content, eyewear, or end-to-end solutions. So, it's not surprising that money and funding for product development, research and other marketing costs are at the top of the list

Technical Limitations - For some, the size of VR systems limits their use in certain clinical settings. For others, mobile VR platforms can only provide so much immersion with a pocket size computer. Computer specifications and resolution of available devices can also be limiting factors for some medical centers.
Lack of knowledge - This is an area of particular interest for the VRARA committee. Many of our contacts and colleagues have heard of VR/AR being used for gaming and entertainment but are unaware of the medical use cases and the research behind them. Disseminating this knowledge is an important goal of the committee. We know many people say they "get it" as soon as they demo VR/AR for the first time because it's very intuitive, but most patients and providers have never had a live VR/AR experience. Understanding immersion is best done through one's own eyes.

Researcher: What would you recommend as solutions to surmount the challenges?
Respondent: Given the obvious benefits of various emerging VR/AR technologies including pain diminution, surgical planning and practice, 3D radiological imaging and medical education, we're confident that it won't be long before customers and investors start to invest in best-in-class solutions. Committee members have noticed that hospitals are increasing budgets for clinical simulation centers to allow them to purchase VR/AR equipment. Third party companies that work with medical organizations are starting to budget for VR/AR solutions as well. AR/MR tech is so new that only a small fraction of published research (574) examines its use in healthcare. Several areas still need randomized control trials to show evidence for mainstream adoption of AR/VR/MR by healthcare providers.

I3

Researcher: How useful would Virtual Reality be to train medical students?
Respondent: Medical students undergo training in clinical medicine and surgery. I believe that virtual reality can be very beneficial. Medical students will be able to improve their skills by practicing using virtual technology instead of practicing on a real person. This decreases the risk of misdiagnosing patients as medical students gain a broader perspective on the diagnosis and treatment of illneses using virtual technology. Virtual technology also allows medical students to make mistakes and learn from it without the risk of harming real patients (I am not sure)

Researcher: What are the types of training that medical students undergo?
Respondent: Simple and complex surgical procedures could be taught and practiced using virtual reality.

Researcher: Okay… Do you think it will be ease/difficulty to use Virtual Reality for training medical students?
Respondent: I believe that it would be easy. It is better and easier to practice using virtual reality instead of using a real person. There could be workshops and programmes that train lecturers and students on how to use virtual reality. There could also be incentives given to individuals who chose to use virtual reality. Financial assistance is important because this technology is expensive. Public hospitals are currently undergoing financial strains and cannot afford many medical and surgical equipment required hence the use of virtual reality will not be prioritized.

Researcher: Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students?
Respondent: Medical doctors and surgeons can influence the use of virtual reality as they have first-hand knowledge the how beneficial it can be. These individuals could motivate for the need of using virtual reality as they are aware of the benefits it will have in clinical medicine and surgery... Students may not know how to use the advanced technology appropriately and will therefore not be able to achieve the desired outcome. Students may eventually treat real patients like 'virtual reality patients' and may not take responsibility for their actions when mistreating a patient. Students may also develop a 'cold' and 'clinical' attitude towards real patients…. Students need to be educated on the appropriate use of virtual technology…. Students must also be aware of the difference between using this technology and treating a real person.

I4

Researcher: How useful will virtual reality be in the context of training medical students?
Respondent: As the population increases all around us, every second another person is falling ill ranging from a common flu to cancer to even life-threatening diseases. Virtual reality then allows medical students to able to witness major surgery simultaneously and be able to stand in and watch these surgery's taking place as well as be lectured on the procedures

Researcher: Could you please describe the types of training that medical students undergo?
Respondent: Skills Training in which they learn how to perform various operations and in that they would need to know how to perform their job in the perfect way or the right way... they undergo team training in that they need to know how to work as part of a team and how to interact with one another

Researcher: How useful do you think virtual reality could be for the different types of training?
Respondent: In terms of Skills Training it will be useful because they will need to learn how to do the job so they will have to know and then for team training it'll allow them to work together as part of the team so that is useful also. And in terms of virtual reality for these types of training with skills training VR would be helpful because as a medical student you will be able to witness this operation happening so you are able to view them and learn from them and for the team training you will see how other professionally equipped medical students or medical people work together and you will be able to work together or learn how to work together in your team okay

Researcher: What benefits do you anticipate from using Virtual Reality for each type of training?
Respondent: Virtual reality offers a potential for engaging in immersive experiences and real opportunities for learning and development for the students. they will be able to be transported to a completely different area, a completely different country, specializing field in which they can witness these surgeries going on and they will be able to learn from them and you know get useful tips on how to complete a procedure and increases their engagement in the field in which they want to venture in as well as it will increase their engagement in the procedures and in the medical field itself okay

Researcher: What is the ICT related Technologies currently used to train medical students?
Respondent: Okay so we had computer technology which is used for medical information to be stored on a database and use it also for research… computer technology which is all to use for research in which they can research different diseases etc. to come up with a profitable information okay

Researcher: Where a virtual reality would be better option for training medical training and compared to ICT?
Respondent: Surgeons can experience visual and physical feedback when practicing a procedure. They can receive training on procedures, equipment and patient interactions okay

Researcher: Could you please give some examples of how virtual reality could be used to train medical students?
Respondent: It creates a better practice environment. Students will need to practice to procedures to perfection, so this virtual reality allows for that. students can also witness what it is like to have certain illnesses... with virtual reality if people are getting old and they experience blindness or are hard of hearing... deafness... virtual reality allows surgeons to be able to witness how it is to have these illnesses

Researcher: What are your perceptions of ease or difficulties about using Virtual Reality for training medical students?
Respondent: For students it might be easy to use because many students can operate on a virtual patient, so it helps to acquire surgical skills by means of simulation. For staff it might be difficult especially because some people have not used such technologies before.

Researcher: Do you think it will be easy or difficult for students and staff to use?
Respondent: I think it'll be easier because there's an ability to perform and practice procedures until perfection. There is also better opportunity to train not one but many students at one time so that's the ease of it

Researcher: What can be done to ensure that the VR technologies are easy to use from the lecturers and students' perspective?
Respondent: I think you can allow more lectures and students to take advantage of virtual reality, use it more practice purposes using until they can practice whatever surgery the difficult ones or even easier ones to practice until they get it to perfection so allow them to take full advantage of the facilities that they have...

Researcher: What are the possible factors that could facilitate the adoption of virtual reality for training medical students?
Respondent: Three factors that have is improvement of Technology
New innovative thinking and maybe 3 increase number of new doctors…. the more the increase in the number of doctors the higher the need for new ways in which... new ways of thinking as well as performing different procedures

Researcher: Do you perceive any social influence that could be exerted that could facilitate or hinder the use of virtual reality for training medical students?
Respondent: Yes, some people may not be comfortable with it the older generation of staff may not like the idea of VR or they may not be comfortable with it. However, the younger generation of staff and students will welcome it more and be more accustomed to using it and training with it…

Researcher: Do you perceive influential people in a society and in the lives of students that could promote or hinder the use of virtual reality for medical training?
Respondent: So socially the government would want virtual reality to improve the ways in which medicine is coming across in order to take a better standing in society and amongst other countries, in the students live their parents because they would want them to better themselves and they would welcome the new change since they want their kids to improve all the time. So, the parents of these medical students that is….

Researcher: How could these people influence the use of virtual reality for training medical students?
Respondent: This can be done by donors or sponsors for the equipment. So, donations in form of cash or in the form of equipment. This would be a help for the sectors… the medical... sorry I meant for the virtual reality field

Researcher: What do you perceive could be the anticipated types of categories of challenges for the option of virtual reality for training medical students?
Respondent: The cost factor because it's obviously expensive but the fact of the second thing is the ability to be able to use virtual reality. The students and staff inability that is and the third factor is they may take advantage of virtual reality and not perform actual surgeries and just take advantage of the virtual side of it and not perform the real surgeries… so like students using it as a game instead of for learning and gaining skills.

Researcher: What would you recommend as solutions to surmount the challenges?
Respondent: Okay for the cost factor I would say get donations or the government could set aside funds for virtual reality but yeah just look for more like donations, sponsorships…. and this could come from the parents and the government or influential people that would like to provide sponsorships. For the inability to use virtual reality and for them taking advantage and not performing surgery here you can spend more time training students, be with them, like the experienced surgeons should demonstrate how it could be used… spend more time with medical students training them and making sure that they are there all the time with them so they can see that they're not taking advantage and that they're putting virtual reality to proper use.

Researcher: Thank you so much for your time.
Respondent: No problem

I5

Researcher: How useful will virtual reality be in the context of training medical students?
Respondent: It would be useful in ways that will help students to learn quicker.

Researcher: Do you think it will be ease/difficulty to use Virtual Reality for training medical students?
Respondent: I would find it difficult because I have not used it before

Researcher: What are the possible factors that could facilitate the adoption of Virtual Reality for training medical students?
Respondent: VR costs a lot. So, in terms of financial cost, it would be an impediment to the adoption of virtual reality. But I think that it’s possible to adopt virtual reality.

Researcher: Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students?
Respondent: I think that social influence from other students, the more senior ones, could facilitate the use of virtual reality. I really need to go now, are there any other questions?

I6

Researcher: How useful will virtual reality be in the context of training medical students?
Respondent: It would be of great help for medical students in the context of actually being involved physically and understanding the medical field. Teaching surgical procedures, teach teamwork, and develop psychomotor

skills. It would be useful in ways that will help students to learn faster and more efficiently in different environments. Allows students to gain experience without any risks, besides saving costs, training in a virtual environment also increases the levels of safety, and also helps students to be more inclined with the practical side than just the theoretical. VR could be used to prepare students for critical medical interventions without putting the patient's or the student's life in danger. VR could be used to train students to identify the correct treatment in cases where there are accidents or multiple casualties. VR allows students to feel the tense environment which requires one to be quick when making decisions and diagnosing conditions. VR provides a good and safe practice environment for aspects that are highly technical but are seldom performed by doctors but need to be well-known by them. An example of a procedure that is seldom performed but needs to be well-known is cricothyrotomy. This procedure involves making an incision into a specific area of the patient's neck to insert a plastic tube through a thin membrane in the trachea. This procedure requires speed and accuracy and can be life-saving if it is performed correctly but deadly if it is not performed correctly hence a quick analysis and decision about the area of incision needs to be taken.

Researcher: Do you think it will be ease/difficulty to use Virtual Reality for training medical students?
Respondent: I would find it difficult because I have not used it before

Researcher: What are the possible factors that could facilitate the adoption of Virtual Reality for training medical students?
Respondent: VR can decrease the operational cost of a physical training facility and it can allow students and medical personnel to train remotely without the additional costs. VR allows for distance training to occur. This means that the campus saves costs because they have VR training via distance.

I7

Researcher: How useful would Virtual Reality be to train medical students?
Respondent: Students undergo 3 years of non-clinical training in which they study skills, anatomy, physiology, pathology etc. at the university and 3 years of clinical training at government hospitals. I think virtual reality would be a very valuable tool that we can use in both our clinical and non -clinical years. It can be used by medical students to look at a simulated human body and see how it functions in 3 dimensions thus assisting medical students in learning anatomy and physiology. Procedures can also be practiced using virtual reality thus, enabling medical students to be more prepared for their clinical years and as a tool for revision in their clinical years. Instead of using pictures and diagrams to illustrate the workings of the human body, virtual reality can be used. It would also allow medical students to gain a better understanding of the physiology of the human body. Simulations of operations and procedures can be used to train medical students. Simulations of dissections can be used by medical students to revise their anatomy. The way in which the organs and muscles work inside the human body can also be shown through simulations.

Researcher: Hmmm… Do you think it will be ease/difficulty to use Virtual Reality for training medical students?
Respondent: I think with the proper guidance it would be a fun and easier way of learning… Maybe Conduct workshops illustrating how to use this technology

Researcher: Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students?
Respondent: The realisation that it can become a valuable tool that facilitates learning. I think lecturers as well as other accomplished specialists in the field can promote it…If these people use it and feel that it is valuable, students will automatically want to use it as well because they value and respect the opinion of the above-mentioned people

Researcher: What are the possible factors that could facilitate the adoption of Virtual Reality for training medical students?
Respondent: Cost as the technology would be expensive. Knowledge on how to use the technology- not everyone would be able to fully utilise the technology and understand how it works. Maybe conduct lectures and train lecturers and students on how to use and operate the technology. The university can find cheaper ways to manufacture and implement the virtual reality programs.

I8

Researcher: How useful would Virtual Reality be to train medical students?

Respondent: Most medical training involves the analysis of body systems through various bodily examinations. The usage of virtual reality would help improve overall teaching by enabling students to immerse themselves into the clinical setting during sessions. As stated above, virtual reality technology will help students visualise and gain a fresh perspective into patient-centred clinical care during teaching sessions. It can also be used during dissection sessions, thus, enabling students to visualise and appreciate the anatomy of the human body. This would be a suitable replacement for the videos screened prior dissections. This is because videos do not allow students to fully conceptualise subject material.

Researcher: What are the types of training that medical students undergo?
Respondent: It can be used in the following circumstances during clinical sessions, during the videos screened prior to dissections and during lectures and practical to improve understanding of concepts via visual aids

Researcher: Do you think it will be ease/difficulty to use Virtual Reality for training medical students?
Respondent: The introduction of this technology would be difficult. This could be due to the poor computer literacy of students, irrespective of their background. Some lecturers and technicians may also experience difficulty with the usage of this technology. The successful implementation of this technology will depend on the attitude of students and staff. There should be courses offered to ensure proficiency in the usage of this technology.

Researcher: What are the possible factors that could facilitate the adoption of Virtual Reality for training medical students?
Respondent: Positive attitude among both students and staff…A high number of resources dedicated to the implementation of this project. But, the economic background of students could hamper the progress of the usage of this technology

Researcher: Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students?
Respondent: The lecturers could influence the perspective of the students regarding their attitude toward using this technology. Their reviews of this technology as learning aids will prompt students to access this resource if available.

Researcher: What, do you perceive, could be the anticipated types (or categories) of challenges to the adoption of Virtual Reality for training medical students? Please elaborate on each challenge category.
Respondent: Finances - most students are funded via bursaries and financial aid schemes which may not allocate funding to this resource. Computer literacy- not all students may be proficient in usage of such technology. Better handling of financial and human resources; courses to ensure students are able to utilise this service.

I9

Researcher: How useful would Virtual Reality be to train medical students?
Respondent: Virtual reality would be quite useful to run real simulations of clinical practice cases. This would help students gain a more "hands on approach to medicine" where patient's lives aren't in any danger and failure isn't fatal. Currently, the course has very little to do with actual medicine as this year is the premedical course. Students are however required to acquire a first aid level one qualification which enables one to have basic knowledge of what to do in emergency health situations. Virtual reality could be useful as I stated in my first response. The benefits were already highlighted in my first response. I also wanted to mention the fields of cell and gene therapy are moving rapidly towards providing innovative cures for incurable diseases. A current and highly topical example is immunotherapies involving T-cells that express chimeric antigen receptors (CAR T-cells), which have shown promise in the treatment of leukaemia and lymphoma. These new medicines are indicative of the changes we can anticipate in the practice of medicine in the near future. Despite their promise, they pose challenges for introduction into the healthcare sector in South Africa (SA), including: that they are technologically demanding, and their manufacture is resource intensive; that the regulatory system is underdeveloped and likely to be challenged by ethical, legal and social requirements that accompany these new therapies; and that costs are likely to be prohibitive, at least initially, and before economies of scale take effect. Investment should be made into finding novel and innovative ways to introduce these therapies into SA sooner rather than later to ensure that SA patients are not excluded from these exciting new opportunities. In conformal radiotherapy and stereotactic neurosurgery, treatment is not possible without pre-operative planning and practice with the aid of a computer and/or simulation. VR can impact on the success and safety of a surgery. I also think it can be used for assisting with the treatment of patients because you know that some doctors do not allow you to assist them. Like when I started off, and I was doing my community service, I had this doctor who did not even

allow me to go near the table, the surgical table. He just wanted me to observe. I was so upset this one day, he refused to let me go near the table, and I was a qualified person at the time. You know how old people are… Hahaha.

Researcher: What are the types of training that medical students undergo?
Respondent: Running realistic medical scenarios.

Researcher: Okay… Do you think it will be ease/difficulty to use Virtual Reality for training medical students?
Respondent: Yes, it will be easy as most medical students are generally smart due to the prerequisites to get into medicine. Efficient training programs, Convenience.

Researcher: Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students?
Respondent: Influential people could range from highly respected doctors. Many would follow the example of such doctors and adopt the method. By proving its practicality – incorporating the use of virtual reality in their practices – e.g. showing patients simulations of possible solutions to their problems where they can decide which best suits them. Dr. Shafi Ahmed is trying to curb the global shortage of trained surgeons. Dr. Ahmed wants to be able to train thousands of surgeons simultaneously using virtual reality. The doctor used Google Glass to stream a surgical training session… I believe that guys like Dr. Ahmed are shaping our future of how we go about providing medical expertise in terms of training and treatment for patients.

Researcher: What are the possible factors that could facilitate the adoption of Virtual Reality for training medical students?
Respondent: Cost is an issue for such simulations because it would cost quite a bit, this would in turn increase the already high fees of studying. Lower costing virtual reality equipment by seeking sponsorships from the government would remedy the funding issue of the adoption of VR. Many of the companies producing VR content like VR systems and programs are start-ups in South Africa. And that is why adopting it in South Africa Is a problem. I mean where would the start-ups get the money to implement such a technology from. The government from South Africa and other countries like Ghana and Nigeria, you know I taught in those countries, and here we think things are bad, in terms of education, there in those countries, education is important, but the conditions are poor. So, the government should increase their budgets allocated to clinical simulation centres. Also, all universities must adopt it not just the private ones. I mean If the government allocates more funds to train medical doctors and nurses. It means, uhm, poorly skilled doctors will disappear. Also, the government should be finding new ways to introduce therapies such as immunotherapy and technologies such as VR into South Africa sooner rather than later to ensure that South African patients are not excluded from these exciting global initiatives.

But you know change management and education should be at the forefront of the adoption of VR for medical training because Universities should empower the staff to the extent that they are excited about gaining new skills. Then there is haptic feedback which is especially important with patient rehabilitation especially those suffering from mobility-related illnesses that require a stimulation of the sense. Like the position of an amputated arm is tracked by 3D sensors in the VR environment or movement of fingers are tracked by the VR motion-sensing gloves. Do you know about Google Glass? Something similar to it would be beneficial. And so, a lack of haptic feedback would prevent patients from feeling progress so that means that real VR environment that provides feedback to patients must be created.

I10

Researcher: How useful would Virtual Reality be to train medical students?
Respondent: Dissection of cadavers (to identify organs, vessels, bones, ligaments and various other structures etc.). Simulated patient interviews for taking a history from a patient. Simulated physical examinations on real people who are paid by the university to let students examine them. Not sure exactly. Would depend on how VR would be applied to the above scenarios.
No need for dissecting kits if a virtual cadaver is used. Chance to undo incorrect dissection method on a holographic projection whereas cannot undo on a cadaver.
Not sure what "ICT" entails exactly in terms of VR cadavers, VR organs

Researcher: Okay… Do you think it will be ease/difficulty to use Virtual Reality for training medical students?
Respondent: Easy if designed to be perfectly user-friendly. User-friendly and perhaps even customizable. Motivation toward e-learning maybe?

Researcher: Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students?
Respondent: Probably an academic who's trained and qualified using VR in the first place. I mean it would only be a properly accepted idea if there was proof of someone successfully having graduated with use of these new technologies, in my personal opinion. Argument of VR not being a proper experience when it comes to actually viewing a cadaver and the "real thing" – having a proper experience rather than using VR to simulate an experience.

Researcher: What, do you perceive, could be the anticipated types (or categories) of challenges to the adoption of Virtual Reality for training medical students? Please elaborate on each challenge category.
Respondent: Honestly, not sure. But I think it would help students, because they get to experience being in a surgery because in reality it is not easy to assist with surgery of patients because senior doctors do not allow it. But a major challenge is the cost of purchasing and maintaining the technology.

<u>I11</u>

Researcher: How useful would Virtual Reality be to train medical students?
Respondent: Practical skills such as an examination of the patients, different procedures and history taking. We learn about physiology, anatomy, microbiology, virology and pathology. I would be able to see and practice a variety of procedures multiple times without any assistance from a facilitator. No. There isn't anything that can be improved upon by virtual reality. Ultimately students need to learn how to do things physically and virtual reality might hinder that. We already have so many opportunities to observe and practice different skills- there is nothing new that virtual reality can add to our current methods of training. We could use virtual reality for anatomy to show the different structures of the human body. It can be used to show and practice different procedures.

Researcher: Okay… Do you think it will be ease/difficulty to use Virtual Reality for training medical students?
Respondent: I believe that using virtual reality will be fairly, simple. I assume the technology for virtual reality will come with a manual. All we'd have to do is read and follow instructions. It shouldn't be too hard. Workshops can be held for lecturers who are struggling and for students, it could be incorporated into our computer literacy module. Making the technology more accessible and cheaper.

Researcher: Can you please tell me, how does community initiatives work? Based on my previous interviews with other participants, they mentioned senior doctors do not allow students to assist with surgery... can you please… I mean in terms of whether the senior doctor allows a resident to assist in surgery
Respondent: Well in my case, I was allowed to assist. My senior thought that it would be beneficial for me. And that is how I am with my juniors.

Researcher: Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students?
Respondent: I suppose if lecturers found that it would be a useful teaching aid, it might be incorporated into our training programme.

Researcher: What, do you perceive, could be the anticipated types (or categories) of challenges to the adoption of Virtual Reality for training medical students? Please elaborate on each challenge category.
Respondent: Funds, Lecturers unwilling to learn how to use such technology, Lack of awareness- not many people would consider using virtual reality as a teaching aid. People need to be shown how virtual reality can be used as a learning tool. If you can prove that by using virtual reality you can make an actual and meaningful difference in teaching and learning, then none of factors mentioned above would be a hinderance.

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Researcher: How useful would Virtual Reality be to train medical students?
Respondent: 1st to 3rd year is theoretical. This training programme is directed by the School of Laboratory Medicine and Medical Sciences. Modules are concerned with educating students about the basic foundational sciences and pathology concerning all body systems. Module content is taught through lectures, vital clinical skills are practised during skills sessions at the skills lab and dissections of human cadavers are carried out at the dissection hall. In addition to this, 3rd year includes visits to various public hospitals once every week for ward-based teaching, in preparation for the clinical years. 4th to 6th year are the clinical years, during which most

teaching and training will be done at hospitals, involving real patients. I think it could be beneficial to students if implemented correctly and effectively. Students will be more enthusiastic to learn with this technologically-advanced method of teaching and training because, this generation tends to be technologically inclined. The university could also save money spent on resources in the skills lab and dissection hall which can be replaced with VR technology.

Researcher: What is the Information, Communication Technologies (ICTs) - related technologies currently used to train medical students?
Respondent: The only ICTs that I am aware of are the projectors in lecture venues used to deliver lectures and the computers at the LAN. I am unable to comment on how VR technology would be better than these forms of ICTs.

Researcher: Do you think if you compare the ICTs you mentioned to using VR, would it be a better option for medical training?
Respondent: Currently, I can only comment on its usefulness for the 1st 2 years. It would assist with practising clinical skills by exposing us to simulated emergency scenarios and allowing students and staff to practise how we would react to stabilise critically ill patients and showing us the consequences of our actions thereof so that we may learn what not to do in such situations. Ultimately, using VR technology in the skills lab will create a more realistic environment to improve and consolidate knowledge on life-saving procedures. It could also be used to assist dissections of cadavers.

Researcher: Based on my previous interviews with the other participants, some senior doctors do not allow students to assist with surgery
Respondent: Is that what some people went through, that is a shame because I was allowed to assist my senior at the time. Even though I was anxious, and I felt like I did not know what I was doing... I had to start somewhere. But you know, its only in South Africa its like that.

Researcher: Have you performed surgery elsewhere in the world?
Respondent: No

Researcher: Okay… Do you think it will be ease/difficulty to use Virtual Reality for training medical students?
Respondent: Initially, it may be slightly challenging to integrate virtual reality with current methods of teaching because the university may not have the funds to implement the resources needed or to employ people to manage this technology or train technicians and lecturers on how to use it. Some older lecturers may oppose the idea because they like their method of teaching and may be hesitant to change. Despite this, I think that students will be able to adjust to it fairly quickly if it is implemented correctly and if the technicians and lectures are trained on how to use it effectively. Separate training sessions could be made available for students and lecturers. Tutorial videos, in isiZulu and English, could be made to facilitate its use.

Researcher: What are the possible factors that could facilitate the adoption of Virtual Reality for training medical students?
Respondent: The need for more effective forms of training to help consolidate and practise knowledge obtained from lectures. There are a few unused venues available at the medical school campus which could be used to create different VR rooms - each used for different aspects of training.

Researcher: Do you perceive any social influence that could be exerted and that could facilitate or hinder the use of Virtual Reality for training medical students?
Respondent: I think past medical students, whom are now qualified doctors and based in Durban, could have the greatest influence on current medical students if they are in support of VR methods of training. So, it could be beneficial to reach out to them for promotion purposes. A lot of the current medical students look up to recently qualified doctors - especially those who used to stay at the residence or those who started societies and were well-known for being actively involved at campus. Through their own experience, they are well aware of the shortcomings in the current training programme implemented at the School of Laboratory Medicine and Medical Sciences, and the School of Clinical Medicine. Thus, they most probably have suggestions on how it can be improved, and the use of VR technology could be one of them. Because of their influence, they can easily share this knowledge with current students and could encourage students to appeal to the university to implement this form of training. These doctors could also assist in developing this VR technology in accordance with the latest norms in medical practice while simultaneously making it suitable for the needs of current students so that the technology is up-to-date and effective.