SONOGRAPHY STUDENTS' EXPERIENCES WITH SIMULATION-BASED LEARNING AS A FORM OF CLINICAL TEACHING AT A HIGHER ACADEMIC INSTITUTION

By

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DECLARATION

I, Geordean Isodore Schwartz hereby, declare that the contents of this dissertation represent my own unaided work and that the dissertation has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

5 October 2022

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Signed **Date**

ABSTRACT

Simulation-based learning (SBL) is an important tool used in healthcare education to replicate a particular clinical scenario as closely as possible in a controlled, safe-space environment without any harm or health risk to patients (Alinier et al., 2004; Hazell et al., 2020). SBL, prior to interacting with real patients, can form an important component for sonography students to develop into skilled sonographers (Gibbs, 2015). Ultrasound simulation is well established in the developed world; however, it is relatively new to South Africa. Despite the introduction of SBL into the curriculum half a decade ago at our higher academic institution in the Western Cape, South Africa, no research had been done to explore the students' experience of using such a teaching tool.

An exploratory, qualitative, and descriptive research study was conducted in 2020 to explore and describe BSc second-year sonography students' experiences of using simulation, prior to patient interaction, within the South African context. Ethical approval was obtained: CPUT/HW-REC2020/H10. One-on-one interviews were conducted with eight BSc second-year sonography students involved with SBL in their BSc first year of study. The interview questions were semi-structured and were done virtually online during the COVID-19 lockdown restrictions. The interviews were audio recorded and transcribed. The research study was conducted in two phases. Phase 1 explored and described the sonography students' experiences using tissue equivalent phantom simulators. In phase 2, guidelines were developed to enhance sonography training in South Africa.

A thematic analysis was utilized to describe the data and three themes emerged from the study: enhancing preparedness for the clinical environment; limitations of the tissue-equivalent phantom and suggestions for the improvement of simulation learning. The participants were very keen and shared all their experiences using simulation. The researcher found that although there was positive feedback of enjoyment using the simulation tool, limitations were also raised. The major limitations included that the simulator lacked realism and was unable to replicate sub-optimal conditions normally encountered while scanning real patients. Guidelines and recommendations to enhance sonography training with regards to students' preparedness for the clinical environment, bridging the lack of realism and suggestions for improvement of simulation could be developed.

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ACRONYMS AND ABBREVIATIONS

2D	Two dimensional
BMI	Body mass index
BSc	Bachelor of Science degree
DHET	Department of Higher Education and Training
EMS	Emergency medical services
FAST	Focused assessment with sonography in trauma
HOD	Head of Department
HPCSA	Health Professions Council of South Africa
IQP	Improvement of Qualification
N-Dip	National Diploma
NQF	National qualifications framework
POPIA	Protection of personal information Act
SA	South Africa
SAQA	South African Qualifications Authority
SBL	Simulation-based learning
T&L	Teaching and learning
UK	United Kingdom
VR	Virtual reality
WIL	Work integrated learning

DEFINITION OF KEY CONCEPTS

Acoustic shadowing - considered an artefact that is caused due to sound beam “drop out” or absorption of sound waves or a structure that blocks out the sound waves over a particular area on the image, causing a well-defined shadow behind it. Also refers to posterior acoustic shadowing (Curry & Tempkin, 2015).

Ultrasound image artefacts - ultrasound image artefacts are structures observed in the ultrasound image that are not associated with the normal tissue being imaged (Curry & Tempkin, 2015).

Bowel gas shadowing - an artefact caused when ultrasound waves are reflected and scattered when interacting with air inside loops bowel and intestines in the human body. It may obscure organs or tissue structures situated behind these bowel loops (Curry & Tempkin, 2015).

Echogenicity - refers to the degree of ultrasound wave reflectiveness of each tissue structure, whether it is very reflective bright/white (echogenic), less reflective/dark (hypoechoic) or non-reflective totally black (anechoic) on a sonogram (Curry & Tempkin, 2015).

Focal zone - refers to a point in the ultrasound beam where the beam is the narrowest with the best resolution (Curry & Tempkin, 2015).

Grey-scale - a scale of achromatic colours that have numerous shades from white to black on a sonogram (Curry & Tempkin, 2015).

Health Professions Council of South Africa (HPCSA) - an important statutory body that guides and regulates healthcare professionals in South Africa through lawful registration, sufficient education and training, professional and good ethical conduct (established in terms of the Health Professions Act 56 of 1974 (South Africa, 1974).

Phantom - an ultrasound phantom is defined as an apparatus/ or a manikin/ or fake part of the body/ or a medical apparatus that will simulate or mimic ultrasound conditions that can be encountered normally in real life (Nolting et al., 2016).

High-fidelity phantoms - are simulators that exhibit greater realism with a more life-like imitation compared to a low-fidelity simulator. These simulators are more expensive, may be more computerised, or virtual, and can be used to demonstrate more complex case scenarios (Massoth et al., 2019).

Low-fidelity phantoms - an apparatus that is limited to a certain set of functions to meet a specific set of intended outcomes. Most ultrasound tissue equivalent phantoms are considered low-fidelity phantoms because they are durable, less expensive and can give a good or relatively good representation of an ultrasound clinical examination (Massoth et al., 2019).

Simulation – simulation may be a model, a process, a case scenario demonstration, or a teaching technique that is conducted under a controlled and safe environment to replicate a life-like situation or imitation of something, for example, a medical or clinical examination (Thoirs et al., 2015).

Sonographer - a sonographer is a healthcare professional that uses high-frequency sound waves to obtain high-quality diagnostic images, videos, and three-dimensional volumes of anatomical regions called sonograms that can aid clinicians with a differential diagnosis (Curry & Tempkin, 2015).

South African Qualifications Authority (SAQA) - an important statutory body that oversees the implementation of the National Qualifications Framework (NQF). The NQF is a set of guidelines and standards to keep a record of learner achievements that are registered to ensure national recognition of skills acquired and to promote life-long learning and education, established in terms of the NQF Act no. 67 of 2008 (South Africa; 2008).

Transducer - a transducer or an ultrasound probe is a hand-held device connected to the ultrasound machine system that transmits and receives sound waves. The probe is in contact with the patient's skin as the sonographer moves the device over the body part that is examined with ultrasound (Curry & Tempkin, 2015).

Ultrasound - the medical definition of ultrasound is that it is the use of high-frequency sound waves above the audible range that is used for medical imaging procedures, such as having an ultrasound scan of the foetus in the mother's womb among other soft tissue structures (Curry & Tempkin, 2015).

Work integrated learning (WIL) – is an umbrella term to characterize instructional strategies that combine formal education with work-related practice across a variety of academic fields, combining theory and practice to improve student-learning. This can be achieved rather than through the use of only formal or informal work or assignments but can occur through a variety of WIL initiatives. WIL's primary goal is to improve student learning, and in order to do this, a number of creative curricula, pedagogies, and assessment methods have emerged in response to worries about graduateness, employability, and civic responsibility. Examples include action-learning, apprenticeships, cooperative education, experiential learning, inquiry learning, inter-professional learning, practicum placements, problem-based learning, project-based learning, scenario learning, and service learning (Winberg, C., Engel-Hills, P., Garraway, J., & Jacobs, C (2011). In short WIL is a structured form of pedagogy that involves combining classroom theory with practical work experience in a specific study field that is in line with students' academic outcomes and career goals. It also refers to experiential learning that is taking place at hospitals or clinical facilities (Hazell et al., 2020).

Work-place learning (WPL) – WPL is part WIL. This includes vetting potential workplaces for student placements, communicating with workplace supervisors, paying visits to students while they are on placement, setting up assessment procedures, and generally supervising and assisting students in their workplaces. Placement officers should make an effort to incorporate, if necessary, both workplace- and university-provided student support systems (such as mentors and counsellors). WPL and work-based learning can be used as interchangeable synonyms. (Winberg, C., Engel-Hills, P., Garraway, J., & Jacobs, C. 2011)

CHAPTER 1
AN OVERVIEW OF THE STUDY

1.1 Introduction

Chapter one gives an overview of the study. Within this chapter sonography, sonography education and simulation-based learning (SBL) will be discussed. Sonography education in South Africa entails training at an institution of higher learning, in this case a university of technology, to become a qualified sonographer. In this study the higher education institution offers a four-year BSc degree course which imbed a SBL component in the sonography training of students.

1.1.1 Sonography

Sonography is a branch of radiography that studies the art of performing diagnostic ultrasound examinations with the use of an ultrasound machine and providing an interpretation of sonographic images. These sonograms are non-invasive to patients and use high-frequency sound waves between 1 and 20 megahertz to capture a range of dynamic images of human anatomical structures and their functioning (Curry & Tempkin, 2015). These examinations are performed by highly skilled healthcare professionals called sonographers (Curry & Tempkin, 2015).

1.1.2 Simulation based learning

Simulation is defined as a process or a framework used to mimic a particular life-like situation, within a secure and controlled environment setting (Gibbs, 2015; Thoirs et al., 2015). In recent years, medical technology education has become more advanced and has led to the introduction of ultrasound simulators in the healthcare training arena (Gibbs, 2014). This teaching and learning method is referred to as simulation-based learning (SBL). Alinier et al. (2004) and Hazell et al. (2020) describe SBL as an effective teaching tool in healthcare education that replicates a particular clinical situation as closely as possible and allows students to develop and apply critical thinking skills in a controlled safe-space environment without any harm or health risk to patients (Alinier et al., 2004; Hazell et al., 2020). These critical thinking skills are among the higher-order cognitive functions included in Bloom's taxonomy hierarchy of learning objectives (Forehand, 2010). Gibbs (2015) and Shiner (2018) aver that simulation is an innovative pedagogical approach used in sonography and other medical professions such as nursing, emergency medicine, medicine, anaesthesiology, surgery and radiography education to enhance clinical preparation. Other sectors such as aviation, manufacturing and even electronic financial banking also make use of computer-based simulation as a form of teaching and learning (Kincaid & Westerlund, 2009).

1.1.3 Advantages and limitation of SBL

According to Gibbs (2015), a main advantage of SBL is that it allows novice sonography students to practise ultrasound examinations at their own pace. Additionally, students are given ample opportunity to repeat the scan several times. All students are unique and use different learning methods to acquire skills and some may take longer than others to contextualize different concepts (Gibbs, 2015). Hence, SBL is viewed as a method to aid in these different learning styles. Raune (2004) asserts that simulation, when used in nursing education for cardiac surgery, enabled students to apply theory into practice in an integrated manner, especially when more than one parameter is involved such as comprehension of anatomy, physiology, pathology, and treatment. Current literature also revealed that some students had more confidence after interacting with ultrasound simulators prior to performing the same examination on a real patient (Gibbs, 2015; Thoirs et al., 2015). For an ultrasound examination to be satisfactorily performed, a student needs prior knowledge of anatomical landmarks, location of organs or tissue structures, normal biometric measurements, shape, outline & composition and normal tissue echogenicity (the degree of reflectiveness of each structure, whether being bright or dark on the sonogram) (Curry & Tempkin, 2015). All of these can, however, be achieved using SBL prior to interacting with a real patient. Some limitations of SBL include the inability to fully replicate a real patient. Simulation only provides a lifelike imitation (Gibbs, 2014). Different ultrasound simulators exist, namely low- and high-fidelity simulators; the latter are usually more costly and include features of greater realism.

1.1.3. High fidelity vs. low fidelity simulators

High-fidelity simulators involve a virtual or computer-based simulation that may use a transducer tracking system where multiple electrodes are embedded in a manikin at different positions and as the operator moves the transducer (the device that conventionally emits ultrasound waves and detects returning echoes to form the image) over the manikin, a dynamic virtual sonogram is created. Other features include user-friendliness, orientation and position tracking accuracy (Curry & Tempkin, 2015; Farsoni et al., 2017). Some high-fidelity simulators can use preloaded ultrasound examination datasets depicting different anatomical variants and clinical scenarios or ultrasound pathology in at least two dimensions (2D). Sonography students are able to do an ultrasound examination with a stationary transducer (similar to a gaming joystick) that can do all the traditional manoeuvres that a conventional transducer can do with added on-screen transducer guidance display on a monitor over the applicable anatomical regions (Thoirs et al., 2015; Farsoni et al., 2017; Intelligent Ultrasound, 2019).

Low-fidelity simulators include manikins or phantoms that can mirror a clinical scenario or ultrasound examination but without the actual realism as seen with high-fidelity simulators

(Nolting et al., 2016). Massoth et al. (2019) describe low-fidelity simulators as simulators with limited functions that only meet selected requirements for practising technical skills. Low-fidelity simulators are less expensive, are durable and can be repeatedly used for training purposes, similar to high-fidelity simulators (Osborn et al., 2015; Nolting et al., 2016; Massoth et al., 2019). Most tissue equivalent ultrasound phantoms are considered low-fidelity simulators. These phantoms are made up of different plastic materials such as polystyrene butadiene plastic suspended in mineral oil and polyvinyl chloride particles that are stable at room temperature and that can exhibit similar ultrasound characteristics that human tissue does when the transducer is used to scan the phantom (Scherzinger et al., 1983; Curry & Tempkin, 2015; Nolting et al., 2016).

Different simulator mannequins for neonatal endotracheal intubation exist that is an important skill for all paediatricians to have according to Al-Wassia et al (2022). It is postulated that low fidelity mannequins lacks chest rise movement, electrocardiograph tracing, and may or may not include availability to intubation in neonatal care simulation, whereas high fidelity mannequins exhibit greater realism and can give cues to interact better with students. High fidelity simulators may demonstrate physiological signals, like breath sounds, heart sounds, pulses, oxygen saturation and blood pressure. (Al-Wassia; 2022)

1.2 Background and rationale

Ultrasound simulation is well established in the developed world in healthcare training facilities however, it is relatively new to South Africa more specifically within the Western Cape. Within the Western Cape Province, in the past sonography students were enrolled for a 3-year National Diploma qualification (N-Dip). These students were placed at accredited hospitals for clinical training from the first year to acquire clinical skills and competency through work-placed learning (WPL). Workplace learning entails students being allocated to various accredited hospitals where they obtain on-the-job training. In 2014, a new four-year, Bachelor of Science (BSc) degree was introduced across all four radiography disciplines (diagnostic radiography, diagnostic ultrasound, radiation therapy and nuclear medicine).

The new BSc Diagnostic Ultrasound degree allowed for an increase in the sonography student enrolment numbers which would, in turn, ensure that more sonographers graduate each year. This was considered necessary as Radiography is considered a “scarce skill” by the South African Qualifications Authority (SAQA) (South Africa; 2008). According to Hazell et al. (2020), healthcare staff shortage due to an increase in workload is very evident in South African public hospitals. This is indeed a challenge for ultrasound service delivery in SA. However, an increase in student numbers led to limited hospital clinical placements, student intake is

determined by the HPCSA rule of staff-to-student ratio of 1:1 in accredited ultrasound clinical training facilities; therefore additional funding was made available to procure tissue equivalent ultrasound phantoms (“manikins”). These phantoms can simulate or mimic the sonographic anatomy and structure similar to scanning a real patient’s anatomy to sonography students.

Prior to the introduction of simulation-based Teaching and Learning (T&L), first-year students were included in the pool of students placed at the clinical training sites e.g., hospitals and clinics. At the research site, a tissue equivalent phantom was purchased for the training of first-year sonography students to enhance their theoretical knowledge prior to clinical placement from 2nd year. It is important to note that SBL is not used to replace clinical training however it is used to enhance it. In the context of the research site 1st year students could not go into clinical due to limited clinical site placements; placement was only available to the 2nd, 3rd and 4th years hence the simulators were purchased to ensure that 1st years at least get simulated clinical training in the first year. The tissue equivalent phantoms that were purchased a few years ago are the Kyoto Kagaku ABDFAN abdominal ultrasound training phantom and SPACE FAN-ST foetus ultrasound examination phantom (Figure 1 & 2). Both these phantoms are high fidelity phantoms with static anatomy used for simulation-based T&L of first-year students to acquire scanning skills in a clinical skills laboratory using tissue equivalent phantoms at the university for the first year. Thereafter, from the second year onwards they are placed at an accredited training hospital. The clinical training facilities can therefore accommodate more second-year, third-year and fourth-year students, and hence the ultrasound student intake can be increased.

Figure 1 below depicts the Kyoto Kagaku ABDFAN abdominal ultrasound training phantom used in the study:

Fig. 1. Kyoto Kagaku ABDFAN abdominal ultrasound training phantom (Ultrasound clinical skills lab; 2020)

Figure 2 below depicts the obstetric SPACE FAN-ST foetus ultrasound examination phantom utilized in the study:

Fig. 2. Obstetric SPACE FAN-ST foetus ultrasound examination phantom (Ultrasound clinical skills lab; 2020).

The English translation of an old Chinese proverb says “I hear, I forget, I see, I remember, I do, I understand” (Raune, 2004). This phrase is very powerful as it explains the usefulness of simulation in the clinical training arena of a student learning a skill from practising it, to perfecting it. This phrase is also linked to pedagogy in higher education where different teaching strategies exist. Pedagogy can be described as a concept that involves all levels of learning that include theory practice of teaching as well as practical teaching. The pedagogy of student centredness is key to teaching and learning. Ahn et al (2018) postulate that there is a five-step approach, designed by Robert Moses, to ensure that pedagogy is student centered. The first step is called the physical situation where students engage in a similar physical activity and gain experience related to an objective. This objective can be mastering a sonographic simulated examination using a simulator. Step two involves a visual Illustration whereby students create a drawing or other visual representation of their experience based on the first step. Students can create a mental picture of their experience and articulate it verbally and

non-verbally. Thirdly the conversational step. In this step students use their own words, including those from their everyday and native languages, to talk about and write about what happened during Step 1. In the context of South Africa where we have diverse students from different cultures and background this step is critical. Step 4 is called feature talk step, where the experience is discussed and documented by students in formal (academic) or mathematical terminology and lastly step 5 the symbolic representation step. Students can express what they learned from the experience in the earlier steps, construct and use symbols for example using graphs, variables etc.

Since the introduction of simulation as a method of teaching sonography students at 1st- year, no research has been conducted to explore their experiences and perceptions of using simulation as a form of clinical training. Since simulation in South Africa is still fairly new the researcher wanted to explore the current student experiences to enhance teaching as well as to add to the greater body of knowledge within sonography.

1.3 Problem statement

The literature illustrates that simulation as a form of clinical training, prior to interacting with real patients, forms an integral component for sonography students to develop into skilled sonographers (Gibbs, 2015). Teaching practices should be evaluated to ensure its successful implementation and use. Despite the introduction of simulation-based training into the curriculum more than five years ago at the research site, no research had been conducted to explore the students' experiences of using such a teaching tool. It is important to evaluate teaching practices to ensure successful implementation of curricula. The BSc 2nd year students were chosen for the study as they have completed their 1st year of SBL and would be in a good position to describe their experiences.

1.4 Research questions

- What are the experiences of sonography students using simulation?
- What can be done to improve or enhance the simulation experience?

1.5 Study aim and objectives

1.5.1 Study aim

The aim of this qualitative research study was:

i. To explore and describe BSc second-year sonography students' experiences of using simulation as a form of clinical training, prior to patient interaction, at a University of Technology in South Africa and to develop guidelines to enhance clinical sonography training.

1.5.2 Study objectives

The study was guided by the following objectives:

1. To explore and describe BSc second-year sonography students' experiences after interacting with simulation-based T&L during the first year.

2. To develop guidelines to enhance clinical training experiences with the use of the tissue equivalent phantom simulators.

1.6 Research paradigm

A research paradigm is described as a philosophical way of thinking to create a worldview or perspective of shared beliefs that can give meaning and interpretation to research data (Kivunja & Kuyini, 2017). In this research study, the researcher chose a constructivist philosophical paradigm that was used as the researcher believes individuals construct their own understanding of their experiences (Kriukow, 2020). In order to interpret and understand the participants' views and thinking based on their individual experiences of using simulation. Chapter 2 offers an in-depth explanation of the paradigm used.

1.7 Research design

The researcher made use of a qualitative, exploratory, and descriptive research design. Qualitative research was chosen for this study as the researcher focused on understanding and interpreting the experiences of students using the simulation tool within the context of sonography education (DePoy & Gitlin, 2020).

1.8 Research method

The research method is briefly outlined below. Chapter 2 provides a more detailed description of the methods used. This study was conducted in two phases, as described below:

1.8.1 Phase 1

This study is consistent with an exploratory and descriptive design whereby the researcher attempted to understand, explore, and describe the student experiences using simulation-based training. This was achieved through individual semi-structured interviews. The process of bracketing was used to ensure that the researchers' own feelings and opinions did not

influence the data collection process. Bracketing is a qualitative process whereby the researcher draws awareness of underlying presuppositions and preconceptions that might have occurred prior to the research conceptualization. The researcher kept a reflexive journal to ensure that preconceptions did not affect the research process (Tufford & Newman, 2010; DePoy & Gitlin, 2015).

1.8.1.1 Research population and sample

The population included all BSc second-year sonography students registered with the HPCSA as student sonographers at a higher academic institution in the Western Cape. The BSc second-year students were chosen because they were exposed to simulation-based clinical training in their first year of studies, prior to patient interaction within a sonography department. In the BSc second year, students are clinically placed to undertake their workplace learning (WPL), with real patients. Therefore, they were able to compare their prior simulation training with their current real-life experiences. Purposive sampling is a non-probability sampling technique used when the researcher relies on his own judgment and deliberately selects a sample to be studied based on predefined criteria (DePoy & Gitlin, 2015). All BSc second-year sonography students (nine in total) were invited to participate in this study through purposive sampling to ensure information-rich data were obtained. For this study, the criteria were all BSc second-year sonography students who were exposed to simulation-based education in their first year of study. The sample size was dependent on data saturation which entailed the repetition of similar ideas and experiences from the participants. The participants were recruited by an independent person that was not directly involved with the students. The recruiter emailed the information sheet and consent form to students. Eight of the nine students invited, volunteered to participate however data saturation was met by the 5th participant when repetitive ideas and themes emerged. To ensure fairness to all volunteers the researcher continued to interview all eight.

1.8.1.2 Data collection

BSc 2nd- year sonography students were provided with an information letter (see Appendix A). The information sheet provided information on the study purpose how the study was conducted and that it is completely voluntary. A consent form (see Appendices B and C) was shared with the participants. Data were collected in the form of semi-structured interviews using a virtual online platform (WhatsApp video call). The use of online platforms was advantageous due to the data collection process being undertaken during the COVID-19 pandemic level3 and 2 lockdown periods that the country experienced; between 1 June 2020 and 17 August (level 3)

and 18 August to 20 September 2020. The level 3 restrictions included being confined to homes between 21h00pm to 04h00am and traveling between these hours with a permit for essential services or when attending to security or medical emergencies. During level 2 restrictions, mask wearing was mandatory in public places and attending gatherings such as funerals be limited to maximum of only 50 people. A semi-structured interview uses a framework that includes different types of questions such as open-ended, theory driven and confrontational questioning to study subjective theories from participants (Flick, 2009:156-159). Furthermore, participants are able to share their experiences freely, spontaneous and explicit to build on everyday knowledge as described by Flick (2009:157). With a semi-structured approach, it allowed for probing questions to be asked. The researcher used paraphrasing to ensure that a true reflection of the participant experiences was captured. The interviews were audio recorded and transcribed by a transcriber. The participants were asked to keep their cameras on for the interview if they felt comfortable. Extensive field notes were made on additional information such as body language for those students who had their cameras on. Interviews took place at a time that was suitable for the participants to ensure no disruption of their academic schedules. So as not to inconvenience the participants, the researcher availed himself as per their schedule.

1.8.1.3 Data analysis

Data analysis occurred simultaneously with data collection. While collecting data, the researcher reflected and started the analysis process. A thematic analysis process using 5 step process outlined by Braun and Clark (2006) was followed to analyse the data. The first step was that the researcher familiarized himself with the data from the interviews' audio recordings and transcriptions. The researcher became immersed in the data. The researcher then allocated preliminary codes to the data that describe its content. Themes were identified according to the codes given. Themes and categories were developed.

1.8.2 Phase 2

In this phase, a description of guidelines to enhance simulation-based clinical teaching and learning in sonography was developed. This is discussed in Chapter 4.

1.8.3 Trustworthiness

Trustworthiness is a concept meaning that research is conducted in an accurate, reliable, logical manner making the research methods explicit and giving enough detail so that a reader can conclude that the research study is credible (Nowell et al., 2017). It is an important tool

used in qualitative research that is subdivided into four categories or criteria, namely credibility, dependability, transferability, and confirmability (Shenton, 2004). The researcher made sure that all these steps were followed in the study. Each of these categories is explained in depth in Chapter 2. Table 1.1 below provides an overview of the criteria and methods followed in this study.

Table 1.1: Criteria and methods for the study

Criteria	**Methods**
Credibility	• The interviews were guided by a framework. • Debriefing was conducted with the supervisors. • Reflexivity maintained using a reflective journal. • An audit trail was kept in the form of field noted. • Triangulation of data were followed and completed (transcribes data, audio recordings and field notes).
Dependability	It was achieved by following a robust research methodology and described data that are well organised and categorised.
Transferability	The researcher gave a thorough description of the research context and ideas that sprouted from the study. It will be possible for other researchers to use these research study findings as a blueprint that applies to similar contexts, situations, and population samples.
Confirmability	The researcher followed the research objectives. The researcher listened to the audio recordings after the interview and member checking was done to ensure that the true interpretation of themes and categories were captured from the participants.

Source: Ondari et al. (2019) and DePoy & Gitlin (2020)

1.8.4 Ethical considerations

Ethical approval was obtained from the Faculty Research Ethics Committee at CPUT (see Appendix G) and a permission letter was addressed to the Head of Department (HOD) of the Medical Imaging and Therapeutic Sciences (MITS) department (see Appendix F) of the Faculty of Health and Wellness at CPUT. Permission was granted by both the HOD and ethics

committee prior to recruitment and data collection started. Permission was needed from the MITS HOD in order to conduct the study with the students.

The important ethical principles of beneficence, non-maleficence, autonomy and justice were adhered to in this study. Beneficence refers to the welfare of the research participants being ensured by minimizing risk and increasing possible benefits (Flick, 2009). No obvious risks were encountered or experienced during this study. There were no direct benefits to the participants. The study was aimed at developing guidelines to enhance the future clinical training of sonography students.

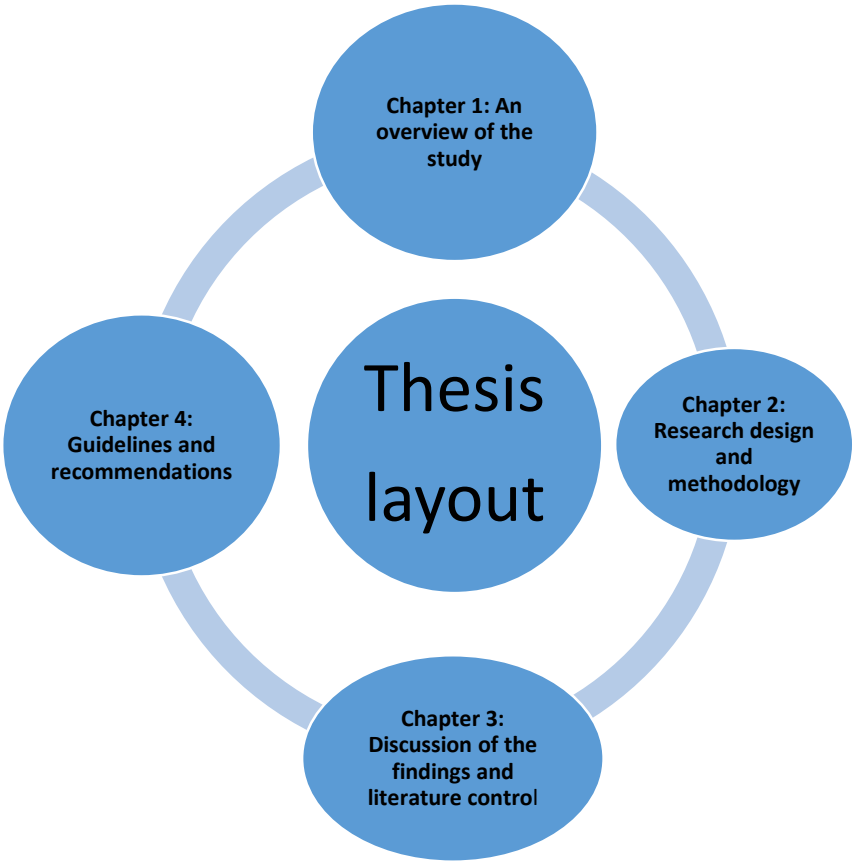
According to Flick (2009) and Arifin (2018), non-maleficence means to do no harm. The participants were not exposed to any harm or distress during the research study. The word autonomy or self-determination refers to the individual participant's values and decisions that should be respected (Flick, 2009; Arifin, 2018). Informed consent was obtained and all the participants had an opportunity to read the information sheet and sign a voluntary consent form (see Appendices A, B & C) that gave the researcher permission to conduct the research study. An independent individual obtained consent from the participants to ensure that the participants were not intimidated or coerced by the researcher. Participation was completely voluntary, and participants were allowed to withdraw at any stage of the study. However, data collected up to the point of withdrawal would be maintained as no identifiers were used in the transcripts to protect the participants' privacy. No participants withdrew from the study.

The participants' confidentiality and autonomy were respected. Confidentiality was achieved by keeping the interviews and audio recordings in a safe. The data will be destroyed five years after publication of the research. No participant names were used in the transcribed data. Access to the interviews was only available to the researcher, supervisors and transcriber. The transcriber also undersigned the confidentiality agreement form (Appendix E). The data provided were referenced and not manipulated. No personal information was captured during the transcription of the data. The final principle of justice holds that all individuals should be treated equally and fairly and it is a fundamental moral right (Flick, 2009; Arifin, 2018). All the students were given an equal and fair chance to participate in this study. According to the ethical guidelines for medical research general principles, student participants are considered to be a vulnerable group to academic, personal and financial pressures (Benatar, 2000). The researcher's role was to facilitate the interview, neither as a sonographer or a lecturer, which made the participants feel comfortable during the interviews. Emphasis was placed on the fact that students' feedback will not affect their position in the programme. Therefore, the students were at ease answering the questions openly and honestly without feeling that they pleased or displeased the researcher.

1.9 Conclusion

In this chapter an overview of the study was provided, whereby the research looked at what SBL is, its advantages and disadvantages, provided a background to substantiate why the study was relevant to conduct at the research study site and to give a brief summary of the methodology used to conduct the study was discussed in this chapter.

1.10 Layout of the following chapters in thesis:



A mind that is stretched by a new experience can never go back to its old dimensions

Sir Oliver Wendell Holmes

CHAPTER 2
RESEARCH DESIGN AND METHODOLOGY

2.1 Introduction

The purpose of this chapter is to give a detailed description of the research design and method that was followed. This chapter discusses the research design, method and data analysis process that was undertaken along with the trustworthiness criteria that was followed.

2.2 Research philosophy

According to Moore (2020), the word philosophy is derived from the Greek word *philosophia* meaning the love of wisdom. Research philosophy underpins a gathering of information in a circular process of ongoing learning, based on previously obtained knowledge and experiences. Furthermore, Edson et al. (2016) report that through systematic steps, a researcher must first identify a particular area of interest that requires better understanding and then develop methods to explore that particular phenomenon. Since this research study focuses on exploring the experiences of sonography students using SBL as a form of clinical teaching at a higher academic institution, the researcher chose specific paradigms of interpretivism and constructivism for the study. However, to understand these paradigms it is important to have knowledge of the positivist perspective, which was one of the oldest paradigms developed in philosophy (Bourdeau, 2018). According to Viljoen (2014: 6), the term paradigm describes “distinct concepts or thought patterns in a scientific discipline or other epistemological context.” The word epistemological is a branch of philosophy that refers to a specific scientific enquiry. Similarly, Ramlaul (2010) also explains research paradigms as a set of assumptions that influence a person’s expectation of what is known and how to go about to know what we know.

2.2.1 Interpretivism

The paradigm of interpretivism was used for this study. Interpretivism is utilized when a phenomenon under investigation are experiences or interview observations. These experiences should be unbiased, truthful, and an authentic recording of the researcher’s observation (Polgar & Thomas, 2020). An interprevist try to give meaning to complex human traits such as language, shared meanings, and perceptions of a particular situation such as experiences as it is evolving over time (Myers, 2008:45). Literature describes interpretivism as being socially constructed and gives meaning or understanding of perceived ideas that are

usually derived more to the end of a qualitative research study (Myers, 2008; Polgar & Thomas, 2020; DePoy & Gatlin, 2020).

In contrast a positivist sees reality as objective and uses a rigorous structured approach (Kriukow, 2020). A positivist can express their findings as a set of measurements that can be understood and that can be replicated by other researchers. Positivism is also known as experimental-type research and forms the basis of deductive and predictive research designs that forms the backbone of quantitative research (DePoy & Gatlin, 2020). In this research study we used an interpretivist and a constructivist approach because it is qualitative.

2.2.2 Constructivism

Constructivism is a sprout of interpretivism and is a belief that knowledge is multiple-faceted and flexible, and allows a researcher to construct a reality of participants' experiences in a subjective manner (Kriukow, 2020). Fosnot, C (2005) postulate the constructivist theory of learning, includes that instruction should provide students with meaningful experiences that will allow them to look for patterns, pose questions, and model, analyse, and defend their ideas and practices. According to the literature, interpretivism is an epistemological branch of constructivism or an extension of it (Kivunja & Kuyini, 2017). Ramlaul (2010) argues that interpretivists emphasize subjectivity rather than objectivity and regard the researcher as inseparable from the phenomena under investigation. Ramlaul (2010) adds that the data that are gathered with this method reflect quality, the theory building of an experience, rather than quantity or theory testing. Based on the above explanations, the researcher deemed constructivism to be the appropriate philosophy to underpin this study as the researcher wanted to explore students' experiences of the phenomenon of simulation-based learning.

2.3 Research design

A research design is a set of procedures for the collection of data, analysis, interpretation and reporting of the data in research studies (Creswell & Plano Clark, 2007; Lelissa, 2018). The researcher used a qualitative, exploratory, and descriptive research design for this study.

2.3.1 Qualitative

Flick (2009) asserts that qualitative research explores individuals' understanding, experiences and perceptions within their own environment. Qualitative research was chosen for this study because the researcher focused on understanding and interpreting the experiences of

students using the simulation tool within the context of sonography education (DePoy & Gitlin, 2020). The researcher used a qualitative approach to explore the meanings and interpretation that is rarely observed using a quantitative research approach (Jeanfreau & Jack, 2010; DePoy & Gitlin, 2015).

Currently, no knowledge exists on the topic of exploring the experiences of sonography students using simulation-based teaching in South Africa. Qualitative research is described as a disciplined analysis examining the meanings of an individual's experiences and actions in the context of their social environments (Polgar & Thomas, 2020). The term qualitative refers to the nature of the data or evidence collected. It consists of a detailed description based on text or pictures recorded by the researcher. The term disciplined analysis means that the analysis is guided by clear methodology principles for defining problems, collecting, and analysing the evidence, and formulating and evaluating theories. Additionally, qualitative research can be viewed as the way in which individuals subjectively distinguish and explain their experiences, actions, and social environment (Polgar & Thomas, 2020).

2.3.2 Exploratory

Exploratory research design is used in studies where the research problem is not defined yet. This method explores the research topic without the intent to formulate a definitive answer to the existing problem, but to take initial research into a hypothetical or theoretical idea of the phenomena under investigation to build on the body of knowledge (Dudovskiy, 2018; Swedberg, 2018). Dudovskiy (2018) further argues that this design is flexible and can be adapted and helps to lay the groundwork that can lead to further studies on a particular topic or worldview. On the contrary, this method can be subjected to research bias as it involves qualitative research that includes interpretation of information, however, if correctly executed to minimize research bias then it is worth using. This design was deemed appropriate for this study as the researcher focused on exploring the phenomenon of SBL in the experiences of sonography students.

2.3.3 Descriptive

A descriptive research design aims to describe a phenomenon and its characteristics (Nassaji, 2015). Swedberg (2018) explains descriptive research as a continuum of the exploratory research idea, and it attempts to explore and explain whilst providing additional or supportive information about the phenomenon. In the context of this research study, the phenomenon of SBL will be described and explored systematically.

2.4 Reasoning strategies

The following reasoning strategies were utilized in this study.

2.4.1 Deductive reasoning

Deductive reasoning involves a thought pattern that moves from the particular to a more general approach (Dudovskiy, 2018). In deductive logic, a specific known theory or hypothesis is used as the starting point and then analysed and tested to confirm or exclude the specific hypothesis. In other words, it can be used as a method of verification and this form of reasoning is highly structured (Chinn & Kramer, 2011; de Chantel et al., 2020; Polgar & Thomas, 2020; Mansi et al., 2022).

2.4.2 Inductive reasoning

Inductive reasoning starts with an observation and concludes with a result of theory or to explore the theory with greater insight. With this reasoning method, specific instances are observed to be consistently part of the larger whole or set, and the set of instances emerges with that larger whole. This larger set can then be considered in relation to another set of events or phenomena in another logic system (Chinn & Kramer, 2011; Polgar & Thomas, 2020).

DePoy and Gitlin (2020) concur that inductive reasoning is especially used in health and human service professionals' research in the form of everyday practice. They argue that within a qualitative research framework, inductive and deductive reasoning are both primarily used, because these types of reasoning approaches do not assert the full truth value of conclusions. Rather, they involve "moving specific cases to a broader generalization about the phenomenon under study or involve fitting data such as observations or propositions into existing theory" (de Chantel et al., 2020: 1085; Mansi et al., 2022: 690).

Reflecting on the inductive logical thinking process the researcher searched for general rules or patterns emerging from specific observations. Using a variety of data collection techniques that included observations and in-depth interviewing the researcher searched for patterns across all observations. From this approach, the researcher developed an understanding of the specific situation and themes were formulated using inductive reasoning. The researcher also considered possible intervention principles and recommendations developed based on the researcher's interpretation.

2.5 Research method

This study was conducted in two phases as follows:

2.5.1 Phase 1

This study is consistent with an exploratory and descriptive design whereby the researcher attempted to understand, explore and describe the student experiences using simulation-based training. The process of bracketing was used to ensure the researchers' own feelings and opinions did not influence the data collection process. Bracketing is a qualitative process whereby the researcher draws awareness of preconceived ideas they might have prior to the research conceptualization taking place. The researcher kept a reflexive journal to ensure that preconceptions did not affect the research process (Tufford & Newman, 2010; DePoy & Gitlin, 2015) (see Appendix I).

2.5.1.1 Research population and sample

All the BSc second-year sonography students registered with the HPCSA as student sonographers at a tertiary institution in the Western Cape were included in the population and sample. The reason for choosing the BSc second-year students was because they were exposed to simulation-based clinical training prior to patient interaction within a sonography department in their first year of study. In the BSc second year, students are clinically based to undertake their WPL with real patients. Therefore, they would be able to compare their prior simulation training with their real-life experiences. All BSc second-year sonography students (nine in total) were invited to participate in this study through purposive sampling to ensure information-rich data were obtained. The sample size was dependent on data saturation. Data saturation occurs when sufficient data has been collected from the participants and it is identified by the researcher when there is a reoccurrence of themes and ideas emerging repetitively from the participants. The researcher can then confidently conclude that further inclusion of participants will not alter the current themes and interpretations that were gathered (Polgar & Thomas, 2020). However for this study 8 participants volunteered and the researcher interviewed all 8 despite reaching data saturation at interview 5. This was to ensure fairness to all that volunteered.

2.5.1.2 Purposive sampling

Purposive sampling, also known as judgment sampling, is a technique that the researcher uses to deliberately select individuals or elements based on predefined criteria (DePoy & Gitlin, 2020). This sampling allows a researcher to actively select the subjects they believe would be the most creative sample to answer the research question. This can be done via a framework looking at the possible variables that might influence a subject's contribution to the study (Ramlaul, 2010). "Qualitative research is not concerned with the meanings of quantities or counting frequencies with categories, but with the individual's experiences and meanings of these experiences for the individual's lived cultural different communities" (Polgar & Thomas, 2020: 128). Therefore sampling in qualitative research is referred to as purposive.

Inclusion criteria:

- All BSc second-year sonography students who were exposed to simulation-based teaching in their first year of study.
- BSc second-year sonography students registered with HPCSA.

Exclusion criteria:

- BSc first-year, third-year and fourth-year sonography students registered with HPCSA.
- Any level BSc Radiation therapy, Diagnostic, Nuclear Medicine
- Where no informed consent was obtained

2.5.1.3 Data collection

Data collection is defined as a process to assemble important research information according to a specific research design (Polgar & Thomas, 2020). For this study data collection only commenced after ethical permission was granted by the research site ethics committee with ethics number CPUT/HW-REC 2020/H10 (see Appendix G) and the researcher gathered the data in the form of individual semi-structured interviews. Sonography students were provided with an information letter (Appendix A) explaining in detail what the study entailed. Consent forms were signed (Appendices B and C) if they wished to participate. Data were collected in the form of semi-structured interviews using a virtual online platform (WhatsApp video call) during the COVID-19 pandemic level 3 lockdown periods that SA faced in August/September 2020.

A semi-structured interview is a model used to study subjective theories to build on everyday knowledge and involves asking open-ended questions and theory-driven questions (Flick, 2009). An open-ended question is a question that allows a person to give a longer and more detailed answer, not just a yes or no answer. If a question is phrased to be answered either yes or no, the participants are given the opportunity to explain their responses. Furthermore, Flick (date) adds that this form of questioning allows the interviewees to exchange explicit and immediate information on a topic. The researcher conducted the interviews as the facilitator and not as a sonographer or lecturer. Interviews are best done by a person that has knowledge of the issues involved and that can ask more relevant questions and follow up on the open-ended questions (DePoy & Gitlin, 2015; Gibbs, 2019). The researcher also used probing questions to gain information-rich data and to ensure a true understanding of the stories shared. The first interview served as an informal pilot interview and extensive debriefing took place afterwards to ensure that questions were appropriate and the interview technique was well aligned to the research methodology.

The following semi-structured questions were used as a framework to guide the interviews and the researcher ensured a comfortable environment during the interviews. Furthermore, the researcher explained the procedure and purpose of the study prior to the start of the questioning. The following questions were adapted from email communication with Vivien Gibbs' semi-structured questions (Gibbs, 2019)

Question 1.

I would like you to reflect on your experiences when you were trained using the tissue-equivalent phantoms.

Question 2.

Now that you are scanning real patients, do you feel the simulator had any impact on your learning?

Question 3.

If yes, please explain how and give some examples.

Question 4.

Did the simulators in any way improve specific areas such as:

i) scanning technique;
ii) use of the equipment controls;
iii) your hand/eye coordination;
iv) recognising normal anatomy or pathology?

Question 5.
What role did the simulator have, if any, regarding your learning experience?

Question 6.
Do you think the simulators were appropriately used in your learning and for the formative clinical assessments? Please explain your answer.

Question 7.
You are scanning real patients now. Could you reflect on the advantages and disadvantages, of any of the simulator interactions and scanning real patients?

Eight of the nine BSc second-year sonography student participants consented to be interviewed. All the interviews were audio recorded and later transcribed by a transcriber. Furthermore, extensive field notes (Appendix I) were taken on additional information such as body language. Interviews took place at a time that was suitable for the participants to ensure there was no disruption to their academic schedules. So as not to inconvenience the participants, the researcher availed himself as per their schedule. The researcher kept a reflective journal and did debriefing with the research supervisor after each interview. The interviews took between 20 and 40 minutes per participant and data collection took three months to complete.

2.5.1.4 Data analysis

Grbich (2013) avers that data analysis is a process that takes place when the researchers are engaging with the transcribed text in a way to gain a greater understanding of the values and meanings which lie within. Data analysis occurred simultaneously with data collection. While collecting data, the researcher reflected and started the analysis process. A thematic analysis approach was followed to analyse the data. A thematic analysis approach was chosen because it was deemed the best approach to identify patterns in the data to derive themes and

categories during the analysis process. Thematic analysis also best describes people's experiences, views and opinions and worked well in exploring sonography students' experiences using SBL. According to Braun and Clark (2006) thematic analysis takes place in six steps, namely:

- Step 1 – Start reading and rereading the transcribed data to familiarize oneself with it and start writing down initial ideas.
- Step 2 – Initialize a coding process to highlight interesting features of the data and to collate data that is relevant or similar to each other to a specific code or phrase.
- Step 3 – Searching for possible themes by gathering all the data relevant to each potential theme.
- Step 4 – Process of reviewing the themes to verify if they are relevant and if the work, in relating to the phrases or codes selected, creates a 'thematic map' of the data analysis process.
- Step 5 – This is the process of clearly defining and naming each theme.
- Step 6 – Writing up a report

The researcher followed each of the steps in the thematic analysis process.

The first step was that the researcher familiarised himself with the data from the interview audio recordings and transcriptions. The researcher then became immersed in the data. The researcher allocated preliminary codes (keywords and phrases) to the data that described its content. Themes were identified according to the codes given and themes and categories were developed. Themes are patterns or repetitive responses from the data and responses with similarities (Boeitjie, 2010). The researcher reviewed, sorted and refined links between the different themes and identified the main themes. These themes were named, and the researcher developed a report (Boeitjie, 2010; Silverman, 2014). As previously mentioned, the process of inductive reasoning was applied in this study to create themes and categories. A confirmability audit was conducted through the process of member checking to ascertain that the information captured reflected the participants' experiences and perceptions correctly in the themes and categories.

2.5.2 Phase 2

In this phase, a description of guidelines to enhance simulation-based clinical teaching and learning in sonography was developed and is discussed in Chapter 4.

2.6 Trustworthiness

Trustworthiness is an important tool used in qualitative research that is subdivided into four categories or criteria namely credibility, dependability, transferability and confirmability (Shenton, 2004).

i) Credibility

Credibility is described as the internal validity of a study following the provision that findings are true and congruent (Shenton, 2004). The researcher sought to ensure credibility when the correct themes were identified and described in the study (Silverman, 2014). This was achieved through debriefing sessions with the research supervisors after each interview and through discussing the possible themes and categories that emerged from each interview after rereading the transcriptions. A robust audit trail (in the form of field notes and a reflective journal) was kept that was transparent (available to the research supervisors) and triangulation of the data was done to ensure credibility. Flick, 2009 describe triangulation as an activity that the researcher performs using different approaches or methods to answer the research questions. These methods used should be aligned and carried out equally across the data (in all the interviews) so that the researcher will be able to conclude and highlight the key significance or the main ideas of the qualitative study. The researcher made use of triangulation of data in the form of audio recordings, transcribed data and field notes that are aligned during data analysis. In addition, the researcher ensured the practice of bracketing throughout the research process.

ii) Transferability

Transferability refers to the extent to which the findings of one study can be applied to other situations (Shenton, 2004). To ensure transferability, the researcher produced analytic summaries and verbatim quotes, together with a thorough description of the research setting and data population. Therefore, other researchers can use this study as a blueprint that can be applied in other contexts, situations, and different population samples.

iii) Dependability

According to Shenton (2004), dependability refers to the extent to which a study can be replicated by another researcher with the same methods and similar results would be obtained. Hence, well-organised methods and detailed audit trials were established and conducted to guarantee dependability. In this study, dependability was achieved by following a robust research methodology and describing data that are well organised and categorised.

iv) Confirmability

Confirmability refers to the objectivity of the researcher's interpretations of the evidence available from the study (Silverman, 2014). Confirmability ensures that researcher bias does not occur and was established through a confirmability audit. The confirmability audit included audio tape recordings, coding details and field notes to confirm the study's findings. Additionally, the themes and categories were shared with the participants to ensure a true reflection of their stories that were shared (see Appendix D). The process of member checking entails assurance that a true interpretation of themes and categories are captured from the participants, is authentic and is a true reflection of their experiences captured during data collection (Carlson, 2010). The findings were shared with the students in the form of a presentation to allow them to provide feedback on the researcher's interpretation of their stories. Feedback was provided immediately during the presentation. Participants could provide feedback in writing or verbally, whatever they were more comfortable with.

2.7 Conclusion

In this chapter, a detailed explanation of the research design and method was given. The chapter discussed the data analysis process that was undertaken, along with the essential criterion of trustworthiness that was considered. Braun and Clark's method of thematic analysis was used from the information-rich data captured from the participants' responses that were obtained from the seven semi-structured interview questions that were asked. The following chapter discusses the themes and categories and provides a literature control.

What we learn from experience depends on the kind of philosophy we bring to experience.

C.S. Lewis

CHAPTER 3
DISCUSSION OF THE FINDINGS AND LITERATURE CONTROL

3.1 Introduction

In this chapter, the findings from the one-on-one interviews are discussed. The researcher explored sonography students' experiences with SBL. Themes and categories that emerged from the data and direct quotations from the participants are provided below to support the themes. A literature control is also provided to conceptualise the findings. Research studies from radiography, other allied healthcare professions and nursing were consulted. However, literature for simulation for sonography within South Africa was not available.

3.2 Demographics

The demographics of a study sample refer to the characteristics of the participants that contributed to the interviews. The population included all the second-year sonography students registered for a BSc Diagnostic Ultrasound qualification in the province of the Western Cape. All participants were registered with the HPCSA as student radiographers. Of the nine students in the BSc second-year sonography class, eight participated in this study—comprising five females and three males—while only one student chose not to take part. The age range was between 19–35 years. Data were collected from all 8 participants that volunteered. The interviews were conducted virtually due to the COVID-19 pandemic. The duration of each interview varied from 20 to 40 minutes. All interviews were guided by the following semi-structured questions:

- Question 1 -I would like you to reflect on your experiences when you were trained using the tissue-equivalent phantoms.

- Question 2 - Now that you are scanning real patients do you feel the phantom (simulator) had any impact on your learning?
- Question 3 - If yes, please explain how it had an impact on your learning experience and can you maybe give a few examples?
- Question 4 - Did the simulators in any way improve specific learning areas for you such as:

    i) Scanning technique
    ii) The use of the equipment controls/ US machine buttons & functions
    iii) Your hand/ eye co-ordination
    iv) Recognising normal anatomy or pathology

- Question 5 - What role did the simulator have, if any, regarding your learning experience?
-
- Question 6 - Do you think the phantoms were appropriately used in your learning and for the clinical assessments? Please explain your answer.
- Question 7 - You are scanning real patients now. Could you reflect on the advantages and disadvantages, of any of the simulator interactions and scanning real patients?
-

The interviews were conducted in a relaxed manner virtually using WhatsApp video call and the call was audio recorded. The researcher sent the semi-structured questions that were emailed to each of the participants, a few hours prior to the interviews started to reduce any anxiety that may have developed of not knowing what to expect during the interview. The participants felt comfortable sharing their experiences and the interviews were generally pleasant. The researcher and participants had the virtual interviews in a private space free from any external noise or disturbances on the interview's audio and with a stable internet source. Apart from a few minor wireless network issues that interrupted one interview call (participant 2), the rest of the cohort's networks were very stable and audibly sound.

A summary of the themes and categories is contained in Table 3.1 below.

Table 3.1: Themes and categories from focus group interviews

Themes	**Categories**
Enhancing preparedness for the clinical environment	1.1 Phantom as an introductory tool 1.2 Improved scanning technique 1.3 Ability to recognize and identify anatomy and pathology 1.4 Ample practice time 1.5 Well-structured and aligned clinical tutorials and assessments
Limitations of tissue-equivalent phantom	2.1 Lack of realism 2.2 Inability to replicate sub-optimal conditions
Suggestions for the improvement of simulation learning	3.1 Creating an authentic clinical environment 3.2 Peer scanning

3.3 Description and discussion of findings

Themes and categories were developed. A theme is an indication that symbolizes a pattern or frequency within a text. Themes consist of various concepts which depict meanings and experiences of individuals (Kiger & Varpio, 2020). Three major themes were identified from the data of the study. The data analysis and interpretation of the findings occurred concurrently and are discussed below.

3.4 Theme 1: Enhancing the preparedness for the clinical environment

This theme focused on the participants' stories and experiences of using simulation as an introduction to the clinical environment. They believed that the phantom provided them with a better understanding of anatomy as well as providing them with the opportunity to develop their scanning technique. Some stories shared indicated amazement of the phantoms as they have never been exposed to it before. Feelings of gratitude were also evident as this tool allowed the participants to gain confidence prior to their first clinical rotation. Participants expressed feelings of relief due to the ample scanning time allowed during the simulation sessions.

From my own personal experience as a student, we did not have simulation in our training as it was considered very expensive at the time and we had to gain all the clinical knowledge from workplace learning experience through hospital rotations. The only time we could practise novice scanning was when we used to ask our peer ultrasound students to be a scanning model, after each lecture to consolidate the theory learned with the practical on how to perform specific ultrasound examinations. This was the only time for us scanning novices prior to scanning real patients in the clinical setting.

3.4.1 Category 1.1: Phantom as an introductory tool

The participants of this study felt that the experience of using tissue equivalent phantoms in SBL was a good ultrasound introductory tool. The use of the phantom prior to real patient interaction eliminated the feelings of anxiety and nervousness. They expressed feelings about the tool being useful in assisting them to prepare for the clinical environment. This is highlighted in the following statements:

“Using the clinical phantom, it was something new, I didn’t even know phantoms exist which has internal organs like humans. The time spent using them was quite good as they’re easy to handle and I think it was a good start for scanning because I don’t think scanning is easy. But I think it was good to see how all the organs look on ultrasound prior to we move to real patients.” Participant 1

“I went into the ultrasound course with no ultrasound experience and very nervous. I didn't know that CPUT had phantoms so when we started scanning the phantoms I enjoyed it a lot. And I was very impressed that we were able to scan a basic obstetric scan and an abdomen within a few days of starting. So I liked it. It was very helpful.” Participant 5

“Okay so it helped us give a wide picture, like a mental picture of what we are looking for on a real patient.” Participant 1

“... So that's actually a great opportunity because if ever at all we didn't have the phantom we would be lost when we go to clinical’s. But now when we go to clinical’s we've got the idea of, let's say we are talking about an IVC. We know what IVC looks like, we're talking about spleen, we know how it looks like and we know how to find where each and every organ in the abdomen. So it was quite good.” Participant 4

“No, if I did not have that experience in the class with that phantom and I had to go to the hospital, I would have been totally clueless, I would not have known what is going on, I would have been useless. The patient and the people would have scolded me for not knowing what's going on.” Participant 3

“I was more comfortable doing my first training on the phantoms than on a real patient. Because I feel like the patients will judge you if you know absolutely nothing about ultrasound.” Participant 6

> “It was very nice, it was a very nice learning method because then we could actually orientate ourselves with how to use the probe properly, how to actually tilt and pan through without actually hurting the actual patient. So I feel like for someone who's starting to scan, the phantom is very nice because then you don't have to worry about how the patient feels and then you can already see what not to do and what to do when you have an actual patient, so it was a nice experience although it's not really the same as scanning the patient but it kind of gives you a confidence to get yourself orientated very well on how to use the probe and where to get the things on the phantom.” Participant 7

These quotations suggest that most students perceived the tissue equivalent phantom interaction as a good introduction to sonography. Sonographic scanning is an abstract practice and students can easily get confused when scanning different abdominal structures depending on the scanning sites and direction they are scanning from. Scanning the tissue equivalent phantom provided a guideline to the student cohort and assisted them to become more knowledgeable and better prepared prior to scanning real patients. Similarly, in a study conducted by Gibbs (2015), ultrasound students expressed feelings of gratitude for being introduced to simulation prior to scanning real patients in the clinical setting.

Another reflection that emerged from the study is that the students achieved greater confidence levels and felt more at ease having the phantom interactions in preparing them for the clinical environment. Other studies concur that simulation phantoms, when used as an introduction prior to scanning patients, students felt better prepared for the clinical environment because it is done in a safe and controlled environment that contributed to novice students feeling more relaxed and less pressured (Gibbs, 2014; Gibbs, 2015; Wells & Goldstein, 2017). Hani et al. (2019) advocate that simulation is a good introductory tool to assist novice students using ultrasound in all medical fields to open a pathway to consolidate theoretical knowledge with extensive practical experience. Furthermore, Osborn et al. (2015), assert in a systematic review of obstetric simulation studies that tested the transferability of clinical skills to students using a high-fidelity simulator compared to that of a real patient setting, that it is very valuable. The findings from the current study are in keeping with the findings in the literature.

3.4.2 Category 1.2: Improved scanning technique

The participants indicated that the phantom assisted in acquiring clinical skills in preparation for the clinical environment. They conveyed that they learned how to adjust the ultrasound machine settings and how to manoeuvre the transducer to obtain the required images needed for diagnostic purposes. The participants felt more at ease practising their scanning technique on the phantom. This is reflected in the quotes below:

> "Ja definitely. Scanning technique, definitely. How to manipulate the transducer, the machine, how to adjust the settings on there, ja." Participant 5

> "It allowed me to practise my ultrasound technique and scanning when it comes to a real patient. I also learned how the organs look and the appearance of how they must look on ultrasound." Participant 6

> "When working on the phantom. I think it recognizes the errors, the mistakes. Like it easier to concentrate on the phantom. You can easily work on it without the interference to think about the patient. Ja." Participant 2

> "I don't have to look where I'm scanning at this stage, I can just look at the screen and with my hand I'll know what I'm scanning." Participant 6

> "Okay the scanning technique, it did help with the scanning technique to get use to like the way that we're scanning from organ to organ, how I'm going to run, how I'm going to start in the midline and how I'm going to move more to the lower and then I'm going to go to the opposite side." Participant 3

> "I learned how to use focal zones and all the frequency to adjust it according to the patient." Participant 6

Acquiring clinical skills through practice, and mastering ultrasound scanning techniques, form an integral part of sonography education (Gibbs, 2015; Thoirs et al., 2015; Wells & Goldstein, 2017). Clinical skills required in ultrasound technique include good hand and eye coordination, the ability to satisfactorily adjust the ultrasound machine settings depending on the tissue structure evaluated and manoeuvring the transducers adequately to display a specific anatomical region of interest (Gibbs, 2015). The participants expressed that the simulator phantom helped improve their scanning technique.

Osborn et al. (2015) state that simulation-based learning allows for practical hands-on scanning which enables the development of high-order psychomotor skills. This is then later integrated with elements of cognitive skills to do pattern recognition and to assist in clinical interpretation. Similarly, Hani et al. (2019) opine that sonography trainees can familiarise themselves during SBL with the transducer orientation, image optimization and practise a systematic approach to ultrasound prior to scanning patients. The experiences of the participants are similar to the findings of Hani et al. (2019) and Gibbs (2015).

3.4.3 Category 1.3: Ability to recognize and identify anatomy and pathology

The participants conveyed that the phantom helped them learn to recognize the basic normal anatomy. This further assisted them with the real patient interaction to identify the normal anatomical landmarks and tissue differentiations. Participants also felt that the simulator played a role in guiding them to identify pathologies when scanning in the clinical departments. This is depicted in the following quotes:

> "To know where the location is and the different echogenicities. If we look at the kidney, we know how it must look and how you must move the probe in what ways to get the full kidney." Participant 1

> "… I think it was helpful. Because following your basic anatomy, the organs, the basics of ultrasound. And also, what can I say? Ja, I think it also helps us to prepare for clinical exam, clinical department. Ja, it prepares some skills and training." Participant 2

“Yes it was a good impact because like I said, I was more familiar with anatomy and orientation of landmarks with the anatomy like looking at the patient and...I mean I could already see, from what I learned from the phantom, where what is, which quadrant to find a certain anatomical body part.” Participant 7

“Ja, sort of the same. Ja, it did play a role. As I said like I can be able to distinguish between a pathological thing and a normal thing. So even with the kidneys, I know that the kidney...especially with the renal cortex is supposed to be a little bit darker or hypoechoic. Then the pathological one, sometimes you can find like it has increased... the echogenicities increased...So I have...with the phantom it really helps in making the learning experience...learning everything so also like be able to incorporate that into the clinical thing. I think I'm fine with that answer.” Participant 8

“Yes, it did. It did help us because we could see the calcification from the phantom and when I scanned patients, I could also see the same calcification. The only difference with the phantom was that it didn't have the posterior acoustic shadowing. So but then as we went on with lectures then I understood that it's actually supposed to have posterior acoustic shadowing. But I think...I don't know, I think it's because of the phantom it's not possible to have it. I'm not sure, maybe I forgot but I don't remember seeing any posterior acoustic shadowing. But the calcification is there, as soon as we saw them on the phantom we could already spot that those are gallstones and when we were scanning the patient, we could familiarise ourselves with the stones, that we've seen them prior to on the phantom.” Participant 7

The research participants expressed that SBL helped to identify normal anatomy and landmarks due to first scanning the tissue equivalent phantom. Gibbs (2015) concurs that exposure to normal anatomy and pathology using simulation can assist students to be more prepared when entering the clinical departments where they will be expected to at least be familiar with normal anatomical landmarks once starting to image real patients. Cook et al.

(2020) report a statistically significant improvement in anatomical knowledge after performing gynaecological and first-trimester obstetric ultrasound SBL with third-year medical students. The students' ability to identify basic pathology was also increased using simulation and was confirmed with theoretical pre- and post-tests prior to and after the initial SBL instruction. Additionally, in a systematic review article on high-fidelity obstetric ultrasound simulation, Osborn et al. (2015) report better performance outcomes in a cohort of first-year radiology residents prior to being on-call. The residents' ability to detect, diagnose and suggest treatment options for relevant pathology was measured and showed better outcomes. Similar experiences were noted with the participants of this current study.

3.4.4 Category 1.4: Ample practice time

The participants stated that they were allowed ample time to practise on the phantoms. This permitted them to make mistakes on the phantom without the pressure associated with scanning a real patient. Owing to this, students felt less pressured and more relaxed in an environment using SBL. The quotes below express the participants' stories shared:

> "It impacted our learning in a way that we could practise on the phantom for long times without us worrying about the patient getting irritated or are you pushing too hard, things like that. So, we could educate ourselves for as long as we needed, and it helped us to know what to look for on a patient if we had to move to a real patient." Participant 1

> "Yes, and also when I scan in the clinical environment, I'm often scared I'm hurting the patient or taking too long or things like that, where starting with a phantom, I think it helps you learn your technique and to get comfortable with the probe, so you don't scan that long on a real patient and you don't feel like you irritate them. I think it helped. If it makes sense" Participant 1

> "Yes definitely. I said it previously, because we could practise for as long as we needed until we felt comfortable. And we didn't have to take into account how a patient is feeling so ya." Participant 1

> “I think like we, in the phantom we can repeat mistakes like several times without getting any pressure from the staff at least. Then in the clinicals like there's that pressure, like you can't repeat mistakes like for several times. So I think I prefer using the phantom like to master my scanning skills and ja adjust the instrument settings.” Participant 2

> “When working on the phantom. I think it recognizes the errors, the mistakes. Like it easier to concentrate on the phantom. You can easily work on it without the interference to think about the patient. Ja.” Participant 2

> “And the advantages are, I would say...oh I would say like in the phantom there's no pressure than in the hospital. Because we can easily master our skills first using the phantom than in a real patient because there is that pressure. They are always pressuring us to finish on time.” Participant 2

> “So the advantages is that, well obviously we have enough time with the phantom, the phantom doesn't complain about anything and ja we could actually press and know and leave and then realise okay, I’m pressing too much and then also decide, okay this wouldn't be good for when you actually have a real patient.” Participant 7

According to Alinier (2013), increased practice time with simulation can improve the clinical skills and outcomes of students. Gibbs (2015) agrees that when students are allowed ample time to practise, it will boost their confidence and preparedness when entering the clinical platform. The stories shared by the participants of this study are in keeping with the literature presented.

The findings from this theme were similar to the findings reported by Gibbs (2015) on SBL. According to Gibbs (2015), sonography students’ experiences with the Medaphor (high-fidelity) simulator gave an excellent basis for clinical teaching prior to attending to patients in the real clinical setting. Thoirs et al. (2015) assert that SBL enhanced Australian students’ initial experiences to identify ultrasound anatomy and to do pattern recognition prior to scanning patients. Similarly, the students in the current research study could better concentrate when scanning the simulator because it was performed in a more relaxed and controlled environment.

The participants also found it easier and could recognize normal anatomy using the simulator. They were able to make mistakes that could be corrected using the tissue equivalent simulator without having anxiety in the case of a real patient setting.

Taylor et al. (2021) explain that SBL should be asynchronous and readily available for students to utilize at a time that suits them best to allow optimal time with the simulator to practise as much as it is needed. Hani et al. (2019) expressed renewed cognition that all students are different. Some students may reach a level of competency after one or two ultrasound practice sessions. However, some students may need more time to be on par. The author also advocated that a minimum number of ultrasound scans cannot accurately reflect a student's skills and that further research should be conducted on the retention of knowledge and clinical skill sets.

3.4.5 Category 1.5: Well-structured and aligned clinical tutorials and assessments.

The participants reflected on the questions of whether the phantoms were appropriately used for their clinical training and if it was appropriately used for the clinical assessments. Below are the experiences shared by the participants:

> "Yes, okay we usually had a lecture when we learn something new, like the abdomen scan had a lecture and then had a clinical tut where we pretend that the phantom was a real patient, we treated the phantom like a real patient or so. Then we could visually see what we just learnt. So I think it was definitely appropriately used. And for the assessments we had to speak to the phantom and clean the phantom as you would clean a patient and we had to take the pictures in ordinary just like we would take it on real patients." Participant 1

> "It was appropriately used in the department, the phantoms with the assessment. I think the phantom did its purpose and the rest is up to us to go practise in the department. Ja." Participant 5

> “I'm not quite sure but I enjoy the way that you guys presented the phantom for the clinical assessment.” Participant 6

> “Yes they were because for clinical I think we had 2 assessments earlier in the year but, I don't know, we had 1 mock assessment, we actually had 2 mocks for each of the assessments for abdo and obstetrics and in both of those, when we were learning how to properly scan and have a protocol for the abdomen, we actually went through the sheet and scanned as the protocol, like as a proper aligned protocol. So I think that was very useful and using what I learned and how I was scanning and the protocol we were using while we were doing the simulations, that's exactly how I'm now learning to scan patients as well. So it has a better systematic way that makes it easy for one to scan without actually forgetting anything” Participant 7

Alinier (2013) found that simulation in healthcare education can assist students in better understanding and practising clinical skills. Clinical tutorials are well-structured, curricula-aligned, practical sessions facilitated by a clinical instructor or tutor to illustrate how an ultrasound exam is succinctly performed. The term clinical tutorial is a step-by-step approach to perfect scanning technique according to Srivastava and Waghmare (2016).

Solli et al. (2020) explain that SBL is usually conducted in three systematic steps, namely briefing, simulation, and debriefing, where briefing occurs prior to the simulation and debriefing post-simulation. Solli et al. (2020) add that the usefulness of briefing is so that the facilitator conducting a simulation learning activity can explain the purpose of the simulation exercise and the intended learning outcomes to students. This allows students time to raise any concerns they might have prior to simulation starting, which can aid in stress reduction.

Elshama (2020) and Solli et al. (2020) concur that during the SBL activity the facilitator should be calm and must be aware of the students’ possible anxiety about the simulation activity. Facilitators should be mindful of the students’ circumstances by creating a psychologically suitable atmosphere to ensure a good learning experience in a relaxed and safe environment for them. According to Palaganas et al. (2016), structured, well-aligned debriefing sessions

after SBL can be conducted through open dialog and discussions after the simulation activity between a facilitator and the students to allow deeper learning to be accomplished.

In this study, the researcher found that the participants enjoyed that the simulation tutorial sessions were presented in a systematic and structured manner that aided in them learning better and remembering the information better.

3.5 Theme 2: Limitations of tissue-equivalent phantom

This theme focuses on the challenges that the student cohort experienced while interacting with the tissue-equivalent phantoms. The majority of the students reported that the simulators lacked features to fully replicate a real human being.

3.5.1 Category 2.1: Students' experiences with abdominal and obstetric phantoms

The participants reported limitations in both the abdominal and obstetric tissue equivalent phantoms. The abdominal phantom exhibited only an upper abdomen torso excluding the pelvic region. Organs such as the bladder and iliac vasculature located in the lower abdomen were not present in the simulator the participants used. The participants felt that the obstetric phantom was more useful compared to the abdominal phantom, because the operator was able to change the position of the foetus in multiple scanning positions to exhibit breech or cephalic presentations. However, the biggest limitation of the obstetric phantom was that the foetus is stationary in the phantom during scanning, which is not the case in a real patient. The below quotations illustrate these feelings:

> “The phantom doesn't have the bladder part connected to it. You also don't have the flow from the kidneys and that is actually one thing that I think some of us found...if I'm talking about myself, I found it a little bit hard….Okay but basically, obviously the obstetric phantom lacks the same points as the abdo phantom, but the obstetrics phantom...because obstetrics is in so much detail with the fingers and the little feet and all of that and the organs, I have to say it helped a bit better, a bit more because it's much more little detail things that you must look for.” Participant 3

> “It did yes, it improved a lot but at some point I feel like we...I was kind of spoiled by the phantom when I was about to scan a real patient because I was used to a phantom, like I know where to find my spleen and it's just a phantom, it's not a real

patient there so there's no bowel gas like which can cause some acoustic shadowing and all that stuff. So when it was time for me to get a real patient, I had some struggles but as the time goes by I got like a way to sort that out, to actually see if ever how are things being done on a real patient compared to a phantom." Participant 4

"Yes, for obs, ja it played a role but it is very difficult as well in especially... Because I know if ever I'm scanning a phantom I know it's either the foetus are either cephalic or breech so I just know where to...but on a real patient the foetus can lie at any position so you have to be open minded and know how your organs looks and everything of the foetus you must be able to master. But for the basics, I feel like that really helped a lot. Just to know how to measure like BPD and all type of thing and all types of measurements with the foetus. So it actually helped a lot." Participant 4

"I started in XXX (clinical facility). For me obs was very difficult, it is very difficult because I'd still have that mindset of I'm scanning a phantom whereas I'm in a real patient so finding BPD, finding femur, it is very difficult because I'd find femur then I'd take time to freeze, then when I'm freezing, it's already...the foetus already moved so I lost my femur so I have to go and look again. So it was kind of taking time for me to get used to that but eventually I got used to how to maintain time and how to know where to find actually ovarian structure on the real patient. Same applies to abdomen, it is same situation. But as the time goes by I will cope. I will manage to do that." Participant 4

"Ja like I said it did have like a bit of impact. As I've said that I know now where things are located, but the only problem is that with a real patient everything is moving and there's gas, and in the phantom there was no gas so it was...everything was just stationary so ja. So it was a bit difficult scanning a real patient." Participant 8

Osborn et al. (2015) reported in a systematic review of four obstetric ultrasound high-fidelity studies that the high-fidelity simulators were very effective for training students, with improved

outcomes if implemented into a training programme. Massoth et al. (2019) maintain that high-fidelity simulation is not necessarily superior to low-fidelity simulation and reported that students using high-fidelity simulators may become overconfident. Furthermore, Toserud et al. (2013) used both low-fidelity and high-fidelity simulators to evaluate nursing students' perceptions using simulation as a learning method and concluded that students felt more satisfied when using the low-fidelity simulator.

There still exists much controversy in literature on whether high or low-fidelity simulators are better. However, when used in the clinical setting, Alinier (2013) opines that both can be used in clinical training because low-fidelity simulators can provide excellent teaching of basic skills sets and high-fidelity simulators that exhibit greater realism may be used for more complex simulated teaching such as case-scenario based training in nursing education. While the participants of this study appreciated the use of a tissue equivalent phantom, their stories indicate a need for a combination of high and low fidelity.

3.5.2 Category 2.2: Inability to replicate sub-optimal conditions

The participants explained that one of the major limitations of the simulators was the inability to replicate a real patient by imitating bowel gas shadowing, cardiac and vascular motion, increased Body Mass Index (BMI) or a moving foetus. These limitations are clearly articulated in the quotes below:

> "Okay now a real patient has bowel gas shadowing that can obscure your pancreas totally, it can make your spleen harder to examine, it can make even your aorta and your IVC harder to examine." Participant 1

> "Ja ja, I think it's easier to scan the phantom compared to real patient, ja it's different from the phantom. Like I wish we like had a phantom that has a larger BMI for example. Ja, because I feel like the one we are using, not that it's simple but it's better compared to what we are doing in clinicals. Like when you get there it just becomes complicated. Especially at the beginning of this year, it was really hard, for a bit." Participant 2

“The phantom doesn't have breathing. It doesn't really give you any vascular flow, it doesn't give you any movement. Ja it doesn't give you like veins that have movement and pulsating and all of that. It doesn't give you any of that.” Participant 3

“It gives you the view, like it gives you the basic shape of the kidney, the shape of the liver and stuff like the anatomy book cannot really give you. So it gives you the shape and what you kind of looking for. But then it also gives you this false appearance because you're never going to see it like that. So it's...I don't know, it's good for like the first few minutes to show this is what you can expect but the thing is when we start scanning on it then and we start practising on it and we start doing dimensions on it and all of that, it's not helping very much. The second you go into the hospital or you scan a real patient, you don't even have to be in a hospital, you can do it there, it changes totally. Nothing looks the same, echogenicity is different, it even feels different.” Participant 3

“It was of help like where to find it but visualizing it is a different thing it on a real patient. Because each patient is different and there's bowel shadowing and there's a pumping heart so the location of the anatomy helped with the phantom but not the actual anatomy, what it looks like.” Participant 5

“I think scanning the phantom as an introduction so then you get to know the machine you know sort of what the patient would be like. But you need a real patient to gain experience. Because there's other factors like the heart pumping blood and there's acoustic shadowing of the bowel. So that all plays a part because it's a lot different from scanning a phantom if you scan a real patient. Ja.” Participant 5

“Disadvantages were the phantom doesn't have breathing or bowel gas. Also it didn't have the chance to practise Doppler on the phantom because it doesn't have any blood flow.” Participant 6

> “The disadvantage is that, well I think the phantom gives us a lot of confidence and then we get the patient and we get very nervous and then we realise, oh, I don't think I can scan. But I don't know if I can say over-confidence from the phantom is a disadvantage but it was a huge turn for me because I was like, okay, what's going on when I had the real patient but also another thing is we were not too...like I was not caught off guard because even through the simulations, my peer and I were scanning each other so I could see even from her that okay, actually it's not the same as the phantom. And then the disadvantage...ja another disadvantage...what's another disadvantage? There's nothing else that I can think of that's a disadvantage for the phantom.” Participant 7

> “I'll give an example, like I said earlier on, the phantom doesn't have bowel gas and the phantom is not...the body habitus of the phantom, it's actually a very slim phantom whereas in most cases you get like medium body habitus patients that have a lot of bowel gas and you can't see much and I feel like...sometimes I feel like the phantom is a little bit exaggerated in terms of normal anatomy. I don't think, even with the best patient that we get, I don't think the patient can actually look like the phantom but ja so it...ja. Everything looks good on the phantom. Everything is perfect on the phantom, it would actually be nice for the phantom to have a lot of bowel gas to have, I don't know, maybe a little bit of movement if that's possible. When we press, I don't think it's possible but ja.” Participant 7

Wells and Goldstein (2017) describe low-fidelity simulators as being low cost, reusable and used to acquire the basic ultrasound clinical skills that students need. Conversely, high-fidelity simulators have greater realism but are more costly. High-fidelity simulators can be divided into two categories, namely those that only demonstrate static anatomy and others that can demonstrate dynamic anatomy, for example, replicating a beating heart (Lewwis et al., 2014).

The tissue-equivalent phantoms used in this study (Kyoto Kagaku ABDFAN abdominal ultrasound training phantom and SPACE FAN-ST foetus ultrasound examination phantom) are part of a high-fidelity simulator group that can only demonstrate static anatomy and are lower in cost compared to the more expensive computerized or dynamic anatomy high-fidelity simulators that are on the market. High-fidelity simulators that have dynamic anatomy can demonstrate a more realistic or virtual simulation experience with better physiological abilities

and a greater degree of complexity in the form of clinical case-based scenarios (Toserud et al., 2013; Lewwis et al., 2014; Farsoni et al., 2017; Intelligent Ultasound, 2019). In this theme, it was evident that the participants felt that the tissue-equivalent phantoms lacked realism. The participants expressed a need for more physiological capabilities such as those found in a dynamic anatomy high-fidelity phantom.

3.6 Theme 3: Suggestions for the improvement of simulation

This theme focuses on the suggestions of the participants regarding how to enhance the SBL experience. Some of the suggestions that came forth were to upgrade the skills laboratory, encourage student peer scanning after the initial phantom simulation interaction and to enforce greater patient care from students when conducting practice sessions on the simulator.

3.6.1 Category 3.1: Creating an authentic clinical environment

The participants conveyed that more ultrasound machines could benefit the skills lab to allow more students to practise at a time. The introduction of dividing curtains could make the skills lab a more realistic clinical environment. One participant indicated the need for greater patient care and improved communication (student scanner to simulator) during simulated-based teaching sessions and a few participants expressed that it would have been beneficial if they could observe clinical staff in their first year after having the simulation interaction prior to working in the hospitals and scanning real patients from the second year. The quotes below explain the participants' suggestions.

> "I think since...I think I remember the last time I saw 2 machines in the skills lab so if were to have 2 machines working, both of them with curtains sealing them, separating them, then the 2 students would work in the other room, the 2 students would...that also limits the amount of time we spend with the simulations. So I think that would be very nice. Then even prior to we have lectures, we can always come in, the 4 of us, the other 2 is working that side and we're working this side and then we could actually even finish practising prior to we actually do our simulation or prior to we actually have to go for a lecture." Participant 7

> "Oh, another suggestion, oh okay I've got another suggestion. If ever, let's say in first year, like let's say even if it's a week or 2, they can go to hospital just to observe, not to scan. Their aim to be there is just to observe how things are being done. So

whenever they go...and when you go there like on second year, don't start at campus, we only go straight to hospital. So we'd be kinda lost and we don't know what to do in the departments so we'd be going around, don't know what to expect to do, what is being expected from us to do as second year because it's our first time to be in clinicals and we don't have anything...like we don't have an idea what we can do. So if ever they can take like a week or two, like in their first year just to go and observe. When diagnostic students and the rest of the students are going to the department, let's say during the vacation during June vac and stuff like that, if ever they can get an opportunity, they can just go and they can just observe." Participant 4

"Okay, I feel like also the other thing that we should also stress on students is on how to do patient care. Especially patient care and how to...greet and stuff so that even though sometimes we are scanning the patient we should also apply that. Because when we get to the hospital some of us really forget that we should greet the patient and so we really forget about patient care. And also communication. That it doesn't matter even if it's the phantom, that we should communicate to it. Because I realise when I read my staff clinical written report they completed, it said she's shy and she must communicate more with the patients. Patient care and patient introduction and everything we must make sure that communicate more with the patient." Participant 8

According to Sundler et al. (2015) and Robinson (2013), an authentic and realistic simulation environment is necessary to deliver the best simulation experience to students. More equipment and accessories to replicate the real patient hospital setting would ensure greater realism, such as dividing curtains between ultrasound beds as found in a real hospital ultrasound department.

Observation of clinical examinations prior to conducting them independently could aid students to familiarize themselves with the clinical setting, build confidence and observe what is expected of them. Hazell et al. (2020) report that radiography students in the United Kingdom (UK) spend approximately five weeks just observing clinical procedures prior to starting to practise actual clinical examinations under strict supervision in the clinical setting. This is in keeping with the suggestion made by the participants of this study. However, Kelly et al. (2016)

conversely aver that in Norway, nursing students do not go to observe clinical examinations but post-operative simulation sessions, under the strict supervision of a facilitator, are observed by students prior to clinical skills proficiency.

3.6.2 Category 3.2: Simulated peer scanning

All the participants strongly conveyed the need to have clinical simulation experience with scanning student peers or real human models prior to interacting with real patients in hospitals. One student suggested that it would be more cost-effective if they could practise on a peer, comparing the price of a low-fidelity and high-fidelity simulator used on a peer willing to be a scanning model. The participants felt that if they had been introduced to peer scanning, they would have been more prepared prior to scanning real patients.

> “And bowel gas is definitely something you're going to see because everyone eats at lunchtime and if you have class after lunch, you're struggling. And people drink water the whole time and I've read a study how many oxygen you actually take into your body with every sip of drink. So I still think the normal human wins in that direction. Because the... CPUT... the educational if they have to take or buy such an expensive phantom, I would rather say it would be better to buy a more expensive machine or maybe 2 or 3 machines. Because you would say now this phantom, it can do this, it can do this, it can do this but the thing is it's only replicating somebody walking around in the class.” Participant 3

> “A suggestion which I would have, especially to first year, like when scanning, I wish you can grant them some time if they can scan on themself. They're allowed to practise on the phantom as well and they can do their assessment on the phantom but just to get like an overview of hows the real patient can look on each other so that they can be aware hows the real patient looks like, like the abdomen and ja. So that ja, will be my suggestion. Since in first year we don't get chances to go to hospital, we only attend skills lab, yes.” Participant 4

> “I feel like sometimes...okay we are being introduced to the phantom. Sometimes I feel like it's much better when they can maybe get a real person, then they start scanning them then maybe we also have an opportunity to scan that patient so that at least when we go the clinical we know what to expect because with the phantom, it's just there and you feel like when you are done with everything...even last year

I felt like ja, I got this, I know what I'm doing. But when I got there it was another thing, especially with the obs. Also with...also you can say even with the abdos. So that's why I had...hey it was a problem at first. But I managed to pull through, but I managed to, I helped myself whenever I was there at the hospital to scan and everything. So it will be much better that sometimes to get a real patient, then scan the patient and stuff. You just introduce us to the phantom, then scan the phantom maybe for maybe 2 weeks and get used to where things are located and bring a real patient especially for assessment. Do assessment on real patient. From first year." Participant 8

"I think we also need to be exposed maybe in the classroom to suboptimal images so that we can get used to...focus on images that are not of the perfect patient. Maybe it would make it easier for us to identify the anatomy on patients when you get to the department with bowel gas and all those things as well." Participant 5

"I think they need to get phantoms that have more adipose and more gas in it or something and not like our phantom. Maybe more exposure to suboptimal images or images that's not so good and ask us to try to identify the structures, ja so that we can get used to images that aren't as pretty." Participant 5

"I just feel that if we might have had a chance to scan on a real patient or classmate later in the year to give everyone else a chance to practise on a patient." Participant 6

"I only have those suggestion that later in the year that the first-year students scan on a real patient. Just to get in the feel of how the real patient's anatomy and everything works." Participant 6.

"I don't know if it's allowed by HPCSA, but I think it would really be good for us to decide upon ourselves maybe or to actually divide ourselves into groups or have a roster where we scan each other. Because I feel like we are patients, we are human, we are more real than the phantom so I think if we were to in every section that we did scan each other and see where is what. Obviously because we also

different, it will actually also give us an experience of having different patients. So that would be nice and ja." Participant 7

"Yes, I feel like we should make time to practise with our mentors at least because started last year, so we couldn't even ask some of the questions. Ja." Participant 2

"Ja we not on that but I think that would be really nice to scan each other and it would also be very nice for us to scan and while scanning, someone has to like maybe recite or say what they're looking at, what they are doing and things like that but I think we already do that but making it more traditional for us to scan in that manner. It would be very nice." Participant 8

Similarly, Hope et al. (2011) found that nursing students conveyed the same sentiment in their simulation experiences and felt that peer support played a pivotal role in their learning. Students are generally more comfortable giving one another feedback during simulation sessions and assisting each other while scanning by actively participating and engaging in experiential learning (Boud & Molloy, 2013). Cho and MacArthur (2010) opine that receiving feedback from multiple peers is more valuable than receiving feedback from one peer or one lecturer/facilitator.

All the participants in the study strongly suggested that it would have been more beneficial if they had an opportunity in the first year to start practising ultrasound scanning on their peers that were willing to be patient models soon after mastering their clinical skills on the phantom simulator. A real patient model would have more realistic abdominal features, like visible bowel gas, cardiac activity and vascular flow within the arteries and veins compared to the abdominal tissue equivalent phantom that does not have these features.

Michael et al. (2019) add that having scan models for patient simulation, as in the case of using sonography student peer models, requires some ethical considerations that include a scan model consent form, Protection of Personal Information Act (POPIA), and data de-identification (Swales, 2021), medical history disclosure form and incidental finding referral form in instances

where an abnormal finding is detected during a routine simulated session. Michael et al. (2019) report that practical and clinical skills training activities may have a varied occurrence of between 1.5-1.9% having unexpected ultrasound incidental findings that would require a referral from medical schools' skills laboratories to clinicians.

3.7 Conclusion

In this chapter, different themes and categories emerged from the data. A literature control was conducted to conceptualise the findings. Three themes were highlighted, namely i) enhancing students' preparedness for the clinical environment, ii) limitations of the tissue equivalent phantoms, and iii) suggestions to improve the simulation experience. It is evident from the findings that sonography students appreciate SBL, however, they would like the opportunity to scan peer or model cases prior to entering the clinical environment. The use of SBL has many advantages and this is clearly explained in this chapter.

André De Shields's 3 rules

"1: Surround yourself with people whose eyes light up when they see you coming; 2: Slowly is the fasted way to get to where you want to be; 3: The top of one mountain is the bottom of the next so keep climbing."

CHAPTER 4
GUIDELINES AND RECOMMENDATIONS

4.1 Introduction

In this chapter, guidelines and recommendations are discussed. These are linked to each of the themes. Guidelines are a set of rules or advice that provides direction for action to be taken to solve a certain problem and recommendations are suggestions given for developing a plan of action (Gerrish & Lathlean, 2015). Guidelines and recommendations are necessary to bridge the challenges or limitation that was mentioned in Chapter 3.

A summary of the themes and guidelines is provided in Table 4.1 below.

Table 4.1: Description of themes and guidelines

Themes	Guidelines
1. Enhancing the preparedness for the clinical environment.	1.1 Development of a framework for a structured simulation process 1.2. Installation of 360-degree (field of view) cameras 1.3. Peer support and mentoring
2. Lack of realism of the tissue-equivalent phantoms	2.1 Investment in high-fidelity phantoms 2.2 Facilitating a patient-centred caring environment 2.3 Promoting inter-professional education
3. Suggestions for the improvement of simulation	3.1 Authentic ultrasound practices 3.2 Development of a volunteer protocol for mock patient scanning

4.2. Theme 1 - Enhancing the preparedness for the clinical environment.

Guideline 1.1: Development of a framework for a structured simulation process

In an attempt to enhance the preparedness of students for the clinical environment a possible recommendation is to develop a framework for a structured simulation process. A structured simulation framework is essential to ensure conceptualization of the curricula and to ascertain whether students are competent to engage with real patients in a clinical environment after the simulation process. This framework should be aligned to the learning outcomes and what the clinical tutor expects the student to achieve after the simulation process (see Table 4.3). It is

vital that each simulated clinical tutorial is guided by a standardized and robust assessment rubric that is given to students and diligently discussed with them prior to having a simulated clinical tutorial or assessment (see appendix H). In the rubric, the assessment criteria for the specific ultrasound examination must be clearly and concisely stipulated to enable the student to be knowledgeable when the simulation is started. (Alinier et al., 2004; Gibbs, 2015; Rutherford-Hemming et al., 2016)

It is important to have a simulation practical schedule including dates and times (time slots) that each student will utilize (see Table 4.2). It is imperative that each student is fairly treated and has ample scanning time when using the simulation tool. A strict attendance register must be kept ensuring that each student is using their scanning practice slots in accordance with the simulation clinical practical schedule. Recommending a mentorship programme to facilitate this process can be fruitful. A mentor overseeing this schedule can work well and be facilitated by the clinical tutor or a senior student at a higher year of study e.g., a BSc third-year or fourth-year sonography student.

Table 4.2: Simulation practical schedule example

Student	Simulator	Date	Available time slots	Mentor/ facilitator
1. BSc 1st year Name	Abdominal phantom	23 Aug 2022	08h30 – 09h30	BSc 4th year mentor – Miss Y
2. BSc 2nd year Name	Obstetric phantom	23 Aug 2022	09h30 – 10h30	Clinical lecturer
3. BSc 1st year Name	Abdominal phantom	23 Aug 2022	10h30 – 11h30	BSc 3rd year mentor – Mr T

Table 4.3: Framework for the simulation process

Simulation activity: Abdominal or Obstetric				
Activity timing	**Simulation tool**	**Learning outcomes**	**Verification example**	**Facilitator**
Prior and during the simulation activity	Abdominal or obstetric tissue - equivalent ultrasound phantoms	Planning is essential Identify what skills or clinical knowledge the student should demonstrate in the activity: Transducer placement and orientation Scanning technique Anatomy Ultrasound pattern recognition Competencies to the developed Ascertain that the student is able to transfer the knowledge written, verbally or clinically demonstrate their skills during the simulation activity	Course documented planning illustrating aims and objectives for simulation activity Informal assessment: Self-assessment (student can use a tick sheet with required views or scanning plane for the simulation activity) Peer-assessment (one peer watches while the other is scanning and give each other feedback) Mock assessment (the tutor or lecturer can do the assessment), however, it will not count towards any formative marks; it is done just to identify areas where students can improve on prior to the real clinical assessment Students should be aware of the marking criteria for the activity with the marking rubrics prior to informal or formative/summative assessments	Lecturer Senior student mentor or Lecturer Senior student mentor or Lecturer Senior student mentor or Lecturer

After the simulation activity	Abdominal or obstetric tissue - equivalent ultrasound phantoms	The student should be able to reflect on the simulation activity on whether the activity was helpful or if more activity sessions are required Assessment criteria must be aligned to the clinical outcomes and competencies required Students should be able apply decision-making skills that are aligned to the simulation activity and specific learning outcome	Questionnaire to establish if student found the activity informative and if there were any short coming regarding the simulation activity Informal interview or discussion between student/peer or mentor can assist to identify any concerns Formal assessment: Theoretical test on the simulation activity or a worksheet on the examination that was simulated should be done prior to a clinical assessment or an Objective structured clinical examination (OSCE) can be performed. Using blended learning methods like instructional tutorial videos from reputable online sources and form hard copy and online course material It can be assessed using clinical case scenario type of questions/ assessing ultrasound pattern recognition using pathology ultrasound images in a quiz or case to be	Lecturer Senior student mentor or Lecturer Lecturer Lecturer

			discussed in class	

Guideline 1.2: Installation of 360-degree (field of view) cameras

Taylor et al. (2021) indicate that virtual reality (VR) 360-degree video cameras now exist which can enable an online and/or virtual clinical simulated environment for students. Online simulated clinical environments allow the students to engage via their personal computer from the comfort of their homes whereas a VR clinical simulated environment is where students wear VR headgear goggles, and the 360-degree cameras project the clinical simulated environment as seen in a skills laboratory. These concepts are useful in the current COVID-19 pandemic that caused limited face-to-face or contact simulation clinical tutorials. Development and fitting of 360-degree (field of view) cameras in the ultrasound skills lab can assist students to visualize in real-time recorded practical scanning sessions. These cameras can zoom in to the phantom and ultrasound machine monitor screen whilst students are practising. This can aid in visualizing the student's hand movements with the transducer in the correct scanning technique for a specific examination. It is advantageous as it allows the clinical tutor to give formative feedback to students, especially after clinical assessments or an OSCE on the areas where a student can improve. The recordings can be replayed therefore students can watch the recording to see any possible errors made to improve on for future assessments.

Guideline 1.3. Peer support and mentoring

Carvalho and Santos (2021) report that peer mentors can communicate, collaborate and share their problem-solving skills with peers to increase higher-order learning whilst they proceed in their own studies simultaneously. Student mentors play an important role to support and guide junior students throughout the academic year because they have prior experience and knowledge of simulation and even scanning real patients. After the SBL clinical tutorials with the clinical lecturer, the junior students can perform an ultrasound on the phantom themselves, however, supervision by a senior student mentor is still needed to guide them. In this study, we recommend that greater peer support be provided by mentors that are senior students (BSc third-year or fourth-year) to junior students so that they can be better prepared when going into the clinical setting.

4.3. Theme 2 - Lack of realism of tissue-equivalent phantom

Guideline 2.1: Investment in high-fidelity phantoms

It is well established that high-fidelity simulators may aid in greater realism, thus ensuring a good simulation experience (Alinier, 2013; Gibbs, 2015; Osborn et al., 2015). Conversely, static anatomy tissue-equivalent phantoms are much more affordable compared to the dynamic high-fidelity instruments. It is imperative that universities keep up with modern trends and embrace new technology, as in the case of dynamic high-fidelity simulators that exhibit a more realistic simulation environment and create better experiences for students. The initial cost of high-fidelity simulation is high but the benefits, in the long run, may outweigh the cost.

Investing in a high-fidelity simulator such as the Medaphor ScanTrainer simulator that was used in Gibbs' (2015) study allows for more complex and different clinical scenarios in both obstetrics and abdominal scanning for students can be valuable. Carolan-Rees and Ray (2015) investigated the cost viability of replacing or substitution of clinical skills training with that of simulation training using an obstetric and gynaecological high-fidelity virtual simulator. They found that there was a cost reduction compared to the cost annually of having a student in the real clinical setting, e.g. in a hospital or clinic. The researcher believes that investing in these high-fidelity simulators may enhance the simulation experience for current and future sonography students as it will enable a more realistic representation of the clinical environment. This may also address the limitations voiced by the participants of this study.

In an international audit of simulation use in pre-registration medical radiation sciences training, the authors found that respondents from a survey questionnaire indicated that COVID-19 was a stimulus that caused an increased uptake of simulation resources in medical radiation science training (Bridge et al., 2021). Similarly, our Medical Imaging and Therapeutic Sciences Department was urged to incorporate our simulation resources during the COVID-19 lockdown and restrictions instead of face-to-face contact classes. The researcher believes that higher education institutions should increase their SBL resources so that everybody can be better prepared in case of possible future pandemics.

Guideline 2.2: Facilitating a patient-centred caring environment.

The cornerstone of simulation should be the promotion of a patient-centred caring environment while simultaneously allowing the students to practise in a controlled and safe teaching environment for the student and protecting the patient (Hazell, 2020). Van der Westhuizen et

al. (2020) opine that sonographers ought to be caring individuals interacting with patients in an empathetic and sincere manner. Communication with the patient is an important aspect of showing interest, brightening up a patient's mood and showing the patient that you care (Nadelson et al., 2016; Naidoo et al., 2018). In this study, one of students expressed that the greater student group perceived the tissue equivalent phantoms as a non-viable object and not a patient, thus it led to no or little communication between the student and the simulator during simulation training.

The researcher recommends that educators encourage students to view the simulator, regardless of it being a manikin, as if it is a real patient, e.g., communicating with the phantom as one would do with a real person and manoeuvring the phantom with care as if it is alive. In the clinical assessment rubric, additional provision should be made to include effective communication to the phantom, even if it is one-way communication, to determine if the students are familiar with what type of questions to ask if confronted in a real clinical setting. These questions may include asking the simulator a rhetorical question like "Ma'm, I have ascertained that your last menstruation date is correct as indicated on the ultrasound examination request." In doing so, students will be more knowledgeable when entering the real clinical setting and feel less stressed and be able to communicate more effectively with real patients.

Guideline 2.3: Promoting interprofessional education

Sonography is practised in many other healthcare professions such as nursing, emergency medical sciences (EMS), clinical technology, emergency medicine, anaesthesiology, paediatrics, and physiotherapy. There is a need for greater interprofessional education among different healthcare professions, not necessarily just clinical practice, but nonclinical skills such as communication and collaboration as stipulated by Kelly et al. (2016) in nursing education. This type of learning and collaboration adds value to the students' real-life experiences within the hospital environment whereby they interact with multidisciplinary healthcare workers.

To promote better interprofessional education, the researcher and lecturer colleagues introduced a sonography workshop in collaboration with the emergency medical sciences (EMS) lecturing team to assist in the focused assessment with sonography in trauma (FAST) scan presented to EMS final year (BSc fourth year) students from 2021. The workshop included a basic introduction to sonography, basic ultrasound physics and principles, ultrasound artefacts, FAST scanning technique and sonography pitfalls to be cognitive of when

scanning. The workshop was conducted over two days whereby the first day was online lectures, and the following day was a practical day with EMS students scheduled to practise scanning, guided by a clinical tutor using the tissue equivalent phantoms (simulated) and volunteer EMS student peer models who were willing (consented with written and signed permission) to be scanned in the skills laboratory.

The researcher recommends greater collaboration between the three sonography education institutions in South Africa (University of Johannesburg, Cape Peninsula University of Technology and Durban University of Technology) that use simulation clinical training in the curricula to benchmark (compare) and share experiences. Hayden et al. (2014) and Rutherford-Hemming et al. (2016) suggest national standardization of nursing simulation recommendations in the United States for education development, ensuring quality simulation training and simulation best practice standards, however, this is still in development as simulation in nursing is still growing. Similarly, the need for a standardized simulated training model for the South African context ought to be developed in the researcher's opinion.

4.4. Theme 3 - Suggestions for the improvement of simulation

Guideline 3.1: Authentic ultrasound practices

During this research study, student participants offered suggestions to improve the simulation experience by creating a more authentic and realistic simulated clinical environment. One recommendation mentioned was to upgrade the sonography simulation skills laboratory by installing overhead curtain rails and purchasing curtains for better division of the simulation stations when conducting simulated training sessions. More ultrasound machines could also aid in allowing students more practice time, using more of the simulation tools simultaneously if more machines were available.

It is important to keep records to maintain excellent stock control of all the accessories available in the skills lab such as ultrasound acoustic gel, paper towel, gloves, masks, sanitizer liquid, linen savers and clean linen, which is needed for each simulation session. In the skills laboratory a high level of care is practised, especially during the COVID-19 pandemic. All the physical distancing measures and mandatory mask-wearing, regular hand washing and sanitization are diligently enforced. A clinical skills lab register is available for mandatory completion by students having practical sessions, asking for all the necessary information of body temperature checks, close contact with any possible individual and screening for any

possible COVID-19 symptoms. These are important considerations as they instil good practices among students and help them when they are in the clinical environment.

Guideline 3.2: Development of a volunteer protocol for mock patient scanning

Another recommendation arising from this study is the development of a volunteer protocol for mock patient scanning. This protocol entails obtaining a volunteer "mock patient" for a simulated scanning session from the student peers. A volunteer mock patient is the closest sonography student trainees can come to replicating scanning a real patient's anatomy. A standardized indemnity form can be drawn up for all mock patients/student peers to complete, sign and date. This will confirm that they have consented to be a mock patient and allow a peer student to practise scanning on him/her. The clinical tutor or facilitator must ensure that the same student is not always the mock patient and alternate between the person scanning and the person being scanned.

Another recommendation is to allow peer students to pair up (two peer-sonography students) during simulated scanning sessions, especially for novice first-timers scanning on the simulators. Students generally feel more comfortable scanning a peer in the skills lab and they give each other valuable feedback to gain scanning confidence.

5. Recommendations

5.1 Future studies

- The researcher believes that for future studies, this study could be expanded to include a larger cohort, perhaps to include other local or international higher education institutions that also utilise tissue-equivalent phantoms for SBL.
- Benchmarking and greater collaboration, as previously mentioned, between tertiary institutions using simulation, could be a good future study. Such a study could be conducted to investigate any similarities or discrepancies, i.e., different types of simulators the various universities use, whether the simulators are low or high fidelity and if the sonography students' experiences using these simulators differ between institutions.
- A study involving the other three disciplines of radiography (Diagnostic radiography; Radiotherapy and Nuclear medicine technology) could broaden the data on the topic of SBL.

- Educators' perspectives on using SBL in the curriculum could be a good topic for a future study.
- Investigating if the data are different for other BSc year levels, i.e., BSc third year and fourth year, in sonography about SBL.

5.2 Radiography education

- Technology in radiography has rapidly grown over the past decades, including SBL (Hazell, 2020). Academic institutions should keep abreast of new technology that is available to improve academic practices, including simulation.
- Investment in more phantoms, both low and high-fidelity simulators, could greatly increase SBL use to better prepare novice students for the real clinical environment.
- Developing a skills lab that can mimic a real hospital setting, i.e., having an emergency unit, radiology unit and an in-patient and out-patient sonographic and x-ray service would be ideal for radiography education and universities' health faculties.

5.3 Clinical practice

- One recommendation is to obtain more HPCSA accredited sites and sonography staff that are available to assist students with WIL in the clinical setting in the government (public) and private practice sectors.
- Collaboration with other higher education institutions or clinical practices to share simulation resources that are available as our student numbers in sonography are relatively low compared to the other radiography disciplines.
- It is recommended that staff assisting with supervision of sonography students in the clinical practice, in government or in private practice, to be more open and knowledgeable of the advantages that SBL can offer students.
- Clinical sites should work more closely with the higher academic institutions to get familiarised with the SBL tools used and to better understand the sonography students rotating through the clinical departments, to see what is expected of the students.

5.4 Research in sonography

- According to the researcher's knowledge, this research study is the first SBL study done in SA that aimed to explore and describe the experiences of sonography students, although similar studies have been done abroad, specifically in sonography education. The researcher wants to encourage other sonography educators in SA to do more research on SBL.

- A comparative study of the different sonography educators' experiences of using SBL could be another study to conduct to enhance sonography research in SA.

5.5 Limitations of the study

- A major limitation of the study was that it was limited to a small cohort of sonography student participants from one of the three tertiary institutions in South Africa that offer sonography. It was also conducted in only one province, the Western Cape.
- The COVID-19 pandemic and lockdown regulations led to all the interviews taking place online instead of in person. Due to the reliance on a stable wireless network, one participant encountered challenges when conducting the interview. No other limitations or challenges were experienced during the research study.

6 Conclusion

Qualitative research enables researchers to conceptualize out of the box, broader thinking and to build onto the greater body of research knowledge through sophisticated, philosophical, and structured methodology and literature control. The aim of the study emanated from the researcher's problem statement and research question—why has there not been any research conducted on SBL in sonography education in South Africa thus far? The researcher was intrigued and motivated to pursue this further. One-on-one semi-structured individual online interviews were conducted with eight BSc second-year sonography students involved with SBL in their BSc first year of study. Three main themes emerged from the data using triangulation and an interpretivist approach.

All the participants felt that the experience using the simulator was an excellent introductory tool to learning sonography, however, there were also many limitations to the simulator that were identified. The participants were able to make numerous suggestions on how to improve the simulation experience and recommendations and guidelines were developed to enhance the clinical training experience with the use of the tissue-equivalent phantom simulator in the South African context. Each of the guidelines is aligned to the themes and categories that emerged from the data. It is recommended that these guidelines are considered for implementation as it is envisaged that they could enhance SBL in sonography education.

PERSONAL REFLECTION OF THE RESEARCH STUDY

This research journey has been one of the hardest and challenging experiences I have ever faced, working and studying part-time. There were many obstacles that I had to overcome to finish this dissertation. I would have given up if, it wasn't for my research supervisor that kept me going and that believed in me. She saw in me, what I couldn't see in myself many times during the writing up of the dissertation. Thank you, Kathleen. Without your guidance and motivation, I would not have made it this far. Thank you for pushing me hard to finish this dissertation. I apologise for the times I could not meet my research deadlines, but I want you to know that I have learned from my mistakes. Qualitative research is such a philosophical, dynamic, beautiful, expressive, broader-thinking and fulfilling research technique to use. I found that describing the sonography students' experiences and perceptions using simulation allowed me to learn how to write scientifically and how to follow a qualitative research methodology well. Finalizing the dissertation is a rewarding feeling. But at the same time "I bow down my head, I look to the ground, and I say, I am insignificant and nothing without the strength from above".

When you are anxious or worried, be patient. The key of patience opens the door of happiness. You suppose that you are the lock on the door, but you are the key that opens it.

Rumi

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APPENDICES

APPENDIX A: RESEARCH INFORMATION LETTER

DEPARTMENT OF MEDICAL IMAGING AND THERAPEUTIC SCIENCES

RESEARCH STUDY INFORMATION LETTER

My name is Geordean Schwartz**.** I would like to invite you to participate in a research study titled: **SONOGRAPHY STUDENTS' EXPERIENCES WITH SIMULATION-BASED LEARNING AS A FORM OF CLINICAL TEACHING AT A HIGHER ACADEMIC INSTITUTION.**

This study is part of a research project being completed as a requirement for a Masters in Science (MSc) Degree in Radiography through the Cape Peninsula University of Technology.

The aim of this qualitative research study is to explore and describe BSc second-year sonography students' experiences of using simulation as a form of clinical training at a higher academic institution in the Western Cape Province to develop guidelines to enhance clinical sonography training. Participation in the study is completely voluntary and will be open to all BSc second-year sonography students that completed simulation-based learning using the tissue equivalent phantoms. If you agree to take part in the study then you will be asked to sign a consent form.

You will be asked to share your experience using simulation-based learning using the tissue equivalent phantoms. This will be done in the form of a semi-structured interview in an office setting (face-to-face) or virtual with the use of Skype or WhatsApp video call platforms. The interview will be conducted be the researcher, thus you will feel comfortable to give your open and honest answers on the questions asked. The interview will be 30-40 minutes long and will be audio-taped which will allow ample time to accurately reflect on what was said during the interview. You will be requested to give permission for the audiotaping on a different consent form. In this research study, there will be no financial gain or direct benefit to you as the participant, however, it is anticipated that this study will benefit the clinical sonography training in the future. The researcher will reimburse the participants the cost of the data used for conducting the interview if it is conducted virtually.

If you decide to participate, you are free to withdraw your consent at any stage without giving a reason and without any consequences. If you wish to withdraw your consent, please inform me

as soon as possible. However, data collected until the time of withdrawal will be retained by the researcher since no names will be used during the interviews. Therefore, audio-taped data will remain anonymous and the researcher will be unable to identify the contribution made by the participant. The data will be destroyed 5 years after publication of the research.

There will be no incentives given for participation in the study**.** You will not be paid to participate in this study, and you will not bear any expenses.

There are no anticipated risks to participants involved in this study.

All data and back-ups thereof will be kept in password protected folders and/or locked away as applicable. Only myself or my research supervisors will be authorised to use your anonymised information in connection with this research study. Any other person wishing to work with your anonymised information as part of the research process (e.g., an independent data coder) will be required to sign a confidentiality agreement prior to being allowed to do so.

My contact details are:
Geordean Schwartz
Tel: 0725868358
Email: Geordean.schwartzgis@gmail.com

You may also contact my research supervisor:
Dr. K. Naidoo
Tel: 0219596538
Email: Naidooka@cput.ac.za

Co-Supervisor:
Ms. F. Isaacs
Tel: 021 9596538
Email:Isaacsf@cput.ac.za

If you feel that any questions or complaints regarding your participation in this study have not been dealt with adequately, you may contact the Chairperson of the Faculty of Health Sciences Research Ethics Committee at the CPUT:

Dr. Dirk Bester

Email: Besterd@cput.ac.za

Should you wish to have more specific information about this research project information, have any questions, concerns or complaints about this research study, its procedures, risks and benefits, you should communicate with me using any of the contact details given above.

Researcher:

Geordean Schwartz

APPENDIX B: CONSENT FORMS FOR PARTICIPATION IN THE RESEARCH STUDY

DEPARTMENT OF MEDICAL IMAGING AND THERAPEUTIC SCIENCES

CONSENT FORM

SONOGRAPHY STUDENTS' EXPERIENCES WITH SIMULATION-BASED LEARNING AS A FROM OF CLINICAL TEACHING AT A HIGHER ACADEMIC INSTITUTION.

Please initial each box below:

☐ I confirm that I have read and understand the information letter dated April 2020 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

☐ I understand that my participation is voluntary and that I am free to withdraw from this study at any time without giving any reason and without any consequences to me.

☐ I agree to take part in the above study

☐ I agree to take part face-to-face or virtually

_____	_____	_____
Name of Participant	Signature of Participant	Date

_____	_____	_____
Name of Researcher	Signature of Researcher	Date

APPENDIX C: CONSENT FOR AUDIO RECORDINGS.

DEPARTMENT OF MEDICAL IMAGING AND THERAPEUTIC SCIENCES

RESEARCH CONSENT FORM OR INTERVIEWS TO BE AUDIO-TAPED

SONOGRAPHY STUDENTS' EXPERIENCES WITH SIMULATION-BASED LEARNING AS A FROM OF CLINICAL TEACHING AT A HIGHER ACADEMIC INSTITUTION.

Please initial each box below:

☐ I hereby give consent for my interview, conducted as part of the above study, to be audio-taped.

☐ I understand that my personal details and identifying data will be changed in order to protect my identity. The audio tapes used for recording my interview will be destroyed five years after publication of the research.

☐ I have read this consent form and have been given the opportunity to ask questions.

_____	_____	_____
Name of Participant	Signature of Participant	Date
_____	_____	_____
Name of Researcher	Signature of Researcher	Date

APPENDIX D: MEMBER CHECKING OF THEMES AND CATEGORIES FROM PARTICIPANT INTERVIEWS

Cape Peninsula University of Technology

DEPARTMENT OF MEDICAL IMAGING AND THERAPEUTIC SCIENCES

SONOGRAPHY STUDENTS' EXPERIENCES WITH SIMULATION-BASED LEARNING AS A FROM OF CLINICAL TEACHING AT A HIGHER ACADEMIC INSTITUTION.

DESCRIPTION OF THEMES AND CATEGORIES:

Themes:	**Categories:**
1. Enhancing preparedness for the clinical environment	1.1. Phantom as an introductory tool 1.2. Improved scanning technique 1.3. Ability to recognize and identify anatomy and pathology 1.4. Ample practice time 1.5. Well-structured and aligned tutorials.
2. Limitations of tissue-equivalent phantom	2.1. Lack of realism 2.2. Inability to replicate sub-optimal conditions
3. Suggestions for the improvement of simulation learning	3.1. Creating an authentic clinical environment 3.2. Peer scanning

Please kindly sign below if you agree that the above themes and categories are representative of your views and opinions and that it is a true reflection and correct interpretation of your experiences the researcher obtained from the interview.

These themes and categories were discussed during a Microsoft (MS) teams meeting online as part of feedback and member checking to ensure creditability and validity of the information collected during the interviews.

		18 Feb 22022
Name of Participant	**Signature of Participant**	**Date**
		18 Feb 2022
Name of Researcher	**Signature of Researcher**	**Date**

APPENDIX E: CONSENT FOR AUDIO RECORDINGS AND TRANSCRIPTIONS- TRANSCRIBER

Consent for audio recordings and transcriptions- Transcriber.

CONFIDENTIALITY AGREEMENT – TRANSCRIBER

I, ELOISE RHODE hereby declare that I understand and agree to the following conditions with regards to the transcription of the audio recordings.

1. I understand that the audio recordings are received for the purpose of transcribing records of interviews held with the participants in a research study.
2. I undertake to treat all audio tapes received as confidential content to which only I will have access. I will keep the audio tapes and any copied material securely in a locked cupboard.
3. I will return all copies back to the researcher on completion of the transcription.

NAME: ELOISE RHODE

SIGNATURE: Rhode

DATE: 31.08.20

APPENDIX F: PERMISSION REQUEST LETTER TO HEAD OF DEPARTMENT (HOD) AT MEDICAL IMAGING AND THERAPEUTIC SCIENCES (MITS)

Cape Peninsula University of Technology

Mr. G. Schwartz
14 Mercurius street
Vredenburg
6380

Mr. A. Speelman
HOD: Medical Imaging and Therapeutic Sciences (MITS)
Faculty of Health and Wellness Sciences
Bellville
7530

17 July 2020

Dear Mr. Speelman

RE: PERMISSION TO CONDUCT A RESEARCH STUDY

I am post-graduate student at CPUT currently undertaking an MSc degree in Radiography: Ultrasound. I would like to conduct a qualitative research study to explore sonography students' experiences using simulation based learning within the context of South Africa. Sonography simulation is well established overseas in healthcare training facilities however, it is very new to South Africa. To the researchers knowledge no research in South Africa have been performed to explore sonography students' perceptions with the use of simulation based learning. The researcher anticipates that

this study may assist in the development of guidelines to enhance clinical sonography training. Literature illustrates that simulation as a form of clinical training, before interacting with real patients forms an integral component for sonography students to develop into skilled sonographers

The researcher wants to explore sonography students' experiences after they have interacted with simulation, using tissue equivalent phantoms. The researcher wants to conduct interviews (face-to-face or virtual) with the BSc 2nd year students, who have now been exposed to scanning real patients within the clinical departments. Data will be collected in phase 1 with the use of semi structured questions. The interview will be audio recorded and a thematical analysis will be followed to analyse the data. In phase 2 a description of guidelines to enhance simulation based clinical teaching and learning in sonography will be produced.

Participation in this research study is completely voluntary and informed consent will be obtained prior to conducting the study.

Your consideration regarding this research study is highly appreciated.
Thank you for your assistance in this regard.

Please contact me in case you require further details pertaining to my request
Yours sincerely,

Mr Geordean Schwartz
(Contact details: 072 586 8358)

Permission: Granted /Not granted

A. Speelman		20 July 2020
Name of HOD	**Signature of HOD**	**Date**

APPENDIX G: ETHICAL APPROVAL LETTER FROM UNIVERSITY HIGHER DEGREES COMMITTEE

Cape Peninsula University of Technology

HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE (HWS-REC)
Registration Number NHREC: REC- 230408-014

P.O. Box 1906 • Bellville 7535 South Africa
Symphony Road Bellville 7535
Tel: +27 21 959 6917
Email: simonsy@cput.ac.za

20 July 2020
REC Approval Reference No:
CPUT/HW-REC 2020/H10

Faculty of Health and Wellness Sciences

Dear Mr G Schwartz,

Re: APPLICATION TO THE HWS-REC FOR ETHICS CLEARANCE

Approval was granted by the Health and Wellness Sciences-REC to **Mr G Schwartz** for ethical clearance. This approval is for research activities related to research for **Mr G Schwartz** at Cape Peninsula University of Technology.

TITLE: **Sonography students' experiences with simulation-based learning as a form of clinical teaching at a higher academic institution**

Supervisor: Dr K Naidoo
Ms F Isaacs

Comment:

Approval will not extend beyond 21 July 2021. An extension should be applied for 6 weeks before this expiry date should data collection and use/analysis of data, information and/or samples for this study continue beyond this date.

The investigator(s) should understand the ethical conditions under which they are authorized to carry out this study and they should be compliant to these conditions. It is required that the investigator(s) complete an **annual progress report** that should be submitted to the HWS-REC in December of that particular year, for the HWS-REC to be kept informed of the progress and of any problems you may have encountered.

Kind Regards

M. le Roes-Hill

Dr Marilize Le Roes-Hill
Acting Chairperson – Research Ethics Committee
Faculty of Health and Wellness Sciences

APPENDIX H: EXAMPLE OF AN ABDOMINAL AND OBSTETRIC PHANTOM ASSESSMENT RUBRIC

Abdominal Ultrasound Phantom Clinical Assessment Rubric

Subject: _____ Date: _____

Subject code: _____

Student Name: _____ Mark: _____ %

APPENDIX H continued

1.3 Gallbladder					
	Good (3)	Good (3)	**Fair** (2) (2)	**Poor** (1) (1)	Critical error/ **Not done (0 or fail)**
1. Scanning technique					
1.3.1. Complete gallbladder in longitudinal and transverse planes within the allotted time (25 minutes = scanning time)		Good (3)	Fair (2)	Poor (1)	Critical error/ Not done (0 or fail)
1.3.2. Measure the length, width and anterior-posterior diameter					
1.3.3. Measure the gallbladder wall					
1.1.1. Scan the AO and IVC in longitudinal and transverse planes				**Sub-total**	**/6**
1.1.4. Scan and measure the common bile duct (CBD)					
1.1.3. Measure the diameter of the AO and IVC					
1.1.5. Assess gallbladder and CBD with colour Doppler					
1.1.4. Identify all the AO branches: Celiac artery, SMA and renal arteries					
1.1.6. Label all the anatomical structures correctly on the ultrasound image					
1.1.5. Assess with Colour and spectral Doppler: AO (Prox, Mid, distal) and IVC					
1.1. Aorta and IVC				**Sub-total**	**/18**
1.1.6. Label all the anatomical structures correctly on the ultrasound image					
1.2. Liver				18	
1.3. Gallbladder				**Sub-total**	**/18**
1.4. Right kidney				18	
1.4. Right kidney				12	
1.4.1. Scan the right kidney in longitudinal and transverse planes				12	
1.5. Left kidney					
1.4.2. Measure the right kidney in longitudinal and transverse planes				15	
1.2.1. Scan the left lobe of liver longitudinal and transverse planes				15	
1.6. Spleen					
1.7. Pancreas					
1.4.3. Assess kidney with colour Doppler					
1.2.2. Scan the right lobe of liver in longitudinal and transverse planes					
1.4.4. Label all the anatomical structures correctly on the ultrasound image					
2. Equipment				9	
1.2.3. Measure the right lobe of liver in longitudinal				**Sub-total**	**/12**
1.2.4. Compare the echogenicity of the liver to that of the right kidney cortex				6	
Total				**123**	**/123**
1.2.5. Scan the hepatic veins with grey-scale and colour Doppler					
1.5. Left kidney					

Comment:

Marks

Technique

Comment:

Comment:

Comment:

Comment:

1.5.1. Scan the left kidney in longitudinal and transverse planes				%
Comment:				
1.5.2. Measure the left kidney in longitudinal and transverse planes			**Sub-total**	**/18**
Comment:				
1.5.3. Assess kidney with colour Doppler				
1.5.4. Label all the anatomical structures correctly on the ultrasound image				
			Sub-total	**/12**
Comment:				
1.6. Spleen	Good (3)	Fair (2)	Poor (1)	Critical error/ Not done (0 or fail)
1.6.1. Scan the spleen in longitudinal and transverse planes				
1.6.2. Measure spleen in longitudinal plane				
1.6.3. Assess spleen with linear probe				
1.6.4. Assess spleen with colour Doppler				
1.6.5. Label all the anatomical structures correctly on the ultrasound image				
			Sub-total	**/15**
Comment:				
1.7. Pancreas				
1.7.1. Scan the head, neck, body and tail of pancreas				
1.7.2. Measure the head, neck, body and tail of pancreas				

Examiner name

Examiner signature

Date

Moderator name

Moderator signature

Date

1.7.3. Identify the splenic vein, SMA, portal splenic confluence, AO & IVC				
1.7.4. Label all the anatomical structures correctly on the ultrasound image				
1.7.5. Compare pancreas and left lobe of liver echogenicity				
			Sub-total	**/15**
Comment:				
2. Equipment				
2.1. Adjust instrument settings appropriately. TGC, focal zone, frequency, gain setting				
2.2. Handle the transducers correctly and with ease				
2.3. Make good use of ultrasound machine				
			Sub-total	**/9**
Comment:				

Obstetric Ultrasound Phantom Clinical Assessment Rubric

Subject: _____ **Date:** _____

Subject code: _____

Student Name: _____ **Mark:** _____**%**

8. Fetal biometry report:

Obstetric phantom clinical assessment	Good (3)	Fair (2)	Poor (1)	Critical error/ Not done (0 or fail)
1. Preparation of the workstation	Good (3)	Fair (2)	Poor (1)	Critical error/ Not done (0 or fail)
1.1. Complete the examination timeously (35 minutes)	Good (3)	Fair (2)	Poor (1)	Critical error/ Not done (0 or fail)
1.2. Ensure paper towel, probe disinfected, and ultrasound gel are readily available				
1.3. Ensure equipment and accessories are clean			**Sub-total**	**/12**
1.4. Ensure good ergonomic are applied			**Sub-total**	**/3**
Comment:				
Comment:				
2. Instrument settings				
2.1. Select new patient and insert correct patient information: Name, Surname, DOB, LNMP			**Sub-total**	**/6**
Comment:				
2.2. Select the OBS preset				
Comment:				
2.3. Set TGC appropriately				
Check list:				
2.4. Set frequency selection appropriately				
Marks	Yes	No		
2.5. Set focal zone			0	
1: Preparation of the workstation			**Sub-total**	**/15**
2. Instrument settings			**Sub-total**	**/15**
Comment:			15	
Comment:				
3. Technique			24	
6. Equipment				
4: Fetal biometry			12	
3. Technique				
3.1. Comfortable maneuvering the probe				
5: Fetal anatomy			15	
3.1. Identify an Intra/extra-uterine pregnancy *				
3.2. Make good use the ultrasound machine				
6: Equipment			6	
3.2. Number of fetuses*				

Gestation (US)				
4.1. BPD				
Gestation (LMNP)				
4.2. HC				
5 minutes – preparation				
20 minutes – scan				
5 minutes – aftercare				
4.3. BPD				
4.4. FL				
5 minutes - report writing				
HC				
AC				
FL				

5. Fetal anatomy

Comment:				
9. Reporting				
5.1. Transcranial anatomy at level of the BPD				
9.1. Correct information reported				
5.2. Umbilical cord insertion				
9.2. Technical report succinct and scientific				
5.3. umbilical 3 vessel cord				
			Sub-total	**/6**
Comment:				
5.4. Fetal bladder				
Comment:				
5.5. Stomach bubble				
Check list:				
5.6. Fetal genitalia (not obligatory and does not count marks)				
IUP			**Sub-total**	**/15**
Singleton			15	
Heart 4 Chamber (left)			24	
Stomach seen			12	
3 vessel umbilical cord			15	
Bladder			6	

2.3. Tidy workstation 2.4. Clean and tidy workstation				Sub-total	/6
3.6. Fetal location *				3	
3.5. Amniotic fluid index (AFI) *				6	
3.1. Clean and tidy workstation 3.6. Fetal heart on left *				99	/99
3.1. Clean and tidy workstation 3.7. fetal stomach on left					%
2.2. Tidy workstation 3.8. Fetal scanning sequence					
7.3. Tidy up dirty bedding *Critical error if missed (fail the assessment)					
Examiner name:				Sub-total Sub-total	/9 /24
Examiner signature: Comment:					
Date:					
Moderator name					
Moderator signature					

APPENDIX I: REFLEXIVE JOURNAL AND FIELD NOTES:

Researcher reflective journal and field notes

Interview timetable:

There were 9 BSc second-year students, 8 chose to participate in the study and 1 declined.

PARTICIPANT 1

Interview setting:

The interview was conducted virtually via WhatsApp video call made from Bloemfontein and the participant was at home in Hartenbos, Western Cape, during the level 3 COVID-19 lock down period. The participant was seated in quiet room with no external noise. The interviewer made sure that his room was free from any disturbances or external noise by closing the door.

The internet connections were weak at times, but generally the interview went well without any network interruptions. The interviewer shared the semi-structed questions via email with the participant an hour prior to the interview started to get familiarized with the questions that will be asked on the experiences using the ultrasound tissue equivalent phantom simulators. This allowed the participant to be feel more relaxed and at ease when the interview started.

Student:	**Date:**	**Time:**	**Venue: Virtual**
Participant 1	Wed 29/7	13h00-13h45	WhatsApp video call
Participant 2	Wed 29/7	14h00-14h45	WhatsApp video call
Participant 3	Thurs 30/7	11h00-11h45	WhatsApp video call
Participant 4	Thurs 30/7	13h00-13h45	WhatsApp video call
Participant 5	Thurs 30/7	15h00-15h45	WhatsApp video call
Participant 6	Fri 31/7	11h00-11h45	WhatsApp video call
Participant 7	Fri 31/7	16h30-17h15	WhatsApp video call
Participant 8	Thurs 10/9	10h00-10h40	WhatsApp video call

Observational notes:

The participant was very relaxed, friendly, and excited to participate. I felt very nervous for my first interview. I had to clear my throat a few times and drank water for the nervous, but the butterflies soon dissipated as the interview went on. The participant gave very interesting and helpful comments on her experiences using the simulation and shared it openly. After the interview we chatted about the difficulties regarding COVID-19 and how it affected us all.

Methodologic notes:

The interviewer aimed to explore and describe the experiences of the participant to get the correct understanding using an interpretivist approach. I tried to be mindful my own “bias” or “preconceived ideas” regarding simulation to stay objective and to let the participant share the experiences authentically. Where there were yes or no answers, I tried probing questions to get a better understanding of the participants’ experience or to elaborate on the specific question that was asked. I was very surprised when the negative aspects of the simulation experiences with phantoms surfaced, because I my mind I only saw the benefits, however the participant taught me that this was not the case.

Theoretical notes:

The participant emphasized the following experiences during the interview:

- Simulation was an exciting new experience
- Good basis prior to scanning patients
- Phantom lacked realism like breathing and bowel gas

- Improved scanning technique
- Built confidence and getting comfortable scanning
- Assisted to help learn about patient care

PARTICIPANT 2

Interview setting:

The interview was conducted virtually via WhatsApp video call for Bloemfontein where the interviewer was based during COVID-19 lockdown and the interview session was audio recorded. The participant was seated in the IT center at CPUT Bellville Campus, Cape town with headphones on to minimize any external noise. The internet connection was problematic and caused interruptions. The interview was paused at times and continued when the connection was better on the participants side thus this interview took longer than first participants' interview. The interviewer also shared the semi-structed questions via email with the participant an hour prior to the interview started to be familiarized with the questions that will be asked on the experiences using the ultrasound tissue equivalent phantom simulators.

Observational notes:

The participant was a little bit stressed and nervous due to network problems that was experienced. I tried to calm the participant down by asking that he take a deep breath and relax at times. The participant mentioned good and helpful comments on his experiences using the simulator. After the interview we chatted about the difficulties regarding COVID-19 and how it affected us. The participant was stuck in Cape town in the lockdown at campus and have not been home in a few months. He also talked about missing the campus-based teaching because the university adopted online teaching and learning. The participant was very worried about clinical hours that was missed due to COVID-19.

Methodologic notes:

The interviewer aimed to explore and describe the experiences of the participant to get the correct understanding using an interpretivist approach. I tried to be mindful my own "bias" or "preconceived ideas" regarding simulation to stay objective and to let the participant share the experiences authentically. Where there were yes or no answers, I tried probing questions to get a better understanding of the participants' experience or to elaborate on the specific question that was asked. I was very surprised when the negative aspects of the simulation experiences with phantoms surfaced, because I my mind I only saw the benefits, however the participant taught me that this was not the case.

Theoretical notes:

The participant emphasized the following experiences during the interview:

- Simulation was good for basic anatomy
- Relaxed environment
- Simulation helps to recognizing errors or mistakes and can be corrected
- Phantom lacked different pathologies
- Increase confidence because of there is less pressure scanning phantom compared to scanning real patients

APPENDIX J: VERBATIM TRANSCRIPTION EXAMPLES

PARTICIPANT 5:
Virtual Interview – Thursday, 30th July 2020 - 13h00am

Interviewer: Okay, so the first question is, when we first started scanning the phantoms, during the clinical tutorials and demonstrations, what was that experience like for you? In a nutshell how was it for you?

Participant 5: I went into the ultrasound course with no ultrasound experience and very nervous. I didn't know that CPUT had phantoms so when we started scanning the phantoms, I enjoyed it a lot. And I was very impressed that we were able to scan a basic obstetric scan and an abdomen within a few days of starting. So I liked it. It was very helpful.

Interviewer: Okay, so you enjoyed that experience, right?

Participant 5: Ja I did.

Interviewer: And it was helpful and you learned a lot during that time?

Participant 5: I did, ja.

Interviewer: Okay, so the next question. Now you are starting...you've scanned real patients, right? So, do you think that the phantom experience really had an impact on your learning?

Participant 5: It did. Mostly technique and machine wise. Not so much anatomy and pathology. Because when you go to the department, scanning a real patient it's so much different, it's actually a shock for that first few days when you have to scan the patient like I felt like I won't be able to do this and then later on you get used to it because you just need practice. But it definitely helps with operating the machine, getting confident because now you're already struggling with the patient, you can't still struggle with the machine as well. So it helped in that aspect. And like measurements, the theory, practising that on the phantom helped a lot. You don't need to go learn that in the department when you get there because you already learned it on the phantom. Ja.

Interviewer: Would you say the realism of the phantom compared to a real patient, how did you find that?

Participant 5: Maybe there are easy patients, I haven't had easy patients like the phantom prior to. My patients were all difficult, so the realism wasn't that good. I struggled a lot,

especially with like the pancreas and just, ja. Struggled a lot in the department with 3 occasions. Slowly getting there.

Interviewer: Great stuff. Okay so, Participant 5, did the simulator in any way improve specific learning areas for you? Say for instance the scanning technique?

Participant 5: Ja definitely. Scanning technique, definitely. How to manipulate the transducer, the machine, how to adjust the settings on there, ja.

Interviewer: And in terms of your hand and eye coordination? How to find certain like anatomy and certain organs? Was it of help?

Participant 5: It was of help like where to find it but visualizing it is a different thing it on a real patient. Because each patient is different and there's bowel shadowing and there's a pumping heart so the location of the anatomy helped with the phantom but not the actual anatomy, what it looks like.

Interviewer: And in terms of pathology? Would you say it helped you or improved your learning areas, comparing the phantoms anatomy to that of pathology?

Participant 5: We only getting to pathology now later on in the year. We never focused on pathology earlier on so we were just basically focusing on anatomy, where to find it and the normal appearance so we weren't really focused on pathology that much. So I wouldn't be able to comment on that. Ja.

PARTICIPANT 6:
Virtual Interview – Friday, 31st July 2020 - 11h00am

Interviewer: So, the first question. If you take a glimpse back prior to COVID-19 when we did the ultrasound clinical demonstrations in the skills lab using the phantoms, what was your overall experience like using clinical training with the phantoms? What was it like for you?

Participant 6: I was more comfortable doing my first training on the phantoms than on a real patient. Because I feel like the patients will judge you if you know absolutely nothing about ultrasound.

Interviewer: And if you say you felt more comfortable, can you explain a little bit more regarding the phantom?

Participant 6: It gave me a chance to practise my ultrasound technique, as well as to see how all the organs look on ultrasound.

Interviewer: Okay perfect. Now that you are scanning real patients, do you feel that the phantom or the simulator had any impact on your learning?

Participant 6: Yes, it did, sir.

Interviewer: And if you...

Participant 6: It allowed me to practise my ultrasound technique and scanning when it comes to a real patient. I also learned how the organs look and the appearance of how they must look on ultrasound.

Interviewer: And can you give me a few examples maybe, in the clinical department?

Participant 6: It helps you to scan organs, the correct planes, how to measure organs, like the liver, how to measure it in the right lobe of liver.

Interviewer: Okay perfect. And in terms of obstetrics, did it also help you a bit?

Participant 6: Yes it did, sir. It was just a bit difficult when it came to the real patient since the baby is moving.

Interviewer: In comparison to the phantom?

Participant 6: Yes, sir.

Interviewer: Okay. Question 4. Did the simulator or phantom in any way improve specific learning areas for you such as the scanning technique? Some of the questions does overlap a bit so ja you can answer them or you can say you've already answered them. Okay, so in terms of the simulator, did it improve your learning areas such as the scanning technique for you?

Participant 6: Yes sir, it did. It helped me a lot when it came to the real patients.

Interviewer: Okay. And when you say a real patient, was the realism, if you compare the phantom to a real patient, was there similarities or how do you feel, how was the transition?

Participant 6: It was more or less the same except for the abdomen phantom which had a few lesions. And it also didn't have blood flow or breathing or any bowel gas but a real patient does have.

Interviewer: Okay and in terms of the phantom improving learning areas such as your hand and eye coordination? Did the phantom assist you in that?

Participant 6: Yes it did, sir. I don't have to look where I'm scanning at this stage, I can just look at the screen and with my hand I'll know what I'm scanning.

APPENDIX K: LETTER FROM GRAMMARIAN

22 Krag Street
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30 August 2022

LANGUAGE & TECHNICAL EDITING

Cheryl M. Thomson

SONOGRAPHY STUDENTS' EXPERIENCES WITH SIMULATION-BASED LEARNING AS A FORM OF CLINICAL TEACHING AT A HIGHER ACADEMIC INSTITUTION

Supervisor: Dr K. Naidoo

Co-supervisor: Ms F. Isaacs

This is to confirm that I, Cheryl Thomson, executed the language and technical edit of the above-titled Master's dissertation of **GEORDEAN SCHWARTZ - Student number 205077099** at the CAPE PENINSULA UNIVERSITY OF TECHNOLOGY in preparation for submission of this dissertation for assessment.

Yours faithfully

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