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POINT OF CARE ULTRASOUND: DISTANCE EDUCATION FOR POCKET ULTRASOUND DEVICES

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DENISE MARCELLE MACIVER

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The future of learning.

Approval of Dissertation

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POINT OF CARE ULTRASOUND: DISTANCE EDUCATION FOR POCKET ULTRASOUND DEVICES

Submitted by:

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In partial fulfillment of the requirements for the degree of

Doctor of Education in Distance Education

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Dedication

In my doctoral journey of six plus years my family has given unconditional support and I dedicate this dissertation to them with all my heart. I thank my husband, Roderick Neil MacIver and our three children from youngest to eldest: Cole Roland MacIver, Keir Norman MacIver, and Lena Michele MacIver, who watched and listened and kept me going.

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If my parents were still alive, they would have cheered me on with all the same enthusiasm they bestowed upon myself and my four sisters throughout our education, always encouraging lifelong learning no matter what age. I dedicate this work to my late parents: Bertha Mary Jane Dandurand Bourgeois and Roland Aristide Bourgeois. Our family love of learning is also shared by my sisters: Monique, Michele (Mimi), Elaine (Bunny), and Lorraine, who have always been interested in my work no matter what the topic, and I thank them for their support.

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Abstract

This interpretive case study, framed in mixed methods inquiry, explored the effectiveness of distance education methodologies for hands-on practical skills training in the use of pocket ultrasound devices (PUDs) in a simulated point-of-care ultrasound (POCUS) environment. Research participants who met pre-specified inclusion criteria (non-probability purposive sampling) were recruited from the School of Health and Life Sciences at the Northern Alberta Institute of Technology (NAIT), a sample representing faculty from the allied health sector. Participants included twenty ultrasound naïve learners from different professions spanning eight allied health disciplines, and two instructors from the diagnostic medical sonography profession (ultrasound). Instructional activities were created to encompass e-learning outcomes in knowledge and PUD skill acquisition in thoracic, cardiac, abdominal, and pelvic ultrasound (sonographic) imaging, according to the Extended Focused Assessment with Sonography for Trauma (EFAST) protocol, including relevant professional behaviors. Over a training period of four to six calendar weeks, learner participants accessed instructor-facilitated, asynchronous theory learning in a learning management system (Moodle). The theory component was followed by three one-hour sessions of synchronous practical skills training in EFAST with live models: learners were remotely connected to an instructor participant, one-on-one in real-time, utilizing the Philips Lumify PUD integrated with the Remote Education, Augmented Communication, Training and Supervision (REACTS®) distance education (DE) tele-ultrasound platform. In addition, learner participants were engaged in pre, mid, and end-study online questionnaires, and instructor participants completed electronic field notes. Learning outcomes were assessed with three consecutive objective structured competency-based examinations (OSCEs) in face-to-face EFAST simulated environments, over a one-hour testing time frame, with ultrasound models behaving as standardized patients, and one assessor assigned per OSCE station. Study results indicate a successful training intervention for learners (sixteen of twenty) and instructor participants and provide educational contributions towards an emerging body of knowledge on POCUS DE approaches, techniques, and tools. Recommendations from research findings inform standardization and consistency of DE POCUS training for medical educational communities, including allied health personnel who use PUDs (or other portable ultrasound devices) in their POCUS scopes of practice.

Keywords: Point of Care Ultrasound (POCUS), Pocket Ultrasound Device (PUD), Remote Hands-on Learning, Extended Focused Assessment with Sonography for Trauma (EFAST), Remote Education, Augmented Communication, Training and Supervision (REACTS®), Philips Lumify, Objective Structured Competency Examination (OSCE), ultrasound naïve, virtual learning, Interpretive Case Study, Mixed Methods Research, New World Kirkpatrick Model, Learning Domains

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List of Nomenclature and Acronyms

allied health professionals: These fields encompass all professions in healthcare except for medicine and nursing (Canadian Association of Allied Health Programs, https://caahp-acpts.ca).

artifact: In ultrasound imaging, echoes are received from human tissue and organs. Some echoes are false and do not accurately represent the regions being displayed. These false echoes, called artifacts, occur because of the limitations of sound propagation physics when inappropriate control settings (instrumentation) are used in the acquisition of images; sometimes they are unavoidable. An understanding of the appearances of artifacts is essential to the proper interpretation of ultrasound images (differentiating real from false) to maximize the available information and to avoid diagnostic errors (Sanders & Winter, 2007, p. 628).

beam: Directed acoustic field produced by a transducer (Sanders & Winter, 2007, p.1).

body habitus: The shape of a person's body, in reference to where body organs lie or reside within the body. For example, in a short wide-chested person the heart may inhabit or lie higher up in the chest whereas the heart of a tall, lean person will almost lie vertically and low in the chest (Sanders & Winter, 2007).

cardiologist: A physician skilled in the diagnosis and treatment of heart disease (Miller & Keane, 2003).

comprehensive ultrasound: This term is not usually associated with POCUS where studies are short and targeted on a single organ or region. A comprehensive ultrasound study is performed when an entire body region is scanned and imaged. For example, comprehensive cardiac sonography would examine the entire heart and its major blood vessels; comprehensive abdominal sonography would image all abdominal and pelvic organs (Dietrich et al., 2017).

clinical: Pertaining to the clinic or to the bedside; pertaining to or founded on the actual observation and treatment of patients, as distinguished from theoretical or experimental (Miller & Keane, 2003, p.225).

clinician: An expert clinical physician and teacher (Miller& Keane, 2003).

crystal: Substance within the transducer that converts electrical impulses into sound waves and vice versa (Sanders & Winter, 2007, p.1).

debriefing: As included in the Healthcare Simulation Dictionary of the Society for Simulation in Healthcare, https://doi.org/10.23970/simulationv2, (Lioce et al. (Eds.), 2020): A formal, collaborative, reflective process within the simulation learning activity; an activity that follows a simulation experience and led by a facilitator where educators/instructors/facilitators and learners re-examine the simulation experience for the purpose of moving toward assimilation and accommodation of learning to future situations (Johnson-Russell & Bailey, 2010; National League for Nursing - Simulation Innovation Resource Center, 2020). Debriefing should foster the development of clinical judgment and critical thinking skills (Johnson-Russell & Bailey, 2010). Following a simulated learning experience, students are guided to reflect on their experience which extends their learning, considered to be as important to attain the learning outcomes as the simulation event itself (Mason Barber & Schuessler, 2018). **(see simulation, simulation in teaching and learning)**

diagnostic images: Images produced with X-ray, MRI, CT, or Ultrasound energies (radiation) whereby a medical diagnosis can be made. The quality of the image depends on the knowledge, skill, and experience of the 'imager'– the professional trained in image acquisition. A lack of technical quality may produce a 'non-diagnostic image', that is, an image that is of poor quality (Sanders & Winter, 2007). To note: MRI and Ultrasound energies are 'non-ionizing' radiation and considered relatively safe compared to X-rays and CTs (Kaproth-Joslin et al., 2015).

diagnostic medical sonographer (DMS): Professionally trained to acquire ultrasound images (sonography) for medical diagnosis, aka diagnostic medical ultrasonography (Sanders & Winter, 2007).

distance simulation: As included in the Healthcare Simulation Dictionary of the Society for Simulation in Healthcare, https://doi.org/10.23970/simulationv2, (Lioce et al. (Eds.), 2020): Implementing a simulation or training at a physical distance from the participant(s) (LeFlore et al., 2014; von Lubitz et al., 2003). **(see REACTS®; remote simulation; telepresence; telesimulation)**

echocardiogram: Term which applies to an ultrasound (sonogram) of the heart (Sanders & Winter, 2007, p.534).

e-Learning: the process of providing courses on the internet or an intranet (Cambridge University Press, https://dictionary.cambridge.org/dictionary/english/e-learning).

extended focused assessment with sonography for trauma (EFAST): A targeted POCUS protocol for acute emergency situations which examines the thorax, heart, abdomen, and pelvis for evidence of trauma (Giraldo-Restrepo & Serna-Jimenez, 2015; Montoya et al., 2016). **(see point of care ultrasound)**

eye-hand coordination (aka hand-eye coordination): Eye-hand coordination is the ability to identify objects by sight and touch, and to grasp, push, pull, or direct their movement with the hand. It is the coordinated control of eye movement with hand movement, and the processing of visual input to guide reaching and grasping along with the use of proprioception of the hands to guide the eyes (Medical-Dictionary.thefreedictionary.com, https://medicaldictionary.thefreedictionary.com/eye-hand+coordination).

hand-eye coordination (aka eye-hand coordination): Hand-eye coordination is the ability of the vision system to coordinate the information received through the eyes to control, guide, and direct the hands in the accomplishment of a given task, such as handwriting or catching a ball. (Medical-Dictionary.thefreedictionary.com, https://medicaldictionary.thefreedictionary.com/eye-hand+coordination).

hand-held ultrasound: The ultrasound scanner/device is small enough to fit in a human hand (Kaproth-Joslin et al., 2015).

manikin (aka mannequin, task trainer): A life-sized human like simulator representing a patient for healthcare simulation and education (Palaganus et al., 2015, https://www.ssih.org/SSH-Resources/Publications/Defining-Excellence). **(see phantoms)**

medical ultrasound: Application of ultrasonic waves to human tissue which manifests in the form of ultrasonic images (sonograms) for medical diagnosis and treatment purposes (Kaproth-Joslin et al., 2015).

non-technical skills: As included in the Healthcare Simulation Dictionary of the Society for Simulation in Healthcare, https://doi.org/10.23970/simulationv2, (Lioce et al. (Eds.), 2020): Skills of communication, leadership, teamwork, situational awareness, decision-making, resource management, safe practice, adverse event minimization/mitigation, and professionalism; also known as behavioral skills or teamwork skills, and informally referred to as **'soft skills'.**

objective structured competency (clinical) examination (OSCE): The objective structured clinical examination (OSCE) is a form of assessment of learning outcomes. In the OSCE format different clinical situations are presented using different evaluation elements where the student interacts with a standardized patient to test integration of technical and communication skills (Harden et al., 1975).

The OSCE is a form of practical examination consisting of multiple stations of testing. Each station evaluates a different competency/clinical skill in a simulated clinical situation where the student interacts with a standardized patient (actor with a script). OSCEs are typically used to evaluate the synthesis of cognitive, psychomotor, and affective skills, for example the application of knowledge together with technical competency and the integration of communication skills (Lang et al., 2004; Rushforth, 2007). **(see standardized patients)**

operator dependent imaging: All ultrasound examinations depend on the operator for the acquisition of images. This is a key point in the educational and training strategies for ultrasound imaging (Sanders & Winter, 2007).

operator dependent POCUS: In POCUS environments quality diagnostic images are dependent on the operator's training and skill. POCUS imaging provides medical findings that are immediately interpreted by the operator/person performing the ultrasound study instead of a third party assessing the images after the study is completed (Moore & Copel, 2011).

operator dependent scanning: Refers to the dependency of the operator's skill in ultrasound image acquisition – aka "scanning". This skill is complex, related to knowing how and where to scan the human body to answer the clinical question or problem. As each patient presents with different locations, sizes, and shapes of anatomical structures (see body habitus), the operator must continually adapt his/her skill to optimally produce the required images for diagnosis and treatment. The operator may be an ultrasound technologist (diagnostic medical sonographer) and/or a physician or other allied health practitioner (Moore & Copel, 2011).

phantom: In the ultrasound industry tissue-equivalent phantoms are available on which students can practice their ultrasound scanning skills (the pelvis, the heart, the abdomen, etc.). Phantoms are commonly used as an alternative to students scanning each other, recruited volunteers, or human models hired for scanning practice. Phantoms are used to 'simulate' the real thing (Sanders & Winter, 2007). **(see simulation for teaching and learning)**

pocket ultrasound device (PUD): Term used when the ultrasound scanner/device is small enough to fit in an average-sized pocket, also called a hand-held ultrasound device (Kaproth- Joslin et al., 2015).

point of care ultrasound (POCUS): Definitions are diverse; however, they all share certain fundamental elements:

- Ultrasound performed by the clinician (a physician or a resident) or the allied health practitioner (a paramedic, a first responder) providing direct care to the patient (Dietrich et al., 2017).

- Ultrasound which is portable and brought to the patient's bedside at the first point of patient care wherever that patient is located (versus the patient having to travel to a dedicated ultrasound department); the 'bedside' may be theoretical, for example, an ultrasound device could be brought to the battlefield, or operating room, even in space (Moore & Copel 2011).

point of care ultrasound (POCUS) terminology: The list below reflects the most common POCUS terms which are often interchangeable:

- **bedside ultrasound**: Ultrasound that is performed literally at the patient's bedside in the hospital or emergency department, or theoretically in any location where the patient is physically present, in traditional and non-traditional locations (Jones et al., 2009).

- **focused ultrasound**: Term used when the ultrasound examination is limited or focused on one or two parts of the body, i.e. the examination is not comprehensive in examining several parts of the body. For examples: only the liver and gallbladder are examined versus the all the abdominal organs; one heart valve versus all four heart valves and four chambers, etc. (Bobbia et al., 2015). Targeted is another term for focused.

- **targeted:** This term is synonymous term with 'focused' where an area of the body is targeted depending on the clinical question and the patient's symptoms. Examples include the following: focused assessment with sonography for trauma (FAST) (Steinmetz et al., 2016) and cardiac limited ultrasound exam (CLUE) (Mai et al., 2013).

- **mobile:** Term used when the ultrasound examination can be performed in most settings because the ultrasound scanner is portable (Dietrich et al., 2017).

- **clinician- or physician-performed ultrasound**: Term to distinguish when the ultrasound examination is performed by the person who has direct care responsibilities for the patient versus another technologist or practitioner being called to perform the examination on behalf of the primary clinician. To Note: This aspect of POCUS has the most impact on training strategies due to the operator-dependent nature of ultrasonography in general (Choo, et al., 2017). **(see clinical, clinician, and operator dependent scanning)**

portable ultrasound: Ultrasound scanners that can be operated on battery power. They range in size from hand-held to small wheeled carts. They enable an ultrasound scanner to be brought to the patient's bedside versus a patient having to travel to a dedicated ultrasound department.
Portable scanners are used for point of care ultrasound (Dietrich, et al., p. 49).

radiologist: A physician specializing in radiology (Miller & Keane, 2003). As an example, a radiologist is specially trained to read diagnostic images produced by x-rays, nuclear medicine, magnetic resonance imaging (MRI), computerized tomography (CT) and ultrasound.

REACTS®: (Remote Education, Augmented Communication, Training Supervision) is a secure, integrated, collaborative platform with unique and unparalleled interactive tools designed to suit the multiple collaborative needs of healthcare professionals and patients. It incorporates innovative tools like augmented reality for remote virtual guidance, supervision, and training. It is used in over 80 countries and has been deployed across various disciplines in both clinical and educational settings (Innovation Technologies, https://reacts.com). **(see distance simulation; remote simulation; telepresence; tele-simulation)**

real time scanning: A rapid series of images produced sequentially providing a cinematic (or motion picture) view of the area being investigated with ultrasound (Sanders & Winter, 2007, p.8). **(see static scanning)**

remote simulation: As included in the Healthcare Simulation Dictionary for the Society for Simulation in Healthcare, https://doi.org/10.23970/simulationv2, (Lioce et al. (Eds.), 2020): Simulation performed with either the facilitator, learners, or both in an offsite location separate from other members to complete educational or assessment activities (Burckett-St. Laurent, Niazi, Cunningham, et al., 2014; Shao et al., 2018). Facilitation and assessment can be performed either synchronously or asynchronously using video or web conferencing tools. **(see distance simulation; REACTS®; telepresence; telesimulation)**

resolution: Ability to distinguish between two adjacent interfaces or structures (Sanders & Winter, 2007, p.1).

scanning: The art of performing sweeps through the body and/or area of interest with a transducer to record the resulting ultrasound images (Sanders & Winter, 2007).

scan plane: The plane in which the ultrasound beam sweeps (Sanders & Winter, 2007, p.628).

simulation: According to the 2014 study sponsored by the National Council of State Boards of Nursing, simulation is defined as: an activity or event replicating clinical practice using scenarios, high-fidelity mannequins, medium-fidelity mannequins, standardized patients, roleplaying, skills stations, and computer-based critical thinking simulations. In the ultrasound industry the term 'phantom' is used to describe the instrument, prop, or tool used to simulate ultrasound scanning, or, ultrasound training will employ standardized patients for simulation in teaching and learning (Hayden et al., 2014). (**see phantom; standardized patients; simulated/synthetic learning methods; simulation in teaching and learning)**

simulated/synthetic learning methods: As included in the Healthcare Simulation Dictionary for the Society for Simulation in Healthcare, https://doi.org/10.23970/simulationv2, (Lioce et al. (Eds.), 2020): The principles, pedagogies, and educational strategies used in health care simulation which includes the strategy of ***simulation / scenario-based learning*** where *l*earners interact with people, simulators, computers, or task trainers to accomplish learning goals that are representative of the learner's real-world responsibilities. The environment may resemble the workplace. Depending on the learning objectives, realism can be built into the equipment or the environment. (**see simulation in teaching and learning**)

simulation in teaching and learning: Simulation is a pedagogical tool and approach to instruction. Simulation is used in the integrated skills that consist of multiple judgments, decisions, and actions that take place in a fluid sequence in response to changing circumstances with the ability to adapt practice to a momentary problem-solving need (Gibbons et al., 2009, p.172). Debriefing after the simulated event is an important component of simulation. **(see debriefing)**

soft skills: An informal term sometimes used to denote the non-technical skills of performance, e.g. effective communication and social skills to interact with people in a respectful, professional, and effective manner. In medicine these skills are often termed: 'bedside manner, professionalism, patient interactions, or people skills.' As included in the Healthcare Simulation Dictionary for the Society for Simulation in Healthcare, https://doi.org/10.23970/simulationv2, (Lioce et al. (Eds.), 2020). **(see non-technical skills)**

sonography: See the term **ultrasonography**.

standardized patients (SPs): SPs can be real patients or actors who are trained in different medical scenarios which simulate real-life situations. SPs are commonly used in simulation-based-medical education (Gates et al., 2001).

standardized patient (SP) clinical experiences: Clinical experiences with SPs afford students the opportunity to develop diagnostic and critical thinking skills; these experiences can bridge the gap between academic and practice; they can be designed to include realism and technology (Kelly & Jeffries, 2012). SPs follow a scripted scenario to portray a medical condition and present a consistent manner in their imitation of a patient. SPs portray psychological and emotional aspects in a way that human patient simulators (mannequins) cannot – the best way to replicate a human being is with another human patient, that is, an SP (Rutherford-Hemming & Jennrich, 2013). SPs are commonly used for assessment of skills/competencies, usually in an objective structured competency examination (OSCE) format. **(see objective structured competency examination)**

static scanning: A mode of ultrasound where images are produced one at a time (like a still photograph versus a motion-picture show) (Sanders & Winter, 2007). **(see real time scanning)**

telepresence: As included in the Healthcare Simulation Dictionary for the Society for Simulation in Healthcare, https://doi.org/10.23970/simulationv2, (Lioce et al. (Eds.), 2020): Telepresence is the bridging of geographical separation using technology that enables interaction and communication approximate to being actually present. (**see distance simulation; REACTS®; remote simulation; tele-simulation**)

telesimulation: "A telesimulation platform utilizes communications technology to provide mannequin-based simulation education between learners and instructors located remotely from one another..." As cited in the Healthcare Simulation Dictionary for the Society for Simulation in Healthcare, https://doi.org/10.23970/simulationv2, (Lioce et al. (Eds.), 2020). **(see distance simulation; Reacts®; remote simulation; telepresence)**

Trauma (Injury): harm or hurt; usually applied to damage inflicted on the body by an external force (Miller & Keane, 2003). **(see focused assessment with sonography for trauma)**

transducer (aka ultrasound probe): A device capable of converting energy from one form to another. In ultrasonography, the term is used to refer to the crystal and the surrounding housing (Sanders & Winter, 2007, p.1).

unfolding case study: A 'case' or situation where the patient's condition and needs change over time, in an unpredictable manner, necessitating the learner to adapt to the new situation and re-evaluating how to respond to the needs of the patient. Unfolding case studies are commonly used to assess the learner's adaptability, critical thinking, diagnostic reasoning, and clinical judgement (Mason Barber & Schuessler, 2018). Unfolding case study scenarios are commonly developed for learner assessment in objective structured competency examinations (OSCEs)**. (see objective structured competency examination)**

ultrasonography (aka sonography): A common medical imaging modality, used worldwide. The ultrasonic energy has no proven detrimental side effects to date and is considered safe, reliable, and non-invasive. In medicine, it is used to screen, diagnose, monitor, and treat conditions such as pregnancy and abnormal conditions such as disease. Ultrasonography or sonography is driven by the science of sound waves, whereby images are generated from the deflected echoes of inaudible high-frequency sound waves transmitted into an object of interest (Kaproth-Joslin et al., 2015).

ultrasound-guided interventional procedures: Ultrasound is now used to guide a variety of invasive procedures that previously relied on fluoroscopy/x-ray or computer tomography (CT) localization or experienced guesswork. Ultrasound is guiding more and more procedures every year that were previously the province of other imaging modalities. If a structure can be seen by ultrasound, it is generally amenable to ultrasound-guided intervention (Sanders & Winter, 2007, p.599).

ultrasound-naïve (aka sonography-naïve): This term identifies a novice scanner, someone with no previous training in ultrasound scanning (sonography) (Steinmetz et al., 2016).

ultrasound scanner: Equipment capable of producing ultrasound images (Kaproth-Joslin et al., 2015).

Chapter 1. Introduction

Overview

The first applications of medical ultrasound occurred in the early 1950s with technological advancements of static and real-time ultrasound scanners with which to image human anatomy and physiology for diagnosis and treatment (Kaproth-Joslin et al., 2015). Early ultrasound scanning equipment was large and non-portable with its operators limited to a small number of physicians who diagnosed the resulting ultrasound images, also known as sonograms (Kaproth-Joslin et al., 2015). Throughout recent decades ultrasound scanners have evolved from their large, non-mobile units to smaller, portable systems, such as pocket ultrasound devices (PUDs), currently in use today (Baribeau et al., 2020; Bowra et al., 2015).

The recent emergence of highly mobile ultrasound scanners, such as the compact and portable PUD, has created opportunity for greater practitioner access to ultrasound imaging in general, from urban to remote areas. This expanded access has facilitated a practice milieu of point-of-care-ultrasound (POCUS) in which practitioners can now provide ultrasound services themselves, and, at any location, rather than referring their patients/clients to a separate imaging facility, as was previously the case (Dietrich et al., 2017). As stated by Choo et al. (2017), POCUS has "revolutionized patient assessment" (p.1077). As a result, the POCUS practitioner-user-base has grown from a limited group of trained specialists to a much wider and more diverse group of users. These users include (but are not limited to) the medical specialties of anesthesiology, cardiology, vascular applications, respiratory examinations, internal medicine, rheumatological disorders, ophthalmology, obstetrics and gynecology, general practice, and surgery. Furthermore, there is increased application in out-patient settings for screening purposes (Cardim et al., 2011; Roelandt, 2004). In addition, POCUS education is mandated in some medical curricula such as the American Council for Graduate Medical Education who state that emergency medicine residents must now demonstrate the core competencies of bedside ultrasound (Amini, Stolz, Javedani, et al., 2016). With this growth in user population, concerns have emerged in the clinical community and related literature pertaining to inconsistency of practice and questionable standards of training with POCUS (Amini, Adhikari, & Fiorello, 2014; Dietrich et al., 2017). A significant area where proper POCUS training is called for is in the field of obstetrics (Kimberly et al., 2010; Liu et al., 2016) towards decreasing morbidity and mortality in maternal-fetal medicine in underserved countries.

In January 2017 the World Federation of Ultrasound in Medicine and Biology (WFUMB) published its position statement on POCUS, citing the need for consistency of practice with improved education and training programs (Dietrich et al., 2017). The need for POCUS education was earlier cited by Singh et al. (2013) who voiced that global benefits of PUD scanning were limited by the lack of trained users and imaging standards. Further, Bowra et al. (2015) assert that, given a wide diversity of users from urban, rural, and remote contexts, the need for more developed distance education (DE) training tools for consistent and efficient use of POCUS is imperative, and necessitates immediate attention.

The importance of educational consistency for learning and training, in compliance with standards of practice, cannot be overstated due to the need for a skilled operator to acquire and accurately interpret the resulting ultrasound images (Choo, et al., 2017). Rural and remote populations are at increased risk of untrained POCUS users, given the reduced opportunities for hands-on education, practice, and the lack of clinical consultation for POCUS practitioners due to geographical isolation (Bowra et al., 2015). The researcher would argue that the lack of consistent POCUS training presents a case of negligence in certain areas of the world. This educational gap can be addressed by exploring appropriate methods for distance delivery of POCUS education for health curricula of post-secondary educational institutions and training programs.

One such post-secondary educational institution with interest in POCUS program offerings is the Northern Alberta Institute of Technology (NAIT, n.d.), a polytechnic organization in western Canada. Evidence of best practice POCUS program offerings would contribute to stakeholder needs in the medical community as well as emerging educational needs for allied health personnel whose scopes of practice now include POCUS, for example, paramedics (Meadley et al., 2017; Yates & Baylous, 2017), nurses (Adhikari et al., 2015) and other non-radiologist medical personnel (Sharpe et al., 2013). For the study, the researcher was able to adapt NAIT's existing medical ultrasound curricula and current face-to-face (f2f) programming to explore online training of POCUS.

Given the calls for consistency in POCUS educational outcomes and the desire to offer POCUS training with DE methods, this interpretive case study research, framed in mixed methods inquiry, explored the effectiveness of DE methodologies for hands-on training in ultrasound with a PUD for a selected population from the allied health sector. Study results will contribute to educational goals of the health professions community towards an emerging global body of knowledge on POCUS DE approaches, techniques, and tools.

A list of nomenclature and acronyms precedes this chapter to include terms and descriptions relevant to the subsequent discussion in this dissertation. The list of nomenclature and acronyms assists to explain educational and medical terms used in general ultrasound and POCUS, such as those used to describe key characteristics of ultrasound scanning.

Key Characteristics of Ultrasound Scanning

Unlike other forms of medical imaging (Computed Tomography, X-Ray, Magnetic Resonance Imaging), ultrasound (aka sonography or ultrasonography) is highly operator-dependent (Moore & Copel, 2011). To elaborate, the ultrasound energy is housed in a hand-held instrument referred to as an ultrasound probe or transducer, which the operator manipulates to acquire various diagnostic images per patient, and image quality can vary from patient to patient due to this constant manipulation of the transducer. The operator-dependent nature of ultrasound practice presents a significant challenge in the training of ultrasound practitioners given the strong variability of scanning technique from patient to patient (Bowra et al., 2015). Scanning techniques must continually adapt as they are dependent on each patient's body habitus, shape, and condition, thereby requiring essential hand-eye coordination skills (Layne, n.d.).

Other foundational elements of ultrasound scanning are critical thinking skills required to discern what is real and what is not real (artifact) while viewing multiple images presented rapidly and sequentially in real-time (Sanders & Winter, 2007). The skills and competence of discerning artifact from non-artifact requires a foundational knowledge in ultrasound physics and instrumentation, knowledge that a novice POCUS operator (ultrasound-naïve) may not possess. Ongoing application of critical thinking and sound judgement is essential as the transducer is manipulated and images of normal and/or abnormal conditions are produced. The operator must apply pre-requisite knowledge of anatomy, physiology, pathology, and sonographic principles to competently produce and interpret the images. Not scanning an important area (missed image) and/or misinterpretation of any single image can have detrimental effects (false or missed diagnoses), thereby steering the patient's treatment plan in an inaccurate and potentially harmful direction (Choo et al., 2017; Sanders & Winter, 2007).

Professionalism and clinical 'soft skills' are other critical elements in the competency framework of medical ultrasound practice especially due to the immediacy of ultrasound imaging. This immediacy is 'close', that is, the ultrasound operator is in direct one-on-one physical contact with the patient while viewing the patient's images as they are produced, continually applying critical thinking to formulate a diagnosis during the scanning procedure. With this direct contact, it is imperative that competencies and ethical standards of the diagnostic medical sonography profession (aka ultrasound) be followed for the entirety of the ultrasound examination (Sonography Canada, n.d.).

Due to the need for ultrasound learners to develop their scanning and professional skills over time with practice, simulators are used in many training programs (Sanders & Winter, 2007; Sonography Canada, n.d.). The role of simulation in healthcare education is expanding as access to 'real-world' clinical practice on the patient population is diminishing, primarily due to competition and practical limitations (Mason Barber & Schuessler, 2018). With simulators (manikins, phantoms) and standardized patients (actors), simulation learning principles and methods are increasingly applied, including important debriefing sessions, considered to be as essential to attaining learning outcomes as the simulation activity itself (Mason Barber & Schuessler, 2018). Following a simulation event, a debriefing session is led by the educator(s) with the student(s) to review and reflect upon the simulation experience towards learning progression and application to future learning situations, including the development of critical thinking skills (Castro-Yuste et al., 2018; Gibbons et al., 2009; Johnson-Russell & Bailey, 2010; National League for Nursing – Simulation Innovation Resource Center, 2020).The above characteristics for competent ultrasound practice require training programs that address the operator-dependent nature of skill acquisition, critical thinking, and soft-skill development, all synthesized in a holistic performance. As a public post-secondary educational institution, NAIT annually graduates competent ultrasound graduates from its current traditional f2f training program in comprehensive ultrasound (non-POCUS). NAIT's current challenge lies in delivering more of its curricula by distance, including expansion to the hands-on practical ultrasound skills essential in POCUS.

A key characteristic of POCUS technique is its targeted and focused nature, where brief imaging sessions (aka as 'quick scans') are required in emergency situations, for example, five to fifteen minutes, and therefore a limited ultrasound examination is performed. Examples of POCUS studies include imaging sections of the heart (Kobal et al., 2017), organ-focused studies of the abdomen (Siso-Almirall et al., 2017), and targeted obstetrical assessments (Dietrich, et al., 2017). With POCUS the operator only examines the acute area of interest versus a larger region of the body (comprehensive ultrasound). For example, with kidney pain symptoms, a POCUS study will only investigate the kidneys and not the whole abdomen. In a cardiac study, a POCUS operator may quickly examine one heart valve, whereas a comprehensive examination of the entire heart would be performed in a non-POCUS environment, with investigation of all heart valves and chambers (Bobbia et al., 2015). For the research study it was important to select the appropriate POCUS protocol to train and test the operator-dependent nature of scanning skills.

Targeted areas of the chest, heart, abdomen, and pelvis were selected for this study, specifically aligned with the Extended Focused Assessment with Sonography for Trauma (EFAST) protocol, a common study performed in emergency medicine (International Federation for Emergency Medicine, 2014; Montoya et al., 2016). Instructional activities for distance delivery were created to encompass learning outcomes in knowledge and PUD practical skills acquisition, as well as relevant professional behaviors that accompany POCUS performance. With non-probability and purposive sampling from the allied health practitioner population, participants received EFAST skills training remotely via an interactive DE learning platform. Study participants learned PUD techniques on four targeted body areas (chest, heart, abdomen, pelvis). The learner participant sample (n=20) was small enough to manage, yet diverse enough to represent the major allied health areas of POCUS practice. Assessment of learning outcomes utilized objective structured competency-based examinations (OSCEs) in an f2f simulated environment at NAIT, with ultrasound models who acted as standardized patients, and with access to the necessary ultrasound equipment and facility infrastructure. Study results contribute to addressing the current problem of inconsistent training and practice in POCUS, and the lack of adequate DE models to deliver the training.

Problem Statement

The relatively easy-to-use nature of hand-held PUDs, as reported by Bornemann and Bornemann (2014), and technical evolution to small portable ultrasound scanners, have led to a markedly large international increase in the number of medical personnel now performing POCUS (Bowra et al., 2015; Choo et al., 2017). From this increase, a global call for consistency in POCUS training standards has emerged (Baribeau et al., 2020; Bowra et al., 2015; Choo et al., 2017; Dietrich et al., 2017). Given remote locations of medical personnel learning and practicing POCUS (Bowra et al., 2015), standardized training protocols would need to be facilitated by DE praxis, and therein lies a core problem: the existing paucity of standardized DE programs to ensure quality in POCUS. Related to this core problem is the lack of validated POCUS DE for allied health practitioners when compared to the literature's emerging studies for physician training in POCUS.

Educational institutions such as NAIT recognize the need to offer POCUS education by distance, however, this type of standardized curriculum delivery is not widely practiced, despite the availability of medical literature and web-based 'how-to' videos to perform POCUS (Choo et al, 2017). In addition, a primary challenge for DE in ultrasound scanning is the nature of ultrasound practice itself, raising questions such as: how do we teach and learn the necessary psychomotor, operator-dependent, hand-eye coordination ultrasound skills by distance? How do we teach and learn the skills of professionalism or affective skills by distance? Also, if simulation is a standard method of practice for ultrasound students and trainees, how can simulation be incorporated into DE methodologies and technologies? Related to the problem is global recognition on a paucity of standardized training protocols from which to design POCUS curriculum, as reported in 2013 (Mai et al.) and later by the WFUMB (Dietrich et al., 2017). Furthermore, there is a lack of exemplary models to inform DE design for optimal POCUS performance (Bowra et al., 2015).

Purpose of the Study

The purpose of the study was to provide evidence-based recommendations for distance delivery of POCUS education for contribution to allied healthcare curricula and other medical training, including a training model which NAIT could utilize for its organizational needs. Study recommendations point to those DE methodologies to attain and sustain the knowledge, hands-on psychomotor skills, and accompanying professional behaviors required of practice in POCUS with the use of a PUD. These recommendations can inform future DE designs of POCUS programming for the broader community of medical ultrasound practice in its current quest to offer standardized programming in POCUS with distance learning. It was anticipated that training needs would likely vary from participant to participant depending on their perceptions, expectations, learning preferences, and respective professional scopes of practice. The researcher believes the training objectives for the learner participants in the study can potentially be applied to other learners' needs in its design to teach basic ultrasound principles which are foundational to most customized POCUS education. The study's methodology, within an interpretive single case study paradigm, was conducted at NAIT, and with a small team of research assistants, the research questions of the study were explored.

Research Questions

The primary research question was: Can allied health practitioners attain ultrasound imaging skills/competency with a Pocket Ultrasound Device (PUD) in a distance education (DE) learning environment? One sub-question arose in relation to the primary question: *How* can the cognitive, psychomotor, and affective operator-dependent skills of POCUS with a PUD be taught and learned in a DE format? The research questions outlined above are discussed in detail in subsequent chapters in the context of the study's research methodology, results and their discussion, conclusions, limitations, and recommendations. The research questions themselves invited related areas of investigation and inquiry to guide the study which was conducted within an interpretive case study research framework.

The selection of an interpretive case study approach to address the research questions was based on its ‘right fit’ in the context of the researcher’s workplace need to explore *if and how* the operator-dependent hands-on skills of ultrasound imaging (sonography) could be effectively taught and learned remotely. Initiating such a workplace project was deemed valuable to institutional goals to ascertain *if* ultrasound imaging skills could be taught and learned in a non-traditional (f2f) environment, that is, remotely via DE design. Furthermore, it was equally important to investigate *how* ultrasound imaging skills could be taught via DE, that is, to interpret study data for insights into the learning and teaching experiences of the study participants. Study findings could influence and shape future instructional design via distance methods with decreased reliance on the traditional f2f methods of delivering ultrasound imaging curricula. In addition, the exploration of DE delivery of ultrasound education, especially its vital hands-on psychomotor skills, could inform the larger ultrasound and medical professional community in providing wider access to sonography education, including the rapidly-emerging practice of POCUS being conducted in urban, rural and remote settings.

Related Areas of Inquiry

With exploration of the primary and sub-research questions, related areas of inquiry guided the literature review, such as:

- What is the current state of training for POCUS and PUD?
- Do recommendations for training and metrics exist to measure quality learning outcomes in the use of hand-held pocket size scanners?
- Are there prescribed training pre-requisites and training lengths?
- Are there other research studies in POCUS and/or PUD training with DE?

- Are there research studies that compare f2f and DE methodologies for the attainment of learning outcomes in ultrasound competency? If yes, is/was there a significant difference in these two modes of delivery? If no, what factors contributed to the lack of significant difference?
- How can DE enable acquisition of the essential hands-on skills to meet the operator-dependent nature of POCUS utilizing a PUD?
- What are the essential DE needs for POCUS and PUD users/operators?
- Are there training differences amongst physicians and allied health professionals?
- What role does simulation learning theory play in the DE training approach?
- What role do simulators and standardized patients play in a DE teaching and learning environment?

Further exploration of the questions above informed the literature review (chapter two) and research methodology (chapter three) which in turn provided focus on the significance of the study.

Significance of the Study

Exploring methodologies and effectiveness of DE in the use of PUDs contributes to the quest for standardized POCUS training for physicians and allied health practitioners, training for consistency and alignment with a framework for competent, safe, and ethical practice. Furthermore, competent and professional practice in POCUS advances patient quality and safety initiatives that physicians and allied health practitioners strive to attain and maintain.

The most significant aspect of the study is related to the nature of current POCUS practice and the popularity of the PUD as it is: 1) relatively easy to use, and 2) highly accessible (Baribeau et al. 2020; Bowra et al., 2015). These two aspects enable multiple users to pick up a PUD and commence scanning, with or without adequate training, especially in rural and remote regions (Dietrich et al., 2017). Novice PUD users may not be aware of the pitfalls involved in the creation and interpretation of sonograms. Pitfalls of inaccurate imaging and interpretation can be avoided with standardized training to include the instrumentation, techniques, and applications of ultrasound for imaging quality when using a PUD. To be able to offer quality PUD training with DE is significant in the current POCUS climate. This study demonstrates foundational needs of POCUS DE training with a PUD, training that is essential to promote safe, ethical, and competent POCUS practice, utilizing the EFAST protocol as a content example. Furthermore, as a variety of medical practitioners now use PUDs (with or without their stethoscopes) to enhance their traditional physical patient exam, the capacity for quality PUD practice to improve global health care and emergent medical settings is significant (Mai et al., 2013). The research study contributes to emerging efforts to deliver consistent and standardized PUD and POCUS training in a DE format.

The study's DE format utilized an online learning management system (Moodle) to deliver the asynchronous theory portion of instruction. To deliver the synchronous hands-on practical training, the Philips Lumify PUD (n.d.) was selected, with its inherent integration with the tele-ultrasound platform of Remote Education, Augmented Communication, Training and Supervision (REACTS®) created by Innovative Imaging Technologies (n.d.). The latter component situated the learner participant in one location equipped with the Lumify PUD, android tablet, headphones, and a human model to scan; with the instructor participant physically separated in a different location with synchronous computer connection to the learner. This geographical distance between learner and instructor replicates the current status for many novice POCUS practitioners who are separated from mentor assistance (Bowra et al., 2015). In this study's remote educational environment for practical skills training, learner and instructor were connected in real-time, using portable and compact interactive tools, allowing live virtual teaching and learning. The researcher's selection of an interactive teleultrasound technology for practical skills training was significant in its contribution to the larger quest to provide effective remote education to the novice POCUS user, no matter where the learner is geographically situated.

A related area of significance was investigating the role that simulation by DE can play with psychomotor and affective skill acquisition, a role that is becoming increasingly essential to provide alternatives to traditional practice in the clinical milieu (Mason Barber & Schuessler. 2018). A parallel benefit to the study was its contribution to interpretive inquiry in the field of DE effectiveness for progression in all three learning domains.

Recommendations from research findings contribute to standardization in POCUS training programs for educational institutions, physicians, and other allied health personnel who use PUDs in their scopes of practice. Ultimately, improved medical practice and patient outcomes in POCUS environments would be realized globally through the implementation of consistent training strategies and greater access to POCUS education by distance.

Summary

This chapter introduces the research study by providing an overview and explanation of why standardized POCUS training is required for physicians and allied health personnel, and why DE training environments would enable greater access to this training. The chapter also describes certain characteristics of ultrasound practice and the key elements required to attain critical ultrasound competencies. Also presented is the rationale to offer quality hands-on training with a PUD by DE for essential psychomotor skills and professional behaviors of POCUS practice. The problem statement informs both the purpose of the study and the research questions. Additional probing of the research questions outlines further areas of inquiry to explore the effectiveness of DE methodologies for POCUS and to inform the approach to the literature review. The chapter ends with the significance of this interpretive case study research to provide insights into effective DE practices for the transfer of ultrasound knowledge, skills, and behaviors in the use of PUDs in

POCUS environments. Evidence of effective DE practice in the POCUS environment is notable in its contribution to safe and competent medical practice. To address the research questions and related areas of inquiry a literature review ensues (chapter two) which informed the study and guided the research methodology (chapter three).

Chapter 2. Review of the Literature

Introduction

The first chapter provides an overview of the research and its purpose to study the global problem of inconsistent POCUS training and the lack of effective DE offerings to provide this training. The chapter also introduces the study's research questions to address the problem by exploring the effectiveness of DE POCUS training, utilizing a PUD, in an interpretive case study research framework. To inform the research study, chapter two presents a literature review, encompassing three areas: 1) current POCUS and PUD applications, 2) DE models to acquire psychomotor and affective skills, and 3) simulation learning theory in skill training. Before launching into the first area, the advantages and emergence of PUDs are presented.

Allan et al. (2011) attributes the popular widespread use of ultrasound to its many advantages including: non-ionizing radiation, cost-effective ultrasound scanners, imaging in real time, and immediate results for decision-making. Recent technological advances towards more portable battery-operated ultrasound scanners have led to POCUS where ultrasound procedures can be completed and interpreted onsite by the imager (clinician) wherever the patient is located (Bowra et al., 2015; Dietrich et al. 2017). Jones et al. (2009) argue that technological evolution to even smaller and highly compact ultrasound systems has transformed the traditional ultrasound examination to be performed at any location where care is delivered, on earth and even in space. An example of a highly compact ultrasound system is the hand-held, pocket-sized ultrasound scanning device which has further expanded the use of ultrasound. Factors contributing to PUD expansion include its easy-to-learn nature and effectiveness in medical diagnosis and treatment planning, as reported by the studies of Bobbia et al. (2015), Bornemann and Bornemann (2014), and Bruns et al. (2015). These PUD advantages in medicine are influencing physician training, with ultrasound practice becoming part of the medical curriculum, as presented by Ojeda et al. (2015) and supported later in 2017 by Kobal et al. Furthermore, recommendations exist for PUDs to augment or replace the traditional stethoscope (Kaul, 2014). Given the above, one can understand the growth in the use of PUDs in several diverse medical fields as reported in the literature, for example: anesthesiology (Kratz et al., 2016), ophthalmology (Johnson, Zeiler, Unger, et al., 2016), first trimester obstetrics (Bruns et al., 2015), and in heart/lung conditions (Guindo, 2015; Gustafsson et al. 2015). These areas of medicine are newly incorporating ultrasound in their direct practice (Dietrich et al., 2017).

With an increase in clinicians as operators and interpreters of ultrasound results, issues of appropriate training for a clinician's ultrasound scanning competence is paramount, with a call for action to establish standardization of POCUS training (Dietrich et al., 2017). In addition, greater access to this training is required via with DE and online models to meet the training needs of clinicians who practice in rural and remote regions where access to f2f learning and mentoring is challenging (Bowra et al., 2015; Ojeda et al., 2015). This call is later supported within the studies of Choo et al. (2017), Baribeau et al. (2020), and by consensus of global organizations such as the WFUMB.

As presented in the WFUMB's January 2017 position paper on the current state of POCUS, the authors assert that standardized training is lacking as "education and training varies from unit to unit, department to department and country to country" (Dietrich et al. p. 3). Although current POCUS curricula exist, they are limited to a sub-set of medicine, for example, POCUS curriculum guidelines for emergency physicians (International Federation of Emergency Medicine, 2014) and clinicians (Society of Point of Care Ultrasound, 2017.). A search for similar curricula for the sub-set of allied health does not offer exemplars for guidance. Another variance that impacts consistent training is related to dependence on the individual performing POCUS, that is, on the operator who must not only interpret the images but must also employ effective hand-eye coordination skills to acquire the images (Bowra et al. 2015). Moore and Copel (2011) argue that unlike Computed

Tomography, Magnetic Resonance Imaging or X-ray examinations, medical ultrasound is highly operator-dependent whether the equipment is large or small, static, or portable. Reliance on the ultrasound operator for competent and ethical practice further highlights and mandates the need for appropriate training of the operator.

Given the following considerations: 1) the convenience of PUDs for diverse POCUS clinical applications (Baribeau et al., 2020; Dietrich et al., 2017), 2) a growing practice of POCUS in multiple and remote locations (Bowra et al., 2015; Dietrich et al., 2017), 3) training challenges presented by the operator-dependence of ultrasound scanning, thus the need for effective hands-on training (Bowra et al., 2015; Moore & Copel, 2011), and 4) assertions that standardized POCUS education is lacking (Baribeau et al., 2020; Dietrich et al., 2017), especially in the allied health sector, it can be concluded that quality POCUS education, including the use of PUDs, is essential to fill the gap. In addition, effective DE is essential to properly meet geographical barriers and learner needs (Bowra et al., 2015), such as the educational needs of generalist physicians in rural areas (Broome Docs, 2015). Research is required to investigate the feasibility of DE in theory, ethics, and competent application of PUDs to address the need for standardized POCUS education and quality patient care, as reflected in the study's research questions.

To support the research questions and related areas of inquiry, the literature review is organized into three areas: 1) current applications and training in POCUS and PUDs, 2) utilizing DE to acquire psychomotor and affective skills, and 3) the use of simulation for hands-on and behavioral skills, especially with DE methods.

Current Applications and Training in POCUS (including PUDs)

To investigate current applications and training in POCUS the following questions guide this section of the literature review: Which medical professionals use POCUS? What are the benefits of POCUS training and what are the rationales to do so? Are there standards of practice for its use including ethical guidelines and measurements of quality? What training programs currently exist in the use of PUDs? Do position statements exist to guide PUD use?

In January 2017, the WFUMB published a position paper in response to the emergence of POCUS (Dietrich et al.). Frederiksen et al. (2012) cite the significance of POCUS to augment the physician's traditional physical examination encompassing the many and diverse fields of medicine. The wide array of medical specialists engaged with POCUS points to the question: What are the advantages of POCUS for these medical professionals?

The ability for clinicians to both perform and interpret ultrasound findings at their patient's 'bedside' is beneficial for immediacy and accuracy of diagnostic and treatment plans. In their 2015 study, Colli et al. reported more accuracy in patients' care plans when POCUS was added to the routine physical examinations of one hundred and thirty-five physicians, following a pre-defined training course in the use of a PUD. Further studies on the efficacy of adding POCUS to the standard physical examination have resulted in the elimination of unnecessary tests being ordered (Kaul, 2014) and promotion of a clinician's level of confidence (Tsai et al., 2016). In addition, the literature reports that pocket-sized, hand-held ultrasound scanners are now replacing and/or complementing the traditional stethoscope in certain medical settings (Kaul, 2014; Ojeda, et al., 2015).

From the researcher's perspective as an ultrasound practitioner and educator, the emergence of highly compact, pocket-sized, hand-held ultrasound scanners, where the operator can perform, interpret, and immediately diagnose and treat the patient, marks a radical shift in the traditional practice of ultrasound. Prior to the portable scanner, and prior to POCUS, a clinician ordered ultrasound tests (referrals) to be performed by a medical practitioner specifically trained in ultrasound imaging, for example a technologist (diagnostic medical sonographer) or physician (sonologist). The clinician also waited for the ultrasound professional's interpretation of the images (sonograms), e.g., a physician trained in reading sonograms (radiologist, sonologist, cardiologist, etc.), who provided a diagnosis from which the clinician would formulate a patient care plan. The research studies cited above identify some of the benefits that POCUS offers for both the clinician and their patients - benefits that would be enhanced with proper training in this emerging practice environment.

In the matter of POCUS education, the literature reflects studies with two notable features of POCUS training: teaching and learning focused on one organ or body area, and 2) training programs ranging from hours to several months. A key feature of POCUS training, including how to scan with a PUD, is that the examination target is focused. For example, Bobbia et al. (2015) conducted a study in which emergency room (ER) physicians were trained to use a PUD to image four specific sonographic planes/views of the heart (versus full multi-plane cardiac imaging); the study also concluded that experienced ER physicians performed better than ER novices. This study addressed the targeted nature of POCUS and the need for pre-requisite medical knowledge and experience prior to PUD education. Colli et al. (2015) examined POCUS training with focus on the diagnosis of ten possible patient conditions using both PUD and physical examination, versus those same ten areas being diagnosed by physical examination alone. Findings concluded that a short, focused training session was effective to improve the accuracy of diagnostic hypotheses in those ten patient conditions. In another study, Kobal et al. (2017) investigated the feasibility and efficacy of implementing a targeted cardiac ultrasound course using a PUD concluding that training first-year medical students with a short, focused course in cardiac sonography allowed students to gain proficiency in the diagnosis of limited heart pathologies as they entered their practical training. In 2017, Sisó-Almirall et al. targeted training in the abdominal aorta, specifically for aortic aneurysm screening. The authors reported that training family physicians to use hand-held ultrasound was safe and effective for early detection of abdominal aortic aneurysms. In 2014, Bornemann and

Bornemann investigated the training and credentialing of military physicians' use of PUDs, reporting that the devices were easy to learn, valuable for diagnosis, and generated physician and patient satisfaction. The targeted nature of POCUS has led to standard protocols in emergency situations, for example the Focused Assessment with Sonography for Trauma (FAST) and the Extended Focused Assessment with Sonography for Trauma (EFAST) (Giraldo-Restropo & Serna-Jiminez, 2015; Montoya et al., 2016). The specific and focused aspect of POCUS indicates varying training times depending on learning goals and patient treatment targets. Study results above provided guidance for the researcher in the content parameters of the research methodology with a PUD, that is, selecting the appropriate focus area(s) for teaching/learning, with consideration of respective training times.

In estimation of training times for focused PUD education, the literature presents the following: fifty practice cases for cardiac residents (Bobbia et al., 2015), three hours for physicians in internal medicine (Ojeda et al., 2015), twelve hours for first-year medical students (Kobal et al., 2017), twenty-five hours for family medicine practitioners (Siso-Almirall et al., 2017); and one month for obstetrical scanning (Dietrich et al., 2017). In 2010, Galderisi et al. advised a three-month program formedical students learning to use a PUD as a stethoscope. In certain isolated POCUS curricula such as guidelines for ER physicians, training times are not prescribed, as training varies with which part of the curriculum is required for practice (International Federation of Emergency Medicine, 2014). With guidance from the literature reporting various POCUS training times and diverse curricular content, the study methodology implemented an overall time frame of six hours for EFAST training over a three-week calendar period. Training hours included an estimated three hours for asynchronous, self-directed online theory learning over two weeks, followed by one week of three one-hour scanning labs for synchronous interactive remote instruction; each scheduled scanning lab was separated by one to three days.

As discussed previously and validated in the researcher's experience as a diagnostic medical sonographer/educator, a key psychomotor skill for the ultrasound operator is hand-eye coordination. In their 2015 article on the future of ultrasound education, Bowra et al. referred to learning psychomotor skills as the primary challenge for learning POCUS by distance, where learners must develop "visuo-motor" and "visuo-spatial" skills to create diagnostic images (p. 49). Grantcharov and Reznick (2008) earlier advocated for this essential skill of hand-eye coordination, asserting that acquiring procedural skills in ultrasound scanning is a complex process requiring visual perception integrated with psychomotor skills. Bowra et al. also explored other challenges and resources when teaching POCUS, such as the unique educational needs of POCUS clinicians who must perform *and* interpret ultrasound results with limitations of time, physical space, and other constraints, versus the general training milieu of traditional comprehensive ultrasound with dedicated ultrasound professionals and facilities. With the POCUS clinicians' needs in mind, Bowra et al. (2015) championed the feasibility of Internet-based online education in POCUS stating:

> it may also be the most practical, cost-effective way of educating the clinicians who need it most: those who practice far from the resources taken for granted by those of us who practice in large, well-funded teaching hospitals. (p. 50).

The recommendation that POCUS education be delivered in an online DE format is a foundational element for the research rationale, that is, 1) if POCUS with a PUD is prevalent, and 2) used by many in multiple and remote locations, a DE format will reach more users, including the allied health sector, towards increased understanding and competent POCUS practice. The primary challenge mentioned above by Bowra et al. (2015) is explored in the study's primary research question: Can allied health practitioners attain ultrasound imaging skills/competency with a PUD via DE? In addition, the study's sub-question aims to respond to the challenge by asking *how* can the cognitive, psychomotor, and affective operator-dependent skills of a PUD be attained by utilizing a DE format?

Utilizing DE to Acquire Psychomotor and Affective Skills

The following section explores selected DE methods and technologies unique to developing psychomotor hand-eye coordination skills and professional behaviors.

Web-based and Online Instruction

To glean recommendations for research methodology, literature on the efficacy of online and web-based training/education for procedural tasks and the use of DE methods for hands-on learning/skill acquisition was reviewed, including the necessary 'soft skills' of professionalism. In this context, studies comparing traditional f2f instruction to online teaching for the acquisition of psychomotor and professional skills were also reviewed.

In their study to examine student perspectives with a web-based online module for teaching physical assessment skills, Leong et al. (2015) reported positive satisfaction rates from students in dentistry, dental hygiene, and pharmacy, stating that this type of media for teaching physical assessment skills can be used "across multiple health care programs" (p. 385). The article does not comment whether students do, or do not, achieve the physical assessment skills, however students reported that online content "supported" their learning and "helped to understand the clinical aspects of performing a physical assessment of vitals on a patient" (p. 384). Of note to the researcher is this study's identified improvements for web-based education such as: enhancing the sound quality in lectures, including quiz answers, providing learner orientation to the web-based learning management system in use, and greater access to the course coordinator in discussion forums. Some of these recommendations informed the study's research design.

To explore greater effectiveness in web-based medical education Jotwani et al. (2014) examined the use of e-learning platforms for neurosurgeons in response to the challenges of traditional education methods. These challenges included patient safety concerns and reduced access to learning resources such as operating room time. By exploring web-based educational methods the authors presented the case for free-access open-source e-learning which is "structured, formulated and validated" with course modules that are "topic-based to provide continuity and flow for effectual knowledge transfer" (p., 358). The authors also stressed the importance of e-learning platforms in developing nations, where access to quality medical education is a greater challenge. These recommendations are pertinent in the context of POCUS education where global access to training is paramount to promote patient safety; relevant updated medical education delivered remotely by DE may offer a solution for greater access.

In an analysis of educational delivery methods, Callister and Love (2016) compared learning outcomes of online skills-based instruction to outcomes of f2f skills-based training. While the authors reported equal outcomes for mastery of content, study results favored f2f training for skills-based training. The findings of Callister and Love (2016) are somewhat in contrast to the study results of Burckett-St. Laurent, Cunningham, Abbas, et al. (2016) which included evidence that ultrasound-guided regional anesthesiology skills could be taught entirely online in conjunction with a tele-simulation training center. The researcher asserts that a key component to the successful results in the study by Burckett-St. Laurent, Cunningham, Abbas, et al. was the adjunct of synchronous tele-simulation, an effective DE technology in use today.

Bowra et al. (2015) also supported the feasibility of teaching and learning ultrasound techniques by distance using technology to assist in "remote ultrasound guidance by ground-based experts" (p. 50). An example of today's interactive technology is the Remote Education, Augmented Communication, Training and Supervision (REACTS®) (Innovative Imaging Technologies, n.d.) platform which enables experienced operators and educators to interact with the learner in real-time, using augmented communication, and a variety of assets such as 3D anatomical models and image overlay to guide the learner's hands-on practice (Steinmetz et al., 2016). The above studies to compare DE and technology-mediated instruction with traditional f 2f learning support the 'no significant difference' phenomenon, that is, the two modes will yield similar outcomes (Russell, 2001). In consideration of Russell's findings, comparing f2f and DE modes is not an element of this research, rather the study investigated DE learning alone in the context of learning ultrasound scanning skills and the knowledge and behaviors that accompany these skills.

The studies above offer future researchers critical success factors for skills-based courses delivered online with remote telemedicine platforms. These factors include online designs which foster greater interaction between faculty and students in group discussions, and the building of relationships to enhance trust in online skills training - a synthesis of teaching, learning, and social presence. Social presence exists when learners identify themselves as members of a community of inquiry in tandem with cognitive and teaching presences (Rourke et al., 1999). Lee and Huang (2018) emphasize the importance of social presence in an online community of inquiry attributing its value to engender collaboration, group cohesion, learner satisfaction, and engagement. Although Lee and Huang's study did not identify a relationship between social presence and learning outcomes most of the students achieved high grades and reported they "learned some great techniques that will be useful in virtual collaboration…with a deeper level of commitment" (p. 123). As levels of learner engagement and satisfaction were important to the purpose of the research study, the element of online social presence was intentionally designed via the discussion forums in Moodle, with anticipation that instructor and learner participants would collaborate in a collegial fashion in the asynchronous theoretical part of their training, as well as during their synchronous interactive hands-on scanning labs.

In their study of success factors in online instruction, Akcaoglu and Lee (2016) also cited the key role that social presence played for positive group dynamics, optimized with small asynchronous group discussions ideally in groups of three to five members. Investigating the impact of positive group dynamics on learning outcomes was beyond the scope of the study by Akcaoglu and Lee, with their recommendation that future research on the relationship between social presence and learning outcomes be conducted. Despite this non-correlation with learning outcomes students reported that they could "think more deeply" in a smaller group size (p. 11). Opportunities for online discussion were implemented in the researcher's methodology to optimize individual and group reflections on their training of EFAST skills via DE.

Further to exploring DE methods in formative skills training, summative skills assessment was examined by Hay et al. (2013) to evaluate clinical skills with an online design. In this study, the authors sought to improve the practical skills of pre-clinical second-year medical students in knee joint examinations utilizing an e-learning methodology for clinical assessment of practical skills, entitled the "eCAPS protocol" (p.522). The authors described an integrated online assessment system in the following sequence: 1) students independently viewing exemplar videos (asynchronous), 2) learner-generated videos of their practical skills with instructor assessment (asynchronous), and finally, 3) synchronous real-time student-instructor video conference assessment. The authors reported that active learning of knee joint examination technique continually occurred during the three-phased assessment protocol due to the design of "learning-oriented, authentic and valid processes for the remote, web-based video assessment of practical skills" (p. 521). These study results reflect earlier research recommendations to design conceptual frameworks in using assessment 'for' and 'as' learning experiences (Black & Wiliam, 1998; Boud, 2007; Earl, 2013). From their study, Hay et al. recommended a scaffolding of video experiences and student tasks for formative and summative assessment in clinical skills attainment. These study recommendations were somewhat applied to the design of the research study in its careful selection of exemplar EFAST videos for independent student viewing (asynchronous), followed by direct application of EFAST practice with learner-instructor interactions (synchronous). The scaffolding of these two active learning phases was intentional to enable the learner to develop, progress, and attain EFAST skills prior to their final OSCE assessment, including the professional 'soft skills' of overall performance.

In the work of Matthews (2011) web-based e-learning was explored to teach 'soft skills' simultaneously with clinical/performance skills, concluding that performance and behavior are synthesized in the final stages of learning, and fostering appropriate communication skills along the way is attainable. Sinclair et al. (2016) also studied the effect of Internet-based education on clinicians' behavior and patient outcomes, pointing to a gap in current research to study e-learning effectiveness to yield behavior change in clinical communication skills of healthcare professionals. The above study identifies a gap in researching the impact of e-learning on behavioral skills.

In their study to examine the effectiveness of self-guided learning of clinical technical skills Brydges, Carnahan, Safir, et al. (2009), addressed two aspects of self-guided learning: access to instruction, and goal setting. Study findings indicate benefits of self-guided learning, strengthened with the combination of free access to materials and the pre-setting of process goals, versus frequently accessing the videos and their outcomes without goals. Sandars et al. (2012) also explored the arena of self-guided learning in the specific context of continuing medical education and the plethora of online options; this abundance of choices requiring self-regulating skills. These authors concluded that the "role of the educator in facilitating the online learning experience, either by structuring the design or by their online presence is essential to enable effective online learning" (p. 94). The authors recommended further research to understand the processes of self -regulating behavior to develop these skills for online learners. The above discussion has focused on DE for hands-on learning and effective strategies. In the next section, effective learning is explored through multimedia instruction for online environments.

Multimedia for Online learning of Cognitive, Psychomotor and Behavioral Skills

Multimedia instruction is defined as the presentation of "words and pictures that are intended to foster learning", learning that is "meaningful", and optimizes the cognitive capacity of the learner (Mayer & Moreno, 2003, p. 43). As cognitive capacity can be diminished with improper instructional design resulting in a potential cognitive overload problem, these authors offer nine ways to address this problem (p. 46). These nine solutions are listed below in relation to the study's multimedia design:

1. "Off-loading" – create a balance in auditory and visual processing. The study's narrated PowerPoints were produced to present words as narration versus on-screen text.
2. "Segmenting" – allow time between learning segments. Study methodology allowed three hours of online theory over two weeks; the scanning labs were short (one hour) and separated by a day(s).
3. "Pretraining" – enable familiarization with names/components – a list of nomenclature and acronyms (glossary) and study introduction were provided for learners prior to theory and practical content/components.
4. "Weeding" - eliminate extraneous material. Learning resources (YouTubes and PowerPoints) were screened to include those pertaining to EFAST learning only and scanning labs were focused on the EFAST competencies.
5. "Signaling" – provide cues to assist processing of material. The learning content in the study was sequenced for the learners in three separate topics, from simple to more complex.
6. "Aligning" - placing printed words near graphics. PowerPoint text & graphics were aligned.

7. "Eliminating redundancy" - Avoid streams of printed and spoken words. As cited in "off- loading" above, the study's PowerPoints were narrated to engage audio-visual capacity in one processingtime.
8. "Synchronizing": ensure representationsare simultaneous, e.g. narration and animation. The images presented in the PowerPoints and videos in the YouTubes were accompanied by narration; all images acquired by learners in the scanning labs were simultaneously discussed/explained by the instructors in real-time, e.g. what the learner was looking at.
9. "Individualizing" - optimize spatial ability effect. YouTube videos were carefully selected to represent EFAST scanning from a novice learner perspective; in addition, a 3D-printed mock ultrasound transducer was created for instructors to use for modeling the hand positions required in the scanning labs, primarily to assist hand-eye coordination development and skills.

With cognitive overload hopefully avoided the study's design anticipated engagement of the cognitive, psychomotor, and affective learning domains towards a synthesized performance of the EFAST examination for learners, and ease of facilitation for the instructors.

A study conducted by Lee and Shin (2012) explored the learning outcomes of seventy-two participants with either low or high spatial ability. This study revealed that learners are better able to retrieve procedural steps and practical skills by viewing images or animated representations. Overall, the authors recommended the use of multimedia modules in the learning of procedural tasks. An earlier study by White (2010) reported that simple low-cost video capture with online viewing, e.g., *iPhone,* was effective in teaching the complexity of psychomotor skills of a spatial nature. Bloomfield and Jones (2013) conducted a study to investigate the effectiveness of e-learning in the clinical skills' training of nurses. Their study demonstrated that video clips were positively received versus online readings. In their 2014 study, van Duijn et al. concluded that learning psychomotor skills via online video instruction may be equivalent to traditional f2f lab instruction, and the combination of both modes, in either order, contributes to higher scores in learning outcomes. The authors called for further research with online learning of clinical skills, especially where traditional f2f methods are not feasible due to geography or economic factors, factors reflected in the purpose of the researcher's study.

Rowse et al. (2015) reported success in using video skills curricula and simulation in a synergistic way to teach the delicate tasks of hand sewing of the bowel for medical students. An earlier study in 2012, led by Ronn et al., demonstrated that medical students competently performed their first female pelvic examination after viewing an online learning module as little as one time. The authors noted the advantageous cost savings with this type of instruction in a medical curriculum. McKenny (2011) used online videos to teach nursing skills where faculty were challenged with the traditional model of teaching practical skills in a f2f mode. A step-by-step video provided efficiencies for educational delivery attaining outcomes that were the same, whether traditional or with an online video. In another example of video utilization for training, Haug et al. (2020) examined seventy-six video-recorded newborn resuscitations to assess the efficacy of the simulation-based training of nurse-midwives in rural Tanzania in their training entitled 'Helping Babies Breathe'. This study highlights the use of video technology to evaluate training as well as a resource for training.

The use of videos for enhanced learning outcomes is also supported by the study of Cooper and Higgins (2015) for cognitive, psychomotor, and affective domains. The authors attributed this success to the following advantages of videos: online access and flexibility, consistency of content, ability to be viewed multiple times, and the fact that they foster independent learning. In 2013 Hayden conducted a study demonstrating that practical skills for safe patient-safety transfers were acquired with some proficiency using streaming videos. Jang and Kim (2014) also used online videos for medical students in learning clinical skills and preparing for their OSCEs, demonstrating an overall positive impact on students' learning outcomes. Moreover, this study recommended student use of mobile devices, e.g., smartphones or tablets, for convenient access to online education to assist students with efficiencies in accessing online resources.

The studies presented above, utilizing online methods and video technology for healthcare education in cognitive, psychomotor and affective domains, informed the design of the research study focused on DE modes for teaching and learning ultrasound scanning skills with a PUD.

Teaching Ultrasound Scanning with Distance Education

This literature review reviewed selected studies where the psychomotor skills of hand-eye coordination and procedural steps of ultrasound were taught remotely, in comparison to traditional f2f modes. One such study is that of Chenkin et al. (2008) who investigated whether ER residents and physicians could learn to perform vascular ultrasound procedures on the web. Results of this study are encouraging for this research study as the authors concluded that vascular ultrasound procedures can be learned on the web. Their methodology compared results of one group with one-hour traditional lecture-based training versus another group with a one-hour web-based tutorial. Both groups were then assembled to practice what they learned using simulation on live models and tissue-equivalent phantoms without any instruction. Subsequently, both groups were formally evaluated within an OSCE format, demonstrating success in web-based learning of clinical skills. The study by Chenkin et al. is notable to the researcher's study to design assessment of learning outcomes via an OSCE format. To address traditional barriers with one-on-one, f2f hands-on teaching, and the associated constraints of travel time and costs for learners, Burckett-St. Laurent, Cunningham, Abbas, et al. (2016) explored the use of simulation models, ultrasound machines, Skype, and web cameras via a tele-simulation center. The authors reported success in teaching ultrasound-guided regional anesthesia remotely with four online sessions and one offline lecture.

These examples to learn ultrasound in online formats also extend to the commercial sector of medical ultrasound, those companies that manufacture and sell ultrasound equipment.

Ultrasound equipment vendors offer online tutorials in a variety of ultrasound topics including POCUS and PUD training. Examples of commercial training include clinical education webinars (GE Healthcare, n.d.), online tutorials (Philips Learning Connection, n.d.), and online ultrasound training courses using laptop computers specifically manufactured for ultrasound training (SonoSim, n.d.). Some options utilize narrated videos, animated sketches, and tele-mentoring with simulators, however, there is no standardized protocol or validation process for assessing if foundational learning outcomes have been achieved or sustained in this diverse fashion (Dietrich, et al., 2017).

The above review has captured different multimedia approaches to the online/remote teaching and learning of clinical skills. Mayer (2019) described the success of incorporating multimedia learning resources in online instructional design in alignment with Mayer’s cognitive theory of multimedia learning. This enables the human mind to simultaneously hear and see incoming information to organize and integrate this information, based upon prior knowledge. The studies presented above also informed instructional design of the online theoretical portion of EFAST training with incorporation of multimedia resources to optimize learning progress in the three learning domains, for example, cognitive understanding of theory, a ready mind-set in the psychomotor domain to apply theory to scanning actions, and an appreciation of the training in the affective domain As several of the studies presented above incorporate the pedagogy and tools of simulation, a review of the literature in simulation-based education ensues.

Use of Simulation for Hands-on and Behavioral Skills

To guide this third section of the literature review on simulation learning theory and simulation tools, the following areas are explored: advantages of simulation in healthcare education and its pedagogical processes, methods for transfer of knowledge, skills and behaviors using simulation as a learning tool, use of standardized patients (SPs) in simulated settings, research on learning ultrasound skills with DE simulation methods, and existing research studies where simulation methodology is used to teach POCUS with hand-held devices.

The literature presents several advantages for simulation-based healthcare education including positive learning outcomes in knowledge, performance, and confidence for the student, with improved clinical outcomes for the patient (Britt et al., 2007; Ma et al., 2011). An additional advantage in the case for simulation training is its potential to reduce the clinical pressures (financial stress, lack of access) associated with the traditional practice of student clinical placements, by offering an alternative clinical experience through simulation (Mason Barber & Schuessler, 2018). Akhtar et al. (2014) also discussed the advantages of simulation in their study to examine the impact of simulation for practicing technical tasks in a controlled and protected environment. These study results identified the positive role of simulation in teaching hands-on surgical skills by accelerating progression on the learning curve in a safe training environment, that is, where patients were not put at risk. The authors encouraged further studies to examine the effectiveness of transferring simulation-based skill attainment to the clinical milieu such as the operating room. In the context of simulation-based education in ultrasound practice, Denadi et al. (2014) investigated ultrasound-guided central venous cannulation on low-fidelity task trainers, thereby allowing residents training on these hands-on skills in a protected and safe environment, before exposure to their patients in the clinical setting. The researcher notes the advantage of simulation to shorten the learning curve for hands-on skills and the complex procedural tasks required in healthcare education, as well as their retention post-graduation.

Bender et al. (2014) studied the retention of procedural skills and teamwork behaviors for medical residents with the addition of a "simulation-enhanced booster session" nine months after their neonatal resuscitation program for a select group (p. 668). Study results demonstrated improved teamwork behaviors six months later, when compared to those residents who did not receive the simulation booster. Study data also demonstrated that focused attention to practice, with debriefing principles directly following a simulation-based training event, had a cumulative and retentive effect on teamwork behaviors. From the results of this study, the researcher hypothesizes a link of improved professional behaviors in the affective learning domain where learners receive, respond, and develop long-term value of the learning and their personal contributions to learning goals, including essential safety behaviors.

Berragan et al. (2014) presented the attainment of safety behaviors with simulation-based education, highlighting the benefits of learning the hands-on skills of nursing practice in a safe manner through simulation methods. Bevan et al. (2015) conducted a study where student learning and nursing practice were enhanced with the integration of theory and simulation in a single unit of instruction versus being taught as separate units. The researcher notes the benefits of integrating knowledge and hands-on training in a learning event to accelerate progression of cognitive and psychomotor domain learning to higher levels. Achieving synthesis in learning and performance through the pedagogy of simulation is further supported in 2013 by Berragan in presenting the concept of "simulation and expansive learning for the development of a competent nursing performance" (p. 253). Berragan asserts that "[r]ather than performing procedural tasks in a step-by-step manner, as students engage with the simulation environment . . .they begin to respond, behave and *feel* like nurses, albeit in a simulated environment" (p. 251).

The fusion of theory and work in the safe environment of simulation is additionally demonstrated in the field of anesthesiology in using simulators to successfully practice needle biopsies prior to the clinical setting (Gupta et al., 2013: Johnson, Herring, Stone, et al., 2014). Bouchoucha et al. (2013) supported this assertion, highlighting an important phenomenon in nursing education where the traditional method of teaching, e.g., internal on-site f2f simulation labs to augment clinical education is replaced with external online modes of teaching. These authors emphasized that skill acquisition of procedural tasks takes time in both f2f and online environments citing the need to review the traditional Objective Structured Competency Assessment/Examination (OSCA/E) simulation tools to validate formative assessment as well as summative assessment outcomes. In further discussion on the measurement of learning outcomes in the use of OSCEs, is the practice and integration of SPs to provide authenticity to the testing process.

The use of an SP is another valuable tool for simulation-based-education as the SP can interact with the student according to a script designed to teach and/or assess a set of clinical skills. Kelly and Jeffries (2012) reported that SP-learning can bridge the gap between the academic world and real-life practice settings with effective realism. Stroud and Calvancati (2013) demonstrated the realism gained with the use of SPs in their study centered around knee arthrocentesis. In this study twenty-four medical residents interacted with SPs to practice communication skills in addition to their courses on technical skills of knee arthroscopy. The realism achieved with SP practice enhanced the competency level of all but one of the residents. Mason Barber and Schuessler (2018) explored SP simulation experiences in nurse practitioner education to test alternatives to the traditional model of clinical training. Traditional models of clinical placements are a challenge for several fields of healthcare education primarily due to reduced access to hospitals and other medical settings. Results of this study concluded that the skill and attitudinal needs of nursing practitioner clinical education can be attained from SP-related simulation experiences, with a caveat that this training model is resource-intensive. Castro-Yuste et al. (2018) investigated the applications of simulation with SPs to assess nursing clinical competencies in an OSCE type of format. Results of this study yielded a reliable and valid tool for measuring observable behaviors and performance, including knowledge application to different situations, technical abilities, patient safety management, and communication skills. Amini, Stolz, Javedani, et al. (2016) conducted a study in the ultrasound milieu to test the effectiveness of simulation-based ultrasound training for ER residents with a focus on cardiac pathology in a POCUS environment. This one-day workshop utilized SPs for instruction and assessment in an OSCE format. The study results validated the effectiveness of the simulation-based ultrasound event for POCUS education and assessment, results to guide the research methodology.

McGaghie et al. (2014) examined the impact of integrating simulation in medical education in their qualitative critical review of those simulation-based education research studies that use the mastery learning model, a model related to competency-based education where learners must fully attain each competency, versus a percentage or partial attainment. The authors asserted that simulation-based mastery learning positively impacts attainment of learning outcomes and clinical skills, skills that translate to improved patient outcomes, calling for further research to validate this assertion. In the context of the researcher's study, learner participants were assessed on a mastery learning model as learners were graded as achieving the skill/competency or not. The research studies discussed above present the benefits of integrating simulation in healthcare education for students and ultimately for patients, however, the researcher asserts that further research is needed to investigate how simulation training can be delivered *remotely* to expand access to the benefits of simulation pedagogy with DE.

Guzic et al. (2012) explored the effectiveness of skills acquisition with DE utilizing point-to-point video teleconferencing and remote operation of a human patient simulator where the instructor and simulation technologist team delivered the instruction to trainees at another location. The study provided evidence that this instructional methodology and technology, delivered over distance via virtual learning was feasible, however the authors acknowledged that the low sample size did not contribute to generalizability of the results. In a later study, LeFlore et al. (2014) tested the feasibility of testing continuing competency for nurses with simulation-based DE, using a remote access desktop program to control software on the laptop at the remote site. This study offered evidence of benefit to healthcare providers and their employers to test continuing competency of physical skills by distance. Moureau (2015) explored online skill/competency acquisition and measurement with online workshops in the field of vascular medicine. Moureau's study results demonstrated the ability of simulation online training to engage the learner in procedural steps while learning the behaviors necessary to adjust their practice.

Woodworth et al. (2014) applied the concept of simulation training by distance to acquire hands-on skills in ultrasound where anesthesiologists viewed a computer-based video for guidance in recognizing anatomical structures on static ultrasound images, followed by hands-on practice with live models. Results indicated improved knowledge scores on written examinations, however, there was no difference in scanning skills. One could argue that the potential passive-nature of a computer-based video is not enough to teach the active psychomotor skills of scanning and this article highlights the need for active hands-on training (the 'doing') for the research.

With the goal of comparing primary care practitioners' diagnostic capabilities given f2f training versus online education (McFadden & Crim, 2016), two groups of primary care practitioners were selected using a convenience sampling methodology. The control group received multimedia and interactive instruction by a subject matter expert while the treatment group received the same instruction online, delivered via an artificial intelligence-driven simulator. Study results indicated a significant improvement in diagnostic accuracy for the treatment group. The authors concluded that online multimedia instruction with simulator practice and feedback were effective for primary care diagnosticians.

Kim et al. (2017) proved that learning ultrasound skills via DE in anesthesiology was successful, where participants completed a one-day simulation-based workshop on catheter placement to practice their hands-on skills on a mannequin. Chalouhi et al. (2016) studied active learning methods to attain dexterity in scanning skills reporting that obstetrical simulators were equivalent to live models to assess practical ultrasound skills. Although practicing on the simulators was advantageous in removing the constraints of time and location, e.g. lack of access to ultrasound clinics, the ability to assess interactions with real patients was lacking. These authors also advised that ultrasound simulators alone are unable to rate the effectiveness of patient interactions that is, the 'soft skills' of professional behaviors. Caution on relying on simulators alone was also shared by Grantcharov and Reznick (2008) who stated that "[s]imulators, whilst being able to assist in the skill development…cannot substitute for actual experience. They have, however, been shown to be useful in the learning of similar complex procedural tasks" (as cited by Bowra et al., 2015, p. 24).

Tips for designing successful simulation-based DE include being innovative and not restricting simulation education to mannequins; instead, there is advocacy for providing short online sessions, holding students accountable, and developing standardized assessment tools (Kane-Gill et al., 2013). In addition, it is both prudent and exciting to explore more authentic high-fidelity simulation tools and methods for enhanced realism of practice, such as today's telemedicine platforms.

Steinmetz et al. conducted a pilot study in 2016 where participants (n=3) were introduced to EFAST ultrasound scanning techniques with tele-assisted principles remotely guided by ultrasound-experienced physicians via the Remote Education, Augmented Communication, Training and Supervision (REACTS®) system in a telemedicine setting. Using a high-fidelity simulator, the study reported the effectiveness of the platform for remote teaching and learning, enabling subject- matter expert physicians to teach ultrasound scanning skills remotely to ultrasound naïve clinicians. The study authors asserted that incorporating traditional telecommunications with augmented communication can provide live virtual guidance in medical training. Weil et al. (2015) reported another example of live virtual guidance where the tele-assistance features of REACTS® were used in the setting of surgical education, in this case in a neurosurgical operating room. In a cardiac ultrasound study, Choo et al. (2017) demonstrated how tele-mentored participants new to sonography successfully learned the hands-on skills to acquire selected cardiac images, reflecting the feasibility of remote ultrasound instruction to teach the psychomotor skills needed for POCUS. Mai et al. (2013) also explored remote acquisition of necessary hands-on skills for POCUS, where trainees used *iPhone* technology attached to a PUD, with data being transmitted wirelessly to an off-site cardiologist for instructional guidance. With the transmitted data compared to gold standard ultrasound thresholds, Mai et al. concluded that a novice could learn cardiac POCUS with a PUD remotely using wireless technology. The design to teach online clinical skills is a challenge and calls for innovative methods for learners to attain ultrasound scanning skills by DE. For this challenge the researcher looks to the studies of Mai et al. (2013), Steinmetz et al. (2016), and Choo et al. (2017) who utilized remote methodologies and simulations for instructional delivery of psychomotor skills of ultrasound scanning.

The literature also offers research into other types of simulated experiences with the creative technology of virtual reality (VR) in medical education where the learning milieu is in cyberspace. One example is research by Lyu et al. (2013) who reported a successful experiential-based virtual training system for surgeons using virtual and haptic elements. As VR is not a component in the research design, this area of the literature was not explored at length.

Before concluding this final section of the literature review it is important to highlight certain factors that enable overall success with DE. Support for online trainees requires interventions that contribute to learner self-regulation as reported by Brydges, Manzone, Shanks, et al. (2015). This study urged educators and researchers to stop thinking of self -regulated learning as a solitary student activity, but rather a shared responsibility between the learner and the instructional designer, where the latter incorporates instructor-supervised interventions throughout the online learning session(s).

The research studies presented above informed elements of the researcher's study design in EFAST training to simulate an authentic EFAST experience to attain synthesis of theory knowledge (cognitive), practical hands-on skills (psychomotor), and professional behaviors (affective learning) in a safe learning environment.

Summary

Recent medical practice utilizing POCUS and the emergence of PUDs provide beneficial clinical practice tools for a large and diverse number of medical practitioners. The WFUMB asserts that standardized training is lacking and is critically required to meet the current widespread use of POCUS (Dietrich et al., 2017). Furthermore, Bowra et al. (2015) call for distance learning methods to deliver essential training for those POCUS practitioners who may not have access to traditional modes of learning. This literature review presents selected studies in the current state of POCUS education and the use of PUDs, noting the gap of research studies to investigate training for the allied health sector. The chapter also presents research studies in the acquisition of cognitive, psychomotor, and professional behavioural skills via DE methods, as well as the use of simulation in the attainment of procedural and professional skills. A review of the literature supported the rationale for the research study drawing upon selected studies for research design. Underlying this research study is the medical community's call for action towards an effective, standardized curriculum for POCUS and PUD competency, designed and delivered in a DE format. The literature review presented above guided the study's research methodology, to be discussed in chapter three.

Chapter 3. Theoretical Framework and Methodology

Introduction

Chapter three presents the study methodology by first describing the researcher's ontological and epistemological positions and overriding theoretical considerations of interpretive case study research which anchored the inquiry. Operationalization of the research questions ensues, followed by the study's mixed methods approach in shaping the research. The next section of the chapter discusses the research design including the pre-study field test, participant selection process, data collection methods, data analysis approach, and certain practical, ethical, and philosophical considerations. The chapter ends with a summary of key elements of the study's methodology which reflects the researcher's ontological and epistemological stance.

Researcher Ontological and Epistemological Positioning

The researcher's ontological position assumes that the nature of reality is in the 'making of meaning' of one's perceptions, feelings, thoughts, and ideas, thereby building an inner reality. Simultaneously, one projects one's inner reality onto the outside world by layering these meanings in a constructive fashion with societal cues. As these cues change, realities change, and a subjective lens is required to make sense of changing contexts, resulting in multiple realities. The above anti-positivist ontological assumptions align with Lincoln et al.'s (2011) paradigms of critical theory and constructivism, with stated attributes of "virtual reality shaped by social, political, cultural, economic, ethnic, and gender values; crystallized over time" and "[r]elativism – local and specific co-constructed realities", respectively (p. 100). These beliefs dovetail with the researcher's ontological position which privileges the construction of multiple realities, a relative viewpoint, and the vital importance of context in the creation and shaping of meaning. Unlike the positivist belief where there is only one truth or reality (Lincoln et al., 2011) the researcher's anti-positivist stance appreciates and values the construction of knowledge via different perceptions and therefore different realities. It is in the fluid, subjective, and dynamic nature of constructed knowledge that social change is possible. As a researcher with an anti-positivist stance, it is important to be grounded in one's own knowledge paradigm while being sensitive to others' points of view (Guba & Lincoln, 2005).

In congruence with an ontological baseline is the researcher's epistemological inquiry, shaped by subjectivism and discovery through experience, a belief that learning lies in doing and in experience. Learning by experience makes it possible to have that transformational inner knowledge which motivates a person and provides foundational confidence to add more knowledge through additional experiences. In this model of experiential learning, knowledge, skills, and attitudes grow in a cyclical and iterative nature with former experiences adding to new experiences in a constructive process. The making of meaning and preference for experiential learning aligns with Dewey's early pragmatic theory (1938) and later-described concepts that human beings need hands-on learning to make sense of the world (Freeman-Moir, 2011; Lindsey & Berger, 2009). The researcher believes that without experiential knowledge one has but a superficial knowledge without depth or inner knowing, and confidence and foundations may be lacking for further learning. For example, in the researcher's first ultrasound scanning experience hands-on practice was first introduced followed by a set of readings on practical scanning. These readings made sense because the prior practical hands-on experiences 'made meaning' of the text in the literature. Additional reading integrated with practice allowed progress to an intermediate scanning level in a cyclical and iterative pattern of reading and doing until an advanced level of scanning proficiency was attained with confidence, the confidence gained from a systematic and scaffolded process of learning. Without that prior and integrative experience of 'doing' new cognitive information may not have been optimally internalized or valued, thereby limiting growth and competence. These primary and secondary experiences reflect Dewey's foundational argument in 1938 to use experience in education. Of note is the role of the teacher with responsibility to ensure the quality of the experience, as cautioned by Lindsey and Berger (2009).

As valuable as the above integrated hands-on experiences were, there were times when content and expectations were beyond the researcher's readiness level which created feelings of being overwhelmed. These episodes were addressed with scaling the content back to anticipate and match preparation levels, an approach reflecting scaffolding theory and the concept of the zone of proximal development (ZPD), as first described by Vygotsky in the 1920s (Guseva & Solomonovich, 2017). Vygotsky's ZPD is redefined in 2018 by Smagorinsky who asserts that the ZPD is really the "zone of next development" (p. 74), an assertion that aligns with how the researcher optimally learns. Knowing by experience and having the capacity for the next experience is a basic summary of the researcher's epistemological position. As with the ontological position described earlier, this epistemological stance aligns with theoretical perspectives of the interpretive case study.

Case Study and Theoretical Perspectives

Case study methodology was conducted with application of phenomenological, interpretive, evaluative, and critical theory perspectives (Koro-Ljungberg et al., 2009; Yin, 1984) to explore a new method of delivering ultrasound training curriculum by distance to improve workplace practice. The researcher and assistants worked collaboratively to operationalize research steps, later described and detailed in Appendices H and K. Research findings provide recommendations for future instructional design of POCUS training for the researcher's workplace, and study results will be shared with the broader allied health community of practice.

The selection of case study research to explore an identified workplace professional community need is supported by Hitchcock and Hughes (1995) who state that case studies are set in specific contexts with established parameters such as the characteristics of a group; in this study the context was the allied health sector with a specific sample of participants eligible for diagnostic medical sonography training with remote technology. Nisbet and Watt (1984) present the realism of a case study as its strength, with data based on participants' direct experiences. This strength is supported by Yin (2009) who states that a case study is a "unique example of real people in real situations" (as cited by Cohen at al., 2011, p. 289). Another feature of case study research with human subjects is the study of emerging events and participant perceptions, features reflecting alignment between case studies and interpretive methodologies (Hitchcock & Hughes, 1995). The exploratory nature of a single case study is fitting with the researcher's ontological and epistemological positions with value on constructing knowledge and experiential learning to explore a phenomenon.

The selection of interpretive case study methodology was suitable to investigate a phenomenon, a phenomenon presenting a current problem; a problem needing solutions to address institutional desire and global needs for DE POCUS training for medical and allied health professionals. In the context of this study, the phenomenon was the unknown efficacy and methodology of teaching and learning the hands-on skills of ultrasound entirely by distance. Interpretation of data gained insight from the voice of participants who experienced the training directly - insights to assist the goal of POCUS instructional design for meaningful and effective learning. Engagement of workplace colleagues reflected the value of collective action to effect change on an organizational scale, as supported by Zuber-Skerrit's (1996) statement of emancipatory research for organizational change.

In contribution to successful learning outcomes within all learning domains in the DE POCUS study design, anticipating the diverse needs of POCUS trainees (adult learner participants) was applied to the research process. MacKeracher et al.'s (2006) State of the Field Report on barriers to adult learning was referenced for guidance with the following four notable classifications: situational, institutional, dispositional (Cross, 1981) and academic (Potter & Alderman, 1992). With these four categories in mind, the researcher sought to mitigate factors that may create barriers for the adult learners in the study, and by doing so increase participation and retention. For example, to avoid potential situational and/or institutional factors, the training intervention was conducted over the less active two-month period of the academic year, when study participants could more easily participate with a work-life balance. This two-month time frame was also beneficial to easily access workplace ultrasound scanning lab facilities, with assurance of back-up technical support. Dispositional and academic factors were also considered where some learners may experience learning difficulties in acquiring POCUS skills while others may not, causing possible lack of confidence and/or embarrassment. The researcher attended to mitigating these potential dispositional and academic barriers with respectful and ethical principles of anonymity and confidentiality, later described.

The approach of case study research to the inquiry reflected practicality and pragmatism in the quest to improve the researcher's educational workplace in the context of DE options for POCUS. This research approach came with ethical and philosophical challenges calling for awareness of researcher reflexivity for credibility (validity) and trustworthiness (credibility), discussed later in the chapter. With engagement of workplace colleagues, the need for mutual trust was significant given the collaborative nature of the research process. A culture of trust between the researcher and research assistant team was enhanced through a pre-study field test phase. This phase included engagement of workplace colleagues in hands-on PUD experience, validation of the study's instructional design and delivery plan (theory and practical), trial deployment of data collection tools, and testing of DE technical factors with REACTS®. Field test data were reviewed as a collective to gain insights for modification of course design and data collection tools prior to the study's formal commencement. Further details of the field test are discussed later.

As participants were recruited from the researcher's workplace, additional measures for trust and validity required foresight and careful attention to the relationship between researcher and researched, as advised by Cho and Trent (2006), who assert that "in order for authentic change to occur, collaborative relationships between researcher and researched should be manifested during (and after) the research process" (p. 331). Clear communication, trust, and collaboration in the research phases were also served with the researcher's subject matter expertise (ultrasound education) and clear focus to address the study's "fitness for purpose" – important requirements in case study research (Cohen et al., 2011, p. 296). The important element of trustworthiness is expanded upon later in this chapter.

As the research environment was the researcher's workplace, detail on the culture of the institution is notable. The 'polytechnic' nature of the environment aligned well with the purpose of the study, as research findings contribute and inform DE POCUS needs of medical and allied health professions within the healthcare industry. To further explain, polytechnic education includes "Industry-focused Programming", technological "Hands-on Experience", with curricula based in "real-world experience" (Polytechnics Canada, n.d.). The above discussion reflects a case study approach, framed in interpretive and critical theorist perspectives, to address and operationalize the research questions.

Research Questions Operationalized

The primary research question reads: Can allied health practitioners attain ultrasound imaging skills/competency with a Pocket Ultrasound Device (PUD) in a distance education (DE) learning environment? One sub-question relates to the primary question: *How* can the cognitive, psychomotor, and affective operator-dependent skills of POCUS with a PUD be taught and learned in a DE format?

Primary Research Question

The study addressed the primary research question by designing DE instructional activities with defined learning outcomes f or ultrasound-naïve allied health participants to attain cognitive, psychomotor, and affective skills required for ultrasound scanning with a PUD. Instruction (training) was delivered asynchronously for theory elements, and synchronously for the practical hands-on training component. Assessment of learning outcomes to measure attainment of ultrasound skills/competency occurred through f2f OSCEs using ultrasound models behaving as SPs.

The overall approach to attain the cognitive, psychomotor, and affective skills for ultrasound practice reflected studies by Chenkin et al. (2008) and Callister and Love (2016) who investigated the effectiveness of online psychomotor skills-based training, and the work of Matthews (2011) to explore online education for behavioral competencies, that is, ‘soft skills’ (affective domain). Learning outcomes were assessed, and learner experiences analyzed to ascertain: did the DE training work and how? For data analysis the researcher applied the four levels of the New World Kirkpatrick Model (NWKM) (Kirkpatrick & Kirkpatrick, 2016) as a framework to evaluate the training, enabling deeper investigation into ‘how’ and ‘why’ the training worked. Investigating how and why were features of the interpretive nature of the research, enabled by the study’s sub-question which narrowed the inquiry to gain insights for best-practice instructional DE design for POCUS training.

Sub-Question

The sub-question reads: *How* can the cognitive, psychomotor, and affective operator-dependent skills of POCUS with a PUD be taught and learned in a DE format? To address the sub-question, attention was focused on the design of instructional and assessment activities to foster meaningful teaching and learning towards attainment of learning outcomes and progression through the learning domains. The instruction was delivered online (asynchronous) in a set of topics to encompass theoretical foundations of POCUS and the EFAST protocol, followed by synchronous tele-assisted practical training (application of theory) of EFAST scanning with a PUD in a lab setting, culminating in f2f assessment of skills in simulated EFAST scenarios.

The selected curriculum content was specifically targeted for thoracic, cardiac, abdominal, and pelvic imaging skills within the EFAST protocol (International Federation for Emergency Medicine, 2014; Montoya et al., 2016). Targeting the instruction for specific organ views aligns with the nature of POCUS, as reflected in the cardiac-focused studies of Andruszkiewicz et al. (2015) and Kobal et al. (2017), and the abdominal aorta study of Siso-Almirall et al. (2017). With the course content of EFAST scanning defined, attention to the study's sub-question of instructional DE design was further expanded, in respect to learning resources and tools.

As guided by earlier-cited studies, multimedia instructional tools were used for theory learning, and remote education interactive technology for practical training. For asynchronous online learning of procedural skills, a primary DE strategy was the scaffolding of instructional videos, as advised by Hay et al. (2013), with step-by-step narrated video instruction, as recommended by Lee and Shin (2012) and McKenny (2011). The case for using videos was also supported by Grantcharov and Reznick (2008) and White (2010), who cite the effectiveness of videos in learning the complex visual and spatial skills of hand-eye coordination/hands-on techniques. As claimed by Bowra et al. (2015), it is a challenge to learn the visuomotor and visuospatial psychomotor skills of POCUS by DE. To meet this challenge narrated instructional PowerPoints and selected videos of EFAST ultrasound scanning procedural tasks were optimized. Some of these resources were already created within NAIT's current ultrasound curriculum delivery. Other resources were available from YouTube, as validated and recommended by the instructors. The multimedia resources used for the theory component were designed to prepare learners for the hands-onpractice in the scanning labs.

For the hands-on learning component, the Philips Healthcare Lumify PUD was selected with its integrated tele-assisted Remote Education, Augmented Communication, Training and Supervision (REACTS®) platform, as guided by the pilot study of Steinmetz et al. (2016), thereby providing the study design with live iterative features and principles of tele-mentoring (Choo et al., 2017). The multimedia and tele-mentoring resources discussed above primarily attended to the cognitive and psychomotor learning domains.

To capture learning strategies for the affective learning domain, professional behaviors aligned with EFAST scanning were included in learning outcomes, course materials, and scanning lab instruction to enable learners to integrate and synthesize behavioral skills towards overall performance and competency. In the study by Matthews (2011) the synthesis of performance and behavior was not apparent until the final stages of online educational sessions, despite being integrated throughout the learning process from beginning to end. This integrated process of professional behavior training guided the study design to incorporate ‘soft skills’ learning throughout the instructional topics versus isolating professionalism into a one-time lesson. Related behaviors and professional skills of EFAST scanning were viewed on the multimedia tools in Moodle for application in scanning labs; these skills subsequently tested on the OSCEs with ultrasound models scripted as SPs. Although professional behaviors and patient interaction experiences of the affective domain were already developed in learner participants due to their various professional backgrounds, professional behaviors within the scope of EFAST practice were tested, with SPs asking a question to simulate what an EFAST patient would likely pose.

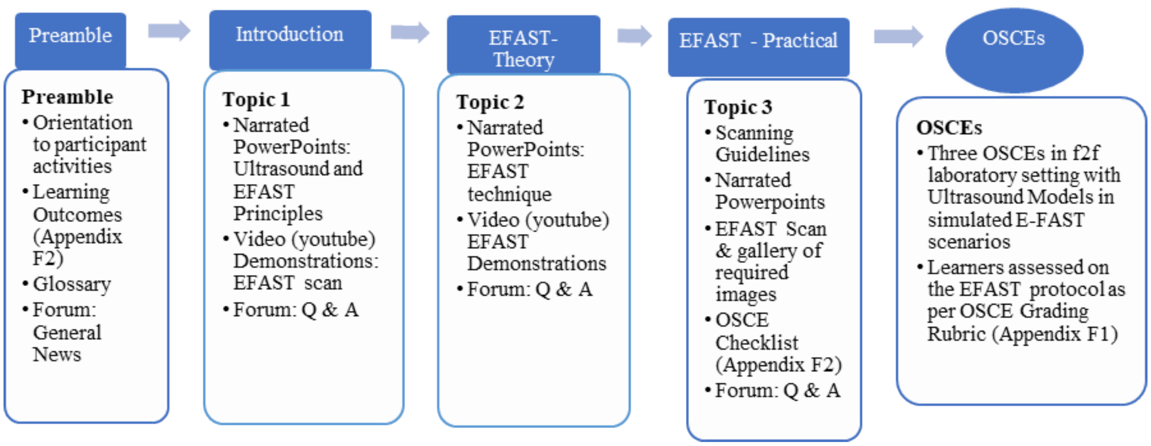
The strategies described above encompass elements to simulate EFAST training, from viewing ‘how-to’ videos to practicing on human models in the scanning labs. As cited by Burckett-St. Laurent, Cunningham, Abbas, et al. (2016) and Bowra et al. (2015), one of the benefits of simulation-based education is the capacity to review best practice performance multiple times on a video and/or practice skills several times in a simulated and safe laboratory setting, which is not the case in the clinical field. In addition, the study design included an instructor-facilitated, self-paced, and self-regulated approach throughout the Moodle theory topics, as advised by Brydges, Carnahan, Safir et al. (2009), who advocate instructor guidance with paced learning goals, versus independent self-guided learning without sequence or goals. These strategies were optimized to assist instructors and learners in the transfer of learning.

With a variety of learners from eight different allied health professions in the study it was possible to observe if different instructional techniques may be required for one profession over another in the transfer of learning, therefore, instructor field notes were templated to document any learner differences observed in the delivery of the EFAST training course. Potential learner differences would inform future instructional design for multiple professions.

To summarize the operationalization of research questions, the study designed an asynchronous multimedia course to teach foundational knowledge and skills within an instructional scaffolding approach, using exemplar procedural narrated task videos and narrated PowerPoints. Following this theory component, a remote synchronous tele-assisted interactive technology was utilized for practical training to attain hand-eye coordination scanning skills and professional POCUS behaviors. Multimedia resources played a significant role for online theory, guided by the work of Cooper and Higgins (2015) who studied the effectiveness of online instructional videos in the acquisition of cognitive, affective and psychomotor skills. The interactive real-time nature of remote learning in the scanning labs was a key resource for instructors to teach the EFAST protocol and for learners to apply theoretical EFAST principles and prepare for their OSCEs. Figure 1 below depicts an overview of the course design with further details provided in the course design template (Appendix A) which includes selected references gleaned from the researcher's literature review to inform course design.

Figure 1

Course Design Visual (Details in Course Design Template in Appendix A)



Study findings related to course structure have yielded recommendations for instructional design, strategies, techniques, resources, and tools for POCUS educators and for ultrasound-naïve health professionals seeking to attain competency in POCUS, such as the EFAST protocol via DE.

Addressing the research questions required quantitative and qualitative data to collect and analyze. Detailed information on the framework used to analyze data in relation to the research questions is provided in Appendix D, which highlights the mixed methods approach to this interpretive case study.

Mixed Methods Approach

A mixed methods approach with quantitative and qualitative data collection tools was designed to explore and determine the effectiveness of DE for PUD competency. This multimodal approach, aka triangulation, is beneficial in its advantage to provide a deeper understanding of the inquiry by studying it from both quantitative and qualitative lenses (Cohen et al., 2011).

Quantitative data garnered by the study were accompanied by qualitative data to interpret the meaning of quantitative data points. For example, OSCE data for a learner participant was a quantitative score, and further data analysis focused on understanding any underlying factors that contributed to the score, such as feedback on their learning experience and which competencies were successful or missed. Qualitative exploration aligned with characteristics of interpretative inquiry with attention on "learning the meaning that the participants hold about the problem or issue [where one] can see how multiple views of the problem can emerge" (Creswell, 2007, p. 39). Variation in learner training needs were anticipated as well, due to the operator dependency of ultrasound scanning, earlier described by Choo et al. (2017). Qualitative analysis of quantitative data contributed to deeper understanding of the teaching and learning experiences versus solely collecting questionnaire demographics and numerical OSCE scores. Qualitative data offered rich insights including recommendations for future POCUS curricular design.

Reams and Twale (2008) suggest that a mixed methods approach will enhance perspectives and corroborate data thereby reducing bias to inform balanced conclusions. The study's mixed methods interpretive case study research design, aligned with the researcher's appreciation of multiple perspectives, was applied with an interpretivist and constructivist lens (Creswell, 2013).

Overall Research Methodology Design

Research methodology included the following elements: pre-study field test, participant selection, activities for learner participants (pre-study questionnaire, training, mid-study questionnaire, OSCE assessments, end-study questionnaire), teaching activities and completion of field notes by instructors, and data analysis. Figure 3, presented later in the chapter, depicts the sequence of participant activities for data collection and analysis.

Pre-Study Field Test Phase

Once the instructional modules and data collection tools were designed, they were tested with the research assistant team in a pre-study field test in the following six steps:

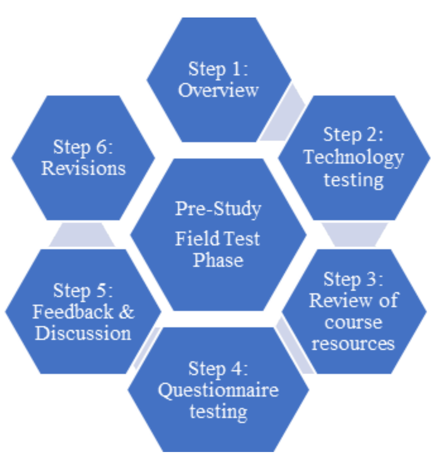
1. An overview of the research project by PowerPoint was provided for the entire research team.

2. Technical testing of Lumify PUD performance in tandem with the REACTS® platform was conducted in the laboratory setting with NAIT instructors and an information technologist (IT) to simulate the hands-on instruction phase of training.
3. Validation of learning outcomes, multimedia course resources, and OSCE rubric was conducted with NAIT instructors.
4. Testing the deployment, completion, and return of electronic questionnaires via Qualtrics software was conducted with the research administrative assistant.
5. Feedback and discussion ensued on required revisions.
6. Revisions were implemented based on feedback, e.g., adjustments to the OSCE grading rubric, more efficient scanning lab set-ups for instruction and the OSCEs, selecting larger android tablets for PUD attachment, and securing IT back-up for the formal study.

The field test experience enabled validation of the study's curricular integrity (pedagogical content), efficacy of data collection tools, and logistics in using NAIT facilities and resources. A key objective was to pre-test possible DE technical difficulties, as advised by earlier researchers such as Yeung (2014) who recommend pre-testing of DE tools/format to avoid later technical difficulties. The pre-study field test sequence is depicted below:

Figure 2

Overview of Pre-Study Field Test



A summative and collective assessment of the field test experience allowed for necessary remediation of research elements/tools prior to the next phase - participant recruitment. One primary revision was applied to the OSCE grading rubric, as highlighted in Appendix E. Field testing of REACTS® technology was critical in the post-field test decision to secure an IT person on site for each scanning lab session.

Sampling Method and Participant Recruitment

A non-probability sampling method was applied for learner participants, specifically, a purposive sampling approach to recruit allied health professionals. This type of sampling was important in this study due to pre-requisite criteria of learner participants to have prior medical (anatomical) knowledge and patient-care experience in allied health, as outlined in the next section. The non-probability sampling approach to select a specific group of allied health personnel does not reflect the broader medical community, however it represents itself, that is, the allied health sector, as described by Cohen et al. (2011). In addition, and critical to the research questions, was the criterion that all learners be ultrasound-naïve, without prior training or experience in hands-on ultrasound imaging. Learner participants were recruited from the non-ultrasound allied health faculty within the NAIT School of Health and Life Sciences. Instructor and assessor participants volunteered from NAIT's diagnostic medical sonography (DMS) program. Ultrasound models for the OSCEs were employed from the DMS program's existing list of models already hired for NAIT DMS students. It is important to note that learners and instructors were contributors to study data, while assessors and models were non-contributors in their roles to facilitate the research phases and steps.

Participant Recruitment and Selection

Learner Participant Selection Criteria. Eligibility for learner participants included the following three criteria, as communicated in their recruitment e-mail (Appendix G1):

1. Learners must possess knowledge of human anatomy of the chest, heart, abdomen and pelvis.
2. Learners must have current or past experiences with patient interactions in the healthcare setting.
3. Learners cannot possess any prior training in hands-on ultrasound scanning (need to be ‘ultrasound naïve’).

The second criterion of previous experience in patient interactions identified above is supported by Bobbia et al. (2015) who emphasize the need for pre-requisite anatomical knowledge for the targeted nature of POCUS training and practice.

Instructor Participant Selection Criteria. Eligibility for instructor participants included the following four criteria, as communicated in their recruitment e-mail (Appendix G2):

1. Instructors must possess instructional knowledge in teaching point of care ultrasound and the Extended Focused Assessment with Sonography in Trauma (EFAST) protocol - theory and practical labs.
2. Instructors must possess active credentials in generalist and cardiac sonography.
3. Instructors must have experience in delivering instruction on Moodle.
4. Instructors must be willing to learn remote live interactive technology to deliver hands-on scanning labs to learners.

Assessor Participant Selection Criteria. Eligibility for assessor participants included two criteria, as communicated in their recruitment e-mail (Appendix G3):

1. Assessors must possess active credentials in generalist and cardiac sonography.
2. Assessors must possess experience in evaluating a learner’s ultrasound scanning skills in a simulated ultrasound examination with live models.

Ultrasound Model Participant Selection Criteria. Eligibility for ultrasound model participants was not specified in their recruitment e-mail (Appendix G4). Study models were employed from the existing roster of DMS models already screened for suitability as an ultrasound subject, that is, possessing a body habitus able to be imaged by learners versus models that possess anatomy difficult to image for a novice learner.

Once selected, and upon receipt of respective signed informed consent, conflict of interest, and confidentiality forms (Appendices G5 to G9), the research administrative assistant provided participants with an alphanumeric code, e.g., L01 for Learners, I01 for Instructors, and A01 for Assessors. Once confidential participant codes were provided, the data collection phase of the study was launched.

Data Collection Phases

Phase 1: Pre-instruction - Pre-study Online Questionnaire

Learner participants completed an online pre-study questionnaire (Appendix B1) utilizing Qualtrics software. Questions were crafted to identify the 'pre-test' status of learners in their knowledge/skill areas and training levels of engagement and relevance, prior to instruction and assessment, for comparison to similar data in the end-study questionnaire. These data assisted quantitative and qualitative data analysis and study recommendations for future instructional design.

Phase 2: DE Instruction

Instructional content was delivered via a learning management system (Moodle) and a tele-assisted interactive platform (REACTS®) in a set of topics, previously depicted in Figure 1 and detailed in Appendix A. In the study's DE design, asynchronous components, delivered online via Moodle, encompassed the first topics in theory, including narrated PowerPoints, instructional EFAST videos, (YouTubes) and discussion forums. The online theory component was followed by a synchronous practical component (three one-hour labs) utilizing REACTS®. The modular instructional design was guided by the study of Burckett-St. Laurent, Cunningham, Abbas, et al. (2016) who used four online sessions to teach specific skills in ultrasound-guided regional anesthesiology remotely, a similar approach to the targeted nature of the study.

As on-campus faculty members of the researcher's workplace, learner and instructor participants were not geographically distant from each other, however, instructors were always physically separated from learners. In the online theory portion of the training, prior to the scanning labs, all participants were separated from each other, as they independently and asynchronously completed online theory learning in preparation for the remote scanning labs. For the scanning labs instructors were situated in another campus location, several floors apart from learners who were physically located in the ultrasound lab space.

During practical instruction, participants scanned each other, as informed in their letters of information and informed consent procedures prior to their voluntary participation. The 'scanning' learner was remotely connected via headphones to the instructor who was able to instruct the learner on imaging skills while viewing the images obtained by the learner in real-time. The 'non-scanning' learner did not hear the dialog between instructor and 'scanning learner' and awaited their turn to switch places and become the scanner. In this design, although one hour was allotted per pair, per lab, actual hands-on scanning practice was really thirty minutes per learner, per lab.

Instruction was delivered by a two-person instructor team who each completed field notes according to a template, as presented in Appendix C. In this phase, instructor participants utilized the EFAST checklist of learning outcomes to guide their remote instructional techniques on the EFAST protocol with a PUD (Appendix F2). The scanning labs were scheduled to enable the instructors one-on-one time with each learner so that all learners would benefit from both instructor expertise.

Learners were scheduled for their labs in NAIT's dedicated ultrasound scanning lab and were provided with a PUD connected to an android tablet with headphones. The PUD selected for the study was the Philips Lumify curved array (Philips, n.d.) connected to a six-by-eight-inch android tablet to display the ultrasound images. The advantage of choosing the Philips Lumify was its integration with the REACTS® collaborative platform which became the first integrated tele-ultrasound system in the world (Canadian Healthcare Technology, 2018). The selection of REACTS® for the remote interactive instruction component enabled 'telepresence' in study design, to bridge in-person separation using technology that enabled the closest situation possible (interaction and communication) to being physically present for hands-on teaching/learning. In this lab scenario learners were physically close to their partner (as with traditional f2f scenarios in ultrasound education) and only connected with the instructor by distance via real-time audio-visual connection to simulate the 'over-the shoulder' teaching of f2f models. In this sense, instructors were 'present' albeit by distance or in a virtual presence. Due to the real-time interactive scanning sessions instructors were able to provide feedback to each learner in a one-on-one setting, simulating the current f2f teaching method for ultrasound labs at NAIT.

Phase 3: Post-instruction – Mid-study Online Questionnaire

Once instructional components were completed, each participant completed an online mid-study questionnaire (Qualtrics software) to capture their post-DE learning experiences, satisfaction levels, and perceptions of OSCE readiness (Appendix B2). Questions were informed by the studies of Mason Barber and Schuessler (2018) and Berragan (2013) to yield the participant's whole experience (facts and feelings), in applying their theoretical knowledge from Moodle resources to their hands-on labs (real-time, interactive remote instruction). The questions also followed 'debriefing' principles where study participants expressed their reflections on their DE learning experience, including if expectations were met, and their readiness for the next step - to be tested via the OSCE phase.

Phase 4: Assessment of Training (OSCEs)

Following the instructional phase and completion of their mid-study questionnaire, learner participants gathered at NAIT for three consecutive f2f OSCEs; each OSCE was independently assessed by an assessor, one per OSCE station. The assessors scored each OSCE according to a pre-defined evaluation grading rubric (Appendix F1). The critical behaviors sought were attainment of each competency of 35 competencies (complete or not) as outlined in the grading rubric and observed/assessed by the study's assessors, trained in practical assessment of ultrasound students. Although the assessors were not aware of what constituted a 'pass', the researcher subsequently analyzed the data from a national benchmark of a minimum of 24.5/35 completed competencies (minimum 70%) and a NAIT standard of a minimum 22/35 completed competencies (62.8% rounded up to 63%).

The rationale to use OSCE methodology in the study design was guided by Walsh et al. (2010) who discuss the psychomotor testing ability of OSCEs to assess and measure nursing students' clinical performance in health sciences. As measurement of study participants' EFAST performances were a key component to the study, scenarios with SPs enabled OSCE assessors to evaluate and score a participant's ability to perform EFAST scanning skills (psychomotor domain) while integrating their knowledge (cognitive domain) and demonstrating their professional and communication abilities (affective domain). This phase of the study was also guided by the research of Castro-Yuste et al. (2018) who developed the Student Assessment Tool for Standardized Patient Simulations (SAT-SPS), an instrument earlier proposed by Walsh et al. (2010). Castro-Yuste's study reports the reliability of the SAT-SPS for OSCE assessment of nurse practitioner skills (cognitive, psychomotor, and affective domains). Appendix F1 presents a similar tool adapted for the study, focusing on PUD performance (instrumentation, image acquisition, ergonomics, exam closure), and professional 'soft skills' (professional behaviors and patient interactions). The rationale for using this rubric/tool was to minimize the subjectivity inherent in assessment by observation. In relation to the field of ultrasound, the OSCE format was further informed by the methodology implemented by Amini, Stolz, Javedani, et al. (2016) in their study to evaluate emergency resident performance with OSCEs after focused POCUS training.

A key component of phase four was the use of ultrasound models acting as SPs, each with a scripted question to pose within the simulated EFAST scenario to assess professional interactions. The scripted questions were general in nature as follows: "I'm very nervous. Will this test hurt?"; "I don't feel so well…How long will this take?"; "When will I get my ultrasound results?" These scripted questions were created to evoke a response from the learner simultaneously as they scanned their ultrasound model within the 15-minute OSCE time frame, thereby, allowing each assessor to rate the professional interaction skills/behaviors of each learner. The preparation of the three ultrasound models was undertaken by a research assistant already engaged in SP and ultrasound model preparation at the researcher's workplace. In this activity this research assistant ensured that the models were notified to arrive to the OSCE appointments with a full urinary bladder (necessary for pelvic ultrasound) and were aware of the details surrounding their one scripted question, to be asked of each learner within the first three minutes of the OSCE and to be repeated once only if they received no reply.

The study's use of SPs was informed by Mason Barber and Schuessler (2018) who recommend strategies for orientation and preparation of SPs. The researcher opines that using a simulated environment, designed as authentically as possible to imitate real-life POCUS settings, contributed to a meaningful learning experience for study participants, parallel to the experience articulated by Berragan (2013) in the context of nursing students who "respond, behave and *feel* like nurses" (p.

251) as they engage in simulation. The study design created an environment where study participants would respond, behave and *feel* like EFAST practitioners.

Phase 5: End-study Online Questionnaire

After completing their DE instruction, mid-study questionnaire, and their three f2f OSCE assessments, and, after receiving their average OSCE score, participants completed an online end-study questionnaire (Appendix B3) via Qualtrics software. Questions reflected those of the pre-study questionnaire to glean pre- and post-study insights on perceived transfer of learning, changes in beliefs or training relevance, final descriptions on the overall learning experience, levels of satisfaction, and recommendations for future instructional design.

Overall, design of the questionnaires captured learner levels of perceived learning progression and training experiences from pre- to end-study, including recommendations for future POCUS training. Questions in the pre- and post-study questionnaires were designed to be similar for comparative analysis of 'pre-and post-test' data, primarily in the areas of training relevance, perceived knowledge/skills transfer, learner beliefs and expectations. Instructor field notes provided data from the instructor lens on their teaching experiences, with templated questions designed for comparison with learner data, e.g., the effectiveness of multimedia resources, REACTS®, and recommendations for future instructional design. Content of the mid-study questionnaire was primarily designed to yield data on learners' self-reported learning experiences, and their recommendations for future instructional design. The study phases as outlined above required research assistants, selected according to pre-determined selection criteria.

Research Assistant Criteria

As Principal Investigator (PI), the researcher engaged other NAIT personnel to assist with the research study. Requisite criteria for instructors and assessors mandated ultrasound-credentialed faculty to serve as: two sonography instructors for DE delivery of the training, and three different sonography instructors to assess the learning outcomes in a f2f OSCE format. In addition, the following human resources were recruited: a research administrative assistant for the participant selection process, questionnaire deployment/collection, schedule coordination, and confidential and secure data management. As well, an information technological assistant (IT) was recruited, and an OSCE facilitator for coordination of timed OSCE sessions and rotations. For data analysis, an external co-coder was employed to assist the PI with learner narrative analysis. Appendix H itemizes the study's research assistant plan.

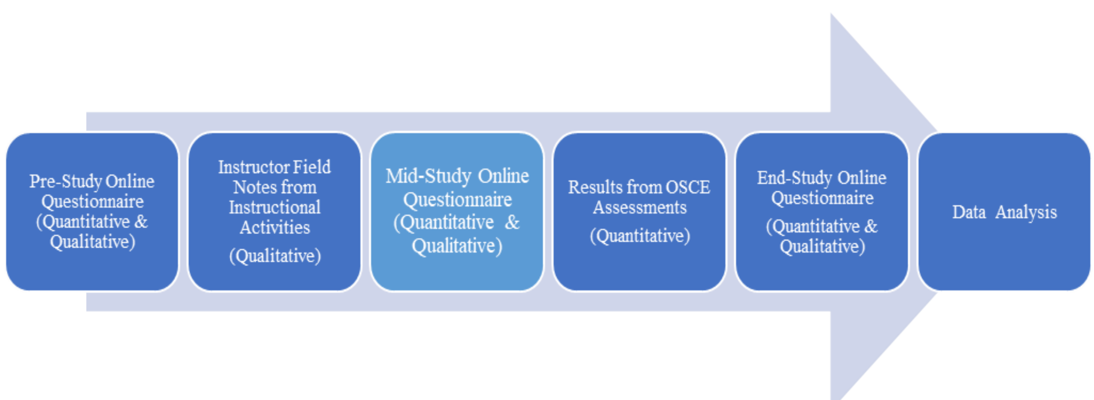
The mixed methods research design outlined above required both quantitative and qualitative data collection tools as described in the next section.

Data Collection Methods and Tools

Data collection methods and tools were designed to yield both quantitative and qualitative data, as depicted in Figure 3 below:

Figure 3

Sequence of Data Collection Activities to Generate Quantitative and Qualitative Data for Analysis



As sequenced above in Figure 3, data collection methods and tools included:

1. pre-study online questionnaire to gather learners' pre-training (pre-test) levels of engagement, training relevance, beliefs in DE, and self-assessments of knowledge/skills areas,
2. electronic instructor field notes derived from instructor observations during instructional delivery to collect teaching experiences and recommendations,
3. mid-study online questionnaire to gather learners' training experiences and recommendations, once the training (intervention) was completed and prior to the OSCE phase,
4. OSCE results recorded on paper to test attainment of learning outcomes (quantitative effectiveness of the intervention), and
5. end-study online questionnaire to test post-training (post-test) levels of training relevance, perceived knowledge/skills transfer, changes in beliefs, if expectations were met, satisfaction levels, and recommendations for future instructional design (qualitative effectiveness of the intervention).

The following discussion further details the data collection methods/tools and their intentions, instruments, and issues.

The online questionnaires were designed to be semi-structured. The primary reason to select an online questionnaire, versus a f2f interview or telephone survey, was due to the anonymity of a questionnaire and lack of researcher presence in optimizing honest disclosure (Cohen et al., 2011), and attending to researcher reflexivity in the research study.

Questionnaire designs were exploratory, beginning with a demographic question, followed by structured and open-ended questions relevant to the phase of the study. The strategy of including open-ended questions aligns with the exploratory nature and collection of "word-based" data as supported by Cohen et al. (2011) who state: "where rich and personal data are sought, then a word-based qualitative approach might be more suitable" (p. 382). The authenticity of "rich and personal" data had the potential to uncover issues and discover new elements of the phenomenon of DE in POCUS. With a well-designed questionnaire, administered appropriately, yielded data would meet the required depth and scope for qualitative data analysis. To attain this goal, issues surrounding a questionnaire data collection tool were identified and addressed.

Issues concerning the deployment of online questionnaires required consideration. As described by Kanuka and Anderson (2007), adherence to ethical principles of privacy (consent, non-traceability, confidentiality, and anonymity) are paramount within an electronic medium. With ethical issues surrounding the personal or sensitive nature of certain areas of inquiry, Sudman and Bradburn (1982) suggest that open-ended questions elicit candid and authentic answers, especially in sensitive subjects. The issues described above called for transparency at the outset in the researcher's recruitment process and materials, for example, clarity of research purpose, beneficence, no maleficence, informed consent, right to withdraw, etc. (Cohen et al., 2011), as well as assurances of "appropriate security measures" within ethical data management principles (Cohen et al., 2011, p. 99).

Another area of concern was the questions themselves. Question writing applied best practice principles, otherwise study data would not have been useful for analysis, and validity compromised. Cohen et al., (2011) offer several caveats in the framing of questions, such as avoiding "leading…highbrow…complex…irritating…[and/or] ambiguous questions" (pp. 396-397). Lewis and Allan (2005) emphasize the need for clarity in the context of what data are being sought to avoid further data collection at the end. This called for optimal questionnaire design prior to implementation.

Attention to issues discussed above, together with well-designed questionnaires, collected participants' direct and honest expectations, feedback and reflections. Questionnaires explored both practical learning experiences as well as participants' feelings, thoughts, and ideas. The researcher believed it was critical to identify and mitigate any issues of sensitivity and/or perceived threat in the research design and administration of an electronic questionnaire. This scrutiny and methodological rigor were served with third-party neutral review of the questionnaire tools prior to their operationalization in the pre-study field test.

Data Collection Method #1: Pre-study Online Questionnaire (Appendix B1)

The intent of the pre-study questionnaire was to collect learners' 'pre-test' data on their: 1) self-assessments of knowledge/skill levels in POCUS from their ultrasound-naïve positions, 2) beliefs in DE to attain hands-on skills and professional behaviors, and 3) levels of training engagement and relevance. Pre-study questionnaire data were primarily analyzed to compare to similar end-study questionnaire data to gain 'pre-and post-test' insights on the effectiveness of the training intervention. These insights contribute to future instructional designs of EFAST and POCUS curricula.

Data Collection Method #2: Field Notes from Instructors' Observations (Appendix C)

Instructors' observations were collected after completion of their instructional roles in the study. Instructors summarized their observations in their field notes using an electronic question template developed by the researcher and provided/collected by the research administrative assistant. The template enabled consistency of observational practice and preserved the integrity of the collected data. The purpose of collecting instructor field notes was four-fold: 1) gain knowledge on their teaching experiences, 2) gain insight into the needs of learners, for example, training areas which needed additional explanations or lab practice and why, 3) assess any differences in teaching needs amongst the different learners and/or allied health professions, and 4) collect instructor recommendations for future instructional DE design. Analysis of field notes data informs future PUD teaching practice and POCUS curricula design.

Specifically, as suggested by Kirk and Miller (1986), the instructors were encouraged to maintain ongoing journal notes to capture in situ observations for the reporting of their summary reflections in their submitted field notes. As stated by Carspecken (1996), the type of data collected with field observations yield rich contextual data. The aspects of realism and authenticity within these focused observations contributed to the internal and external validity of these data (Cohen et al., 2011). Once completed, the data were analyzed by the researcher.

Data Collection Method #3: Mid-study Online Questionnaire (Appendix B2)

The rationale for a mid-study questionnaire was to capture learner participants' DE experiences *prior* to being formally tested in the OSCE phase. Collecting data from learners before they were 'tested' preserved the integrity of these data without the potential of an OSCE experience or score being a variable in the analysis of the learning experiences. Comparing learners' feelings of readiness for testing with their actual OSCE scores assisted future curriculum DE POCUS design to optimally identify learning outcomes that are structured for learner success in hands-on scanning skills and professional behavior competencies.

Data Collection Method #4: OSCEs - Skill Assessment and Grading (Appendices F1 and F2)

Once mid-study questionnaires were completed learner participants were scheduled for their OSCE rotations within three to seventeen days, according to participant and assessor availability. Assessment of learning outcomes per learner were conducted at NAIT in an f2f format with each participant performing three consecutive OSCEs, assessed independently each time by a different assessor. Ultrasound models were employed for each OSCE station; each model was given one question to ask, the same question asked for each learner, a strategy to assess professional behavior competencies. The grading rubric and OSCE content yielded a maximum score of thirty-five competencies per OSCE station allowing each learner to attempt a competency three times within their OSCE rotation. OSCE score sheets (paper) were identified by learner and assessor participant codes only, and results remained confidential. A learner's average OSCE score was communicated by e-mail to the learner by the research administrative assistant, after completing their last OSCE and before completing their end-study questionnaire, thus the learners knew their grade before they were given access to completing their online end-study questionnaire via Qualtrics. To note, the letters of information and informed consent for learners, instructors, and assessor participants offered certificates of research participation and associated hours, upon request to the research administrative assistant, once their participation was fully completed with the submission of their end-study questionnaire.

The study's OSCE design was informed by research conducted by Amini, Stolz, Javedani, et al. (2016), Berragan (2013), Castro-Yuste et al. (2018), Chenkin et al. (2008), and Mason Barber and Schuessler (2018), who investigated OSCE methods of assessment and validation including scripted scenarios with SPs. This was a key data collection step to answer the primary research question – did the DE training work or not? In other words, did the ultrasound-naïve status of learners change to one of ultrasound knowledge/competency, as validated by their OSCE score, a standard clinical skills assessment method used in medicine and allied health sectors for competency attainment. The degree of change from a learner's ultrasound-naïve status (no prior training or experience in ultrasound, including POCUS) was also informed via gathering learners' self-assessments on their knowledge/skills areas on the pre-study questionnaire for comparison to their perceived acquisition of those same knowledge/skill areas on the end-study questionnaire. In addition, instructor field notes were structured to capture observations on the transfer of learning in the scanning labs and to comment on learning progressions. Data analysis further gleaned *how* it worked from other data collection tools described thus far, as well as the final data collection tool, the end-study questionnaire.

Data Collection Method #5: End-study Online Questionnaire (Appendix B3)

The intent of the end-study questionnaire was to collect data on learner participants' 'post-test' status of: 1) change/no change in training relevance, 2) perceptions on acquired knowledge/skill areas, 3) change/no change in beliefs in DE to attain hands-on skills and professional behaviors, and 4) feeling knowledgeable in being able to perform the EFAST scan and demonstrate required professional behaviors. Data collection method #5 further explored learner participants' 'post-test' reflections on their training and OSCE experiences, and, at this stage their summative levels of training satisfaction. As earlier described, the same attention to integrity was applied to the end-study questionnaire, well-designed to collect learners' direct and honest reflections at a post learning/assessment point. As with pre- and mid-study questionnaires learner feelings, thoughts, and ideas were also explored in the end-study questionnaire.

The quantitative and qualitative data collection methods and tools described above provided critical content fordata analysis. In congruence with a mixed methods approach to data collection, multiple methods for data analysis were utilized.

Data Analysis

In context of the study's research questions, data analysis was guided by the NWKM (Kirkpatrick & Kirkpatrick, 2016) of training evaluation, and the three learning domains as articulated by Anderson et al. (2001) for the cognitive and affective taxonomies, and Simpson & Illinois Univ. (1966) for the psychomotor domain, as outlined in Appendix D. For analysis of learner participant narratives, the researcher employed a co-coder research assistant, non-NAIT and external to healthcare - an off-site neutral party who had no vested interest in the study's outcomes. The researcher and co-coder worked together to pre-determine an analysis framework and coding procedures to attend to inter and intra coder reliability (Appendix L). The researcher and co-coder worked together to ensure alignment and common understanding behind the data collected.

Questionnaire Data

Questionnaire data were both quantitative and qualitative with analytic induction applied to generate categories and themes. Questionnaires were constructed in a pre/post-test design to compare learner participants' pre- and end-study data, whereas the mid-study questionnaire was structured to capture data at the end of instruction and prior to OSCE testing. Analysis was also aligned to the project's research questions. The advantages to this approach included accumulation of relevant data in a cohesive manner, reducing the data to the "exact issue of concern to the researcher, and [preserving] the coherence of the material" as well as "closing the loop on the research questions" (Cohen et al., 2011, p. 552). Cycling back to the research questions was advantageous in clarifying the data collection process within the research project and highlighting its overall purpose (McNiff & Whitehead, 2002). Data were investigated to seek distinguishing features in participants' construction of their own meanings and experience in learning a new hands-on skill by DE. Questionnaire data represent study findings aligned to all four levels of the NWKM (Kirkpatrick & Kirkpatrick, 2016) to investigate reaction, learning, behaviors, and results of the training intervention. In addition, narratives within questionnaire data were analyzed in accordance with affective, cognitive, and psychomotor learning domains for evidence of hierarchical progressions within each of the respective taxonomies of educational objectives.

Field Notes Data

Instructor field notes were summarized by each instructor according to a structured electronic template to capture their teaching experiences, reflections, and recommendations for future instructional design (Appendix C). Narrative analysis of compiled field notes enabled the researcher "to understand the situation vividly from the perspective of the [instructor] participants" (Cohen et al., 2011, p. 583). Instructor reflections attended to credibility (validity) issues in respect to research principles, with case study participants being the "main knowledge producers" (Koro-Ljungberg et al., 2009, p. 689). Field note authors held essential data to be triangulated and correlated to other collected data, i.e. that of learner participants. Preservation of this essential data for integrity and quality was required in its significance to each participant. Content analysis and data reduction were applied to ascertain the core meaning of instructor field notes per question and it was equally important to interpret the data broadly to get a sense of the whole. With this holistic view in mind, field notes' data were compared to learner data, including learner and instructor recommendations for future instructional DE designs for POCUS and EFAST practice.

OSCE Scores

Data from OSCE scores directly answer the primary research question at a quantitative level. These data also contribute to qualitative analysis of other study data to gain insight into the efficacy of the educational intervention to learn PUD ultrasound competency in EFAST by distance. These insights also inform which cognitive, affective, and psychomotor learning domains were engaged in the training, insights for future recommendations for instructional design. The researcher applied the OSCE learner scores to the third level of the NWKM (Kirkpatrick & Kirkpatrick, 2016) which evaluates to what degree was learning demonstrated at the behavioral level, because of the training.

Quality of Data Analysis

Meaningful insights gained from data analysis depended on the quality of data interpretation. As mentioned earlier, a co-coding approach was used for narrative analysis of learner data. The researcher and co-coder first established a coding framework towards coding congruency to attend to their inter and intra coder reliability, for example, agreement on definitions, and the 'unit of analysis'. The data analysis tools utilized were Qualtrics software (Qualtrics, May 2019) and Microsoft Excel for Office (version 1905) to assist the review of aggregate data, data management (storage and organization), coding processes (categorization) and to explore data connections.

The approach to data analysis was consistent with interpretative inquiry into a phenomenon (Koro-Ljungberg et al., 2009). In this study, the phenomenon was the possibility of a learner participant attaining EFAST competencies with a PUD entirely via DE as an ultrasound-naïve individual, and an ultrasound instructor being able to teach these competencies remotely. The inquiry was based on data collected from those individuals experiencing the phenomenon themselves. Data analysis methods reflected strategies to critically understand the phenomenon and uncover issues, probe further into unexpected areas of discovery, and explore possible solutions.

The data analysis strategy also aligned with a critical theorist paradigm in its interpretation of emerging data towards change and improvement of the community (Koro-Ljungberg et al., 2009). In context of the research study, 'change and improvement of the community' could include new and effective DE instructional designs in POCUS for the researcher's workplace/organization, as well as the broader healthcare industry. With this lens, evaluation of the study's training design and outcomes required a process that would measure individual participant outcomes as well as potential change for improvement of the POCUS community – an evaluation model that would 'fit' the purpose of the study.

Selecting the four-level NWKM to evaluate the study's training intervention aligned with 'fit to purpose' in the following ways. In the first two NWKM levels, evaluation of learner reaction and learning enabled analysis to address the research sub-question to learn *how* the learning would or would not transfer. Within the third NWKM level, where trainee performance is measured as manifested in behavioral change, measuring the EFAST performances of the learners in the simulated 'on the job' environment of POCUS, was key to address the primary research question. Lastly, with the fourth NWKM level going beyond measuring individual training/performance to also assess the impact on organizational outcomes, the study's results could be applied to the educational needs of the POCUS community. This last level of the NWKM has also been viewed as a fifth level with assessment of an organization's 'return on investment' when resources are applied to organizational training needs (Pearlstein, 2008). For the study, the fourth NWKM level was applied to the training intervention's contribution towards effective future instructional design of benefit to the POCUS community, in response to the call for standardization of POCUS training, and the community's need for access to training via DE.

Despite careful planning of data collection methods and data analysis strategies, internal and external factors could have rendered the study inoperable or may have required modification. Thus, a review of practical issues, limitations and delimitations, ethical considerations, trustworthiness, and related philosophical implications required critical consideration.

Other Considerations

Practical Issues

A key consideration in the study was determining the feasibility of the research project and related practical issues of access, time, and resources. With a case study research design and the engagement of faculty at the researcher's workplace, a presentation of the research plan to senior administration was a necessary priority for access. As advised by Burns (2015) securing support from the top of the organization was a first step in attaining not only approval but cooperation as well. Although the first expression was in outline form, clarity and precision were critical in presenting key elements, such as project purpose and scope, "access to what" (budgetary factors, material resources, time factors), access to whom (human resources, sampling), as well as a guarantee of adherence to ethical principles (Cohen et al., 2011, p.109). Together with general support for research and innovation at NAIT, research activity must also be purposeful, beneficial, and aligned to organizational goals. It was necessary to answer, practically and philosophically, the question: What difference will this research make? As stated by Hopkins (2008), researchers need to give attention to whether their research will do any workplace good if their results are rendered inert, or, are without influence towards organizational change. With an overall research purpose aligned with the organization's commitment for quality DE, a letter of executive level of approval and access was granted (Appendix I), and all tenets of research integrity were clearly presented, and transparency assured.

In consideration of the availability of resources, human and material resources were in place for this project. Credentialed faculty for EFAST instruction and assessment agreed to participate according to the timelines proposed; this participation included the creation and/or updating of instructional videos, and training on the Lumify PUD with its integrated REACTS® platform for the remote tele-assisted scanning labs. In addition, access to necessary ultrasound equipment lab facilities and PUDs were confirmed for the purposes of the study.

The primary resources required were human and material. The number of faculty engaged in research was reasonable with their pedagogical skills in place; administrative assistants and support personnel were confirmed. Data collection tools were secured for data collection and aggregate analysis. In-kind costs were incurred for instructors, research assistant time, questionnaire deployment and return, data storage, co-coding in data analysis, and other logistic expenses to facilitate the study's collaborative activities, for example, meeting costs of the research team in the pre-study field test. Cost considerations, direct or in-kind, included impacts to workload capacity and time commitments of researcher/faculty participants. All of these were key elements of negotiation, and agreement was secured at the institutional level. Research activities occurred in synergy with the regular instructional duties of instructors and were aligned with scholarly activity and research priority outcomes for the institution. For example, research participation hours for the NAIT instructor and assessor participants were aligned with their regular professional development and scholarly pursuits within the academic year. In contrast, the research hours dedicated to the project by the research administrative assistants were tallied and 'time off in lieu' was granted or banked, to be taken at the discretion of their supervisor. In the case of the IT assistant, research hours were approved in advance and were aligned within the IT support job description, to support the institution with IT needs, as approved.

With regards to project scope, the research plan attended to parameters with "clear, perceptible, realistic, fair and manageable boundaries" (Cohen et al., 2011, p. 110). These elements called for precision in the research design and an achievable estimate of time. Following approvals of the research proposal, and subsequent research ethics board reviews (Appendices J1 and J2), the research timeline unfolded as presented in Appendix K. In relation to clear and manageable boundaries, the limitations and delimitations of the project scope were articulated for research ethics approvals and responsible communication to study participants.

Limitations and Delimitations of the Study

The limitations and delimitations of the study were communicated to participants in their respective letters of information/informed consents, with exception of ultrasound models. Study limitations and delimitations, itemized below, are taken directly from letters provided to participants at the beginning of the study during the recruitment phase (Appendices G5 to G7).

The study encompasses the following limitations:

1. The scanning of pre-selected live subjects (ultrasound models) will occur for the OSCEs, as well as participants scanning each other. This 'pre-selected 'element does not represent the real world of clinical ultrasound as the ultrasound models will be vetted and selected for the suitability of their body-habitus to standardize the subject matter for all research participants. This element will avoid the myriad of variables that present themselves with non-vetted random human subjects and the variations of body habitus and unexpected conditions. Participants cannot expect their scanning experience to fully represent the clinical field where patient conditions vary.

2. Unexpected and/or emerging technical delays with the DE instructional methods. These potential difficulties hope to be prevented by pre-study field testing to test the DE instructional resources and tools and by engaging dedicated technical help during the instructional phase of the study.
3. Convenience sampling: restricting a sample from the allied health sector may limit the generalizability of study results. The sample does not represent the full practitioner demographic of POCUS environments however, the sample does represent itself. This limitation is somewhat offset by the diversity of multiple professions in the sample.
4. Potential lack of a viable sample from the recruitment process or drop-outs after the start of the study could affect robust data outcomes, however, even a small sample would be worthy to answer the primary research question. Low participation from an allied health professional group would affect the second research sub-question, however, the net is being 'cast wide' in this element with the hopes of a minimum of 3 professions participating from a potential of 8 professional groups on the NAIT campus. The potential of not enough volunteers and/or lack of balance in professions can be offset with a well-planned recruitment strategy.
5. Targeted Ultrasound: The study's PUD scanning experience encompass certain body areas only, which does not represent the full scope of PUD and POCUS practice. Participants will not be proficient in scanning other body organs that could be investigated with PUDs. This factor is both a limitation and delimitation.
6. Limited Internet Availability: This limitation was not included in participant letters of information/informed consents and is worth mentioning in this dissertation as a valid limitation for remote educational activities which rely on effective bandwidth and stable

internet coverage for e-learning. As identified in the next chapter (study results), internet/technical connectivity was sporadic even in an urban setting.

The study encompasses the following delimitations:

1. Participant instruction with a PUD will be restricted. The goal of the study is for participants to attain competency in limited views of the lungs, heart, abdomen, and pelvis. Learning how to perform a complete (comprehensive) lung, heart, abdominal, or pelvic ultrasound will not be possible for the learners. This delimitation is in alignment with the actual practice of POCUS which is quick and focused with the intention of producing a limited ultrasound study for diagnosis and treatment plan. In addition, learning ultrasound scanning in the study does not represent the full practice of ultrasound in general, a delimitation related to limitation #5 above.
2. The study will not investigate the attainment of PUD competency with DE instruction for physicians (non-allied health) and diagnostic medical sonographers (non-ultrasound-naïve). Despite the restriction to allied health professions the researcher believes that the study's findings will be transferable to other health professions with a POCUS scope of practice.

Communicating study limitations and delimitations to participants provided clarity in what the study could and could not do, thereby providing a level of transparency in the research project, a transparency which engendered an element of trustworthiness.

Trustworthiness and Credibility

Issues of trustworthiness and credibility required additional scrutiny in this case study research method. Kelly (1989) advises careful and ethical consideration for researchers who must be alert and aware of potential pitfalls that may emerge. Potential pitfalls could have included: misperceptions of conflict of interest and/or misassumptions of inappropriate power relations between the researcher, the instructors, the assessors, and research assistants who are regular workplace colleagues. To offset potential research pitfalls, Hopkins (2008) advises the researcher to work within one's scope of practice and expertise. This translates to researcher grounding, understanding of researcher reflexivity, and self-awareness of possible personal and professional bias (Newby, 2010). Study outcomes could have reflected positively or negatively on NAIT and/or the researcher's workplace position. Another source of possible bias was the researcher's ultrasound-educator background where the desire for certain results could have been perceived. These areas of potential bias reflected a place where "ethics, validity, and political agendas collide" (Cohen et al., 2011, p. 359).

In this mixed methods study, triangulation of multiple data collection methods in the research design assisted researcher objectivity (Cohen et al., 2011). To contribute to research trustworthiness, the services of a co-coder from a non-health background and external to NAIT were secured to provide a neutral lens to data analysis of study results. To offset potential researcher bias and foster a culture of trust the researcher was purposely mindful to remain objective and avoid hands-on contact with the on-site research activities once the pre-study field test was completed and formal participant recruitment of the study commenced. Ongoing communications and study tasks were coordinated and managed via the administrative research assistant. This purposeful arms-length researcher behavior promoted adherence and respect of research protocols and ethical considerations.

Ethical Considerations

In alignment with the study's principles and adherence to research ethics, the following three areas were carefully considered: 1) privacy, anonymity, and confidentiality of participants, especially with the collection of electronic data, 2) informed and voluntary consent procedures, and 3) issues that could potentially arise due to conducting research at the researcher's workplace.

A key ethical consideration was the assurance of privacy, confidentiality, and anonymity for participants. Researcher credibility was paramount, as study participants needed to fully trust the researcher, the research assistants, and the research process itself, to deliver on their privacy, confidentiality, and anonymity. Additional and critical factors in these assurances were the complexities involved when conducting research in an online environment. As emphasized by Kanuka and Anderson (2007), the e-learning field poses ethical uncertainty in three primary areas of confusion: "(a) participant consent, (b) public versus private ownership, and (c) confidentiality and anonymity" (p. 21). Attention to ethical factors with collection of electronic data was relevant to the study due to the online questionnaires, electronic field notes, and subsequent management of these electronic data. Participants were assured of privacy and anonymity of their data by utilizing their unique alphanumeric participant code for all data collection activities. In addition, the informed consent process clearly articulated the confidential manner of data storage, including the data retention period. Also, privacy for data analysis and its adjuncts of anonymity and confidentiality were assured via aggregated and anonymized data for the questionnaires and field notes (Cohen et al., 2011).

It is important to note that complete privacy and anonymity of participants was not realistic in the instructional and assessment phases of data collection due to the nature of the case study research design and recruitment of workplace faculty. However, as suggested by Cooper and Schindler (2001), confidentiality was protected by securing signed statements of non-disclosure from the researcher, all research participants, and assistants prior to the onset of the study. These written assurances to comply with confidentiality addressed two potential ethical dilemmas which could have arisen due to the sensitive nature of the study: 1) the intimate nature of learners scanning the body of another learner, and 2) the vulnerability of participants willing to teach or learn a new skill amongst workplace colleagues. In consideration of the first dilemma, informed consent procedures carefully outlined the intimate nature of participation in the scanning labs, as well as the potential of incidental medical findings in ultrasound imaging and how they would be managed if they emerged. For the second potential dilemma, where participants may have been concerned about their learning progress or OSCE scores, pro-active measures were put in place via anonymized data coding procedures and declarations of confidentiality by all research personnel. The discussion above highlights the importance of providing full and transparent information prior to a participant's voluntary consent.

In the initial research phase of informed and voluntary consent, careful attention to articulating the study's beneficence and any maleficence elements was essential for recruitment. These elements were precisely identified in the study's limitations and delimitations, included in the content of comprehensive letters of information prior to voluntary consent, also reflecting ethical requirements of transparency in the information provided. The comprehensive nature of informed and voluntary consent also speaks to clarity of information for study participants to ensure full comprehension of the study's purpose, its voluntary nature, and commitments involved. In addition, participants were not permitted to begin the study (pre-study questionnaire) until their informed and voluntary consent forms were signed and received by the research administrative assistant. The above discussion reflects a rule-based deontological perspective for ethical research practice. In the researcher's opinion, application of this deontological lens to the study was critical for integrity of the research design, activities, collected data, and researcher credibility.

In this case study research, the researcher, research assistants and participants were embedded in their employment settings and ethical dilemmas could have presented themselves in the context of workplace issues. One such issue was perceived inappropriate power relations due to the hierarchy of staff positions within research personnel. To address potential misperceptions of power relations, upfront discourse occurred as follows:

- o communication to convey lack of workplace hierarchy and promotion of a peer structure in the research study,
- o clarity regarding non-maleficence and beneficence of the research,
- o compliance with all respectful workplace policies, and adherence to NAIT's vision, promises and values (NAIT, n.d.), and
- o role-modelling and advocacy to promote the concept of research conducted *with* the people and not *to* or *for* them (Cohen et. al., 2011, p. 86).

Objectives to promote lack of hierarchy were strengthened by emphasizing the researcher's self-perception as an insider, working collaboratively with other insiders (McNiff & Whitehead, 2002). An ethical dilemma of workplace research could have been the issue of betrayal, explained by Kelly (1989) when teachers (study instructors and assessors) may feel betrayed when they have been treated every day as collaborators and later their interactions are potentially judged by their colleagues, post-study. The researcher employed transparency and full engagement of faculty in the research process to foster connectivity and promote the project's beneficial goals to the team and institution. The pre-study field test interactions assisted to engender a collaborative culture of trust within the research team of instructors, assessors, and assistants.

Once the formal study commenced with participant recruitment within the milieu of the workplace, the researcher's relationship to study participants remained at arms-length, with the only point of contact to answer participant questions prior to the study (participants who self-disclosed), as part of the informed consent process. All other conversations and communication related to the study were conducted through and with the research administrative assistant. In addition, adherence to research principles of privacy, anonymity, and confidentiality as earlier described, contributed to researcher credibility in this case study research.

The ethical principles discussed thus far were considered carefully to ensure that study results were “dependable, credible, transferable, plausible, confirmable and trustworthy”, elements of “legitimation” (Onwuegbuzie & Johnson, 2006, as cited in Cohen et al., 2011, p. 198). Credibility (validity) and trustworthiness (reliability) can be in fragile positions due to perceptions of vulnerability for participants involved in onsite research. For this critical theorist paradigm and research style, it was important to spend more time than normal in preparing the environment for the workplace ‘actions’ of the study to establish capacity for collaboration, validity, and trust, as demonstrated by the willingness of DMS instructors and administrative assistants to participate in the field test. In addition, the triangulation methodology of mixed methods maximized consistency and eliminated potential bias for subsequent data analysis. As advised by Johnson (1997), consistency testing in qualitative research can be assisted by using multiple methods for the data collection stage. Multiple methods are also supported by Cho and Trent (2006) to achieve a “holistic view of validity in qualitative inquiry” (p. 335).

Ethical considerations were applied at every step of research planning, from the initial gaining of organizational access to post-research activities, for example an “indebtedness to participants” (Cohen et al., 2001, p. 88). Whatever the research topic and design, social researchers are required to attend to preserving human dignity (Cohen et al., 2011). It was the researcher’s responsibility to adhere to sound ethical principles of research inquiry, e.g. researcher objectivity, integrity in the treatment of data, and consistency in data interpretation/analysis.

Consistency in data analysis lay in the challenge of data reduction whilst retaining the integrity and quality of the data collected (Cohen et al., 2011). Strategies to co-code learner narrative data (researcher and second coder) were utilized according to a pre-determined framework, to promote consistency in data interpretation and to maintain researcher objectivity. Appendix L outlines the approach used for categorizing and organizing: 1) learner narrative data for co-coding analysis within the NWKM of training evaluation (Kirkpatrick & Kirkpatrick, 2016), and 2) learning domain taxonomies according to Anderson et al. (2001) for cognitive and affective domains, and Simpson and Illinois Univ. (1966) for the psychomotor domain. The services of a neutral co-coder, from a non-health background, promoted researcher credibility and trustworthiness to data analysis.

Electronic data were examined with reliable analysis tools known for preserving quality in thematic and word-based data analysis and management, with specifications to assure privacy for all participants. Data analysis was derived from questionnaire reports by Qualtrics software (May 2019), electronic instructor field notes in MSWord, with paper OSCE data entered and managed with version 1905 of Microsoft Excel for Office (2019).

Ethical factors considered above were aligned with a mixed method interpretive case study research design, guided by a critical theorist paradigm. A critical theoretical framework was a practical fit with this case study approach, where self-assessment for ongoing quality improvement/assurance is a common activity in an educational environment. Adjunct philosophical issues also required reflection in their relevance to the research study, as expanded in the next section.

Philosophical Factors

Attention to philosophical issues answered the following questions: Why study POCUS education delivered by distance? Why was a PUD selected? Why was the investigation conducted at one's workplace? What difference did the research make and to whom? The following discussion addresses these questions from the researcher's perspective.

The research purpose to study the phenomenon of POCUS training with DE aligned with the researcher's ongoing career practice towards pedagogical improvements in learning and teaching. This also aligned with the post-secondary education nature of the researcher's workplace institution with academic commitments to being relevant and responsive to stakeholder needs, such as quality

DE. Education by distance offers alternatives and flexible pathways for prospective learners (stakeholders) should traditionally forms of education be inaccessible or not preferred, as is the case for POCUS practitioners in restricted or remote areas. The offering of alternatives to promote learners' success abiding by the philosophy of progress in learning and improved healthcare were driving factors behind the researcher's philosophical stance.

Selecting a hand-held PUD for the study was due to its popularity in POCUS and ease of use, elements which motivate many medical personnel to use it, so much so that it is reported to replace the traditional stethoscope (Kaul, 2014). Given the study's contribution to quality DE in POCUS it was best to conduct the investigation with a tool that was reported to be popular and widely accessible (Choo et al., 2017).

The decision to conduct the research study at the researcher's workplace served the interests of the following groups: NAIT's clients (students and healthcare industry), workplace colleagues, post-secondary institutional goals, broader educational needs of allied health and medical personnel, and other domestic and international educational healthcare needs. Practical research is not new to the researcher's organization, however, with evidence of global gaps in standardized POCUS education, especially for the allied health sector, and the need to address this problem with DE, the results of this practical research may benefit several stakeholders.

As previously mentioned, strategies to address existing or emerging power relations between the researcher and workplace colleagues/participants were in order. In practice, the researcher held an insider researcher stance as well as a senior leadership position. A peer-type of relationship did not exist with workplace colleagues/participants. Achieving an insider-working-with-insiders model may not have been achieved. The researcher's philosophy included honest and respectful acknowledgement of what the relationship was (and what it was not) along with the practice of transparency and researcher intentions of collaboration. In addition, thorough and iterative communication with research colleagues (in-person meetings and e-mails) to clarify their roles helped to balance perceived power relations as well as promote ongoing team cohesion (McNiff & Whitehead, 2002). Another factor enabling a balanced group dynamic was alignment with ethical principles of evaluative research, described by Strike (1990) to maximize benefit and apply pedagogical reform, in this case, the development of new online programming in POCUS. Whether the research outcomes resulted in actual benefits was not of philosophical importance in this discussion, rather, it was the research design for practical *potential* benefit that was important.

In alignment with a respectful approach to participant recruitment, the researcher's philosophy on incentives was that they can be desirable in that they reflect recognition for participants' professional time and expertise. In the research study monetary incentives were not provided, however, other factors were attended to as follows: for workplace faculty who were research assistants (instructors, assessors, assistants) there were in-kind negotiations in faculty-researcher workload balance, accomplished in the initial steps of gaining senior leadership approval and organizational access. The subject matter expertise of instructors and assessors was important for integrity of data, also contributing to trustworthiness of the study. Thus, any type of incentive for faculty was seriously and positively negotiated in accordance with philosophical and financial principles of the institution. In addition, perceived benefits of the study were aligned with the shared purpose and spirit of the research design.

The design of the case study research study allowed for learner and instructor participant involvement with an active voice, e.g., questionnaires and field notes respectively. The main knowledge producers in all data collection phases were the participants themselves, a characteristic of case study research (Nisbet & Watt, 1984). The instructors and assessors were empowered by collaboration to engage in the problem under investigation. This self-empowerment and collective activity can influence the level of individual and organizational change driven by research results.

The individual and collective voices were active engagement, not passive observation, and with its advocacy for improvement and organizational change, the researcher voice was also political in nature (Koro-Ljungberg et al., 2009, p. 690).

Summary

In summary, chapter three describes the research methodology applied in context of the research questions, framed in critical theorist and interpretive paradigms to investigate the effectiveness of EFAST training with a PUD delivered in a DE format. In addition, alignment to the researcher's ontological position and epistemological stance is discussed. The study's mixed methods interpretive case study research design is presented, including outline of the study's sampling and participant selection process. Data collection strategies, methods, and tools are described, followed by the study's framework for data analysis. Other considerations, relevant to the study's research design, are also discussed, namely, practical issues of implementation, and limitations and delimitations of the research. Key elements of trustworthiness, specific to the project are also presented including essential ethical and philosophical considerations. Elements described in this chapter, singly and cohesively, present the researcher's methodology implemented to explore effective DE in the use of PUDs in the POCUS protocol of EFAST. In the study's design for participants to learn 'by doing' from their varying and multiple perspectives and experiences (learners and instructors), the study methodology reflects the researcher's epistemological and ontological positions. Upon the completion of data collection activities, study results were ready for review and analysis, as presented in the next chapter.

Chapter 4. Results

Chapter four first describes the overall approach to analysis and presentation of research findings, followed by study results in their detail. The reader is directed to Appendices D and L which provide the respective data analysis evaluation framework, and co-coder guidelines for narrative analysis, to address the research questions.

Overall Approach

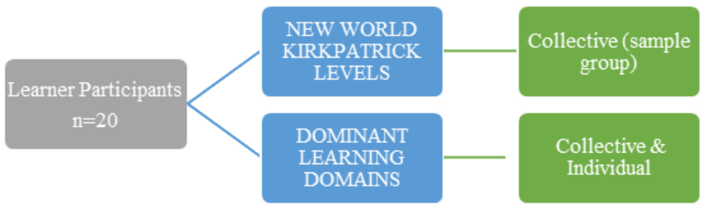
Participants who contributed to data were 1) learners and 2) instructors. Other research personnel in an assessor or ultrasound model role were non-contributors to data, however, they were involved in the study to facilitate data collection activities.

Learner participant data (n=20) consisted of three compiled online questionnaire reports (Appendices M1, M2, M3) and sixty individual online questionnaire reports. Samples of an individual learner questionnaire report are provided in Appendices M4 and M5 with the former reflecting the code used by the learner during data collection, and the latter representing the same learner's code used for data analysis. The conversion of a learner participant's code, e.g., L01, to a data analysis code included their profession, e.g., L01RET; this task was conducted upon completion of the data collection phase by the research administrative assistant to enable researcher analysis of data that may emerge or pertain to the different professions within the learner sample. Learner data also included sixty OSCE assessments and their scores (three each per twenty learners) recorded on paper during the OSCE phase. An individual OSCE assessment example from one learner is provided in Appendix N2, as submitted by the assessor (A02) to the research administrative assistant. Learners' OSCE scores were recorded by the research administrative assistant on an Excel file (Appendix N1), who communicated the OSCE average score by e-mail to the learner, before deployment of their end-study questionnaire.

Learner data were analyzed to align with the four levels of Kirkpatrick and Kirkpatrick's NWKM (2016). In addition, learner data were assessed for evidence of learning domain application to glean *how* learners were engaged affectively, cognitively, and within the psychomotor domain, and, to see if learners experienced any hierarchical taxonomical shifts within these domains as a result of their learning experience/training. These analyses were applied by reviewing questionnaire reports compiled by Qualtrics software (May 2019), and narrative analyses of participants' open questionnaire comments managed with the tools of Microsoft Excel and Word (Appendices V2-V13). In the investigation of learning domain themes, narrative analysis of learners' open comments (words or phrases) were assigned to a learning domain and hierarchy in the co-coding process, in alignment with references from Anderson et al. (2001) for the affective and cognitive taxonomies, and Simpson and Illinois Univ.'s classification of educational objectives in the psychomotor domain (1966). Although learning domains are attended to as a sole section later in this chapter, they are referenced earlier with presentation of results. For this reason, it is prudent to outline selected hierarchies within each taxonomy. For the affective domain references are made to progressions from: 'receiving' (awareness, willingness), 'responding' (motivation to learn) and 'valuing' (learner beliefs and attitudes of worth). In the cognitive domain progressions from 'understanding', 'applying', 'analyzing', to 'evaluating' are noted. And lastly, in the psychomotor domain, there is mention of the 'set' level (ready mindset) through 'guided response' and 'mechanism' (imitation). Figure 4 depicts the overall approach of data analysis and presentation of study results for learner participants.

Figure 4

Overall Data Analysis Approach to Study Results for Learner Participants



Instructor field notes, narratives organized by pre-determined questions, were analyzed by the researcher to glean insights into instructor reflections on their teaching experiences with the learner group, including their comments on any observable learner differences requiring unique teaching accommodations - individual or within a profession (Appendices O1 and O2). On this latter point, the researcher notes that instructor participants were already acquainted with learner participants as colleagues from the NAIT School of Health and Life Sciences faculty; this familiarity enabled instructors to offer their insights into any differences in teaching strategies amongst the different professions in the sample group, if observed. The field notes were also analyzed to capture instructor recommendations for future instructional design. A third lens applied to field notes' analysis was a comparison of what instructors recorded and what learners provided in their questionnaires; this comparative analysis is presented in Appendix O3. Figure 5 depicts the overall approach to data analysis and presentation of instructors' field notes.

Figure 5

Overall Data Analysis Approach to Study Results for Instructor Participants

Mixed data are found in learners' questionnaire reports, quantitative data in learner OSCE scores, with instructor field notes yielding qualitative data alone. The study's research administrative assistant collected all learners' questionnaire reports, also creating an Excel file of learner data to enable individual learner analyses (excerpt in Appendix M6). Quantitative OSCE scores were also collected by the research administrative assistant for entry onto the Excel file by participants' study codes. Instructors directly e-mailed their field notes reports to the research administrative assistant. Open comments from learner questionnaires and instructor narratives yielded qualitative data, requiring narrative analysis.

For narrative analysis of learner participant data, a co-coder was employed to assist the researcher. The co-coding exercise was guided by a pre-established agreement between the researcher and co-coder to assign data units (selected words and/or phrases) to align with: 1) one or more of the four levels of the NWKM (reaction, learning, behaviors, results) and, where applicable, to 2) learning domains (affective, cognitive, psychomotor) and their respective hierarchies within the taxonomies. Each coder analyzed the data independently and telephone discussions and e-mails ensued to collaborate on consensus of themes. Ongoing iterative discussions and comparisons promoted consistency of method. Emergent NWKM levels and learning domain themes were identified during the co-coding process. Once co-coding results were completed the researcher integrated these data for overall analysis and presentation of study results. Quantitative OSCE data analysis by the researcher followed the same approach as the co-coding exercise, that is, alignment to the NWKM and learning domains, where applicable. Instructor field notes were analyzed by the researcher to summarize emergent themes and compare with learner data.

As stated above, when units of narrative learner data were evaluated, they were assigned to a NWKM level(s) utilizing pre-determined guiding questions, as outlined in Appendix L. These guiding questions are expanded upon with the presentation of results per NWKM level. Assigning data units to the learning domains was a second step in co-coding, primarily applied to attain insights to participants' learning experiences to address the research questions and for future instructional design. Further discussion on the guiding questions for learner domain assignment ensues later in the chapter.

Data from instructor participants (field notes) were reviewed to gain themes in their teaching experiences with learners, as well as their feedback on the instructional resources of the study. These instructor reflections provide further insight from a teaching lens on recommendations for future instructional design of DE for hands-on EFAST skills and POCUS. Instructor data were also compared with learner data to assess congruency levels of what instructors experienced and what learners reported. Data contributions from both learners and instructors will now be presented in their detail.

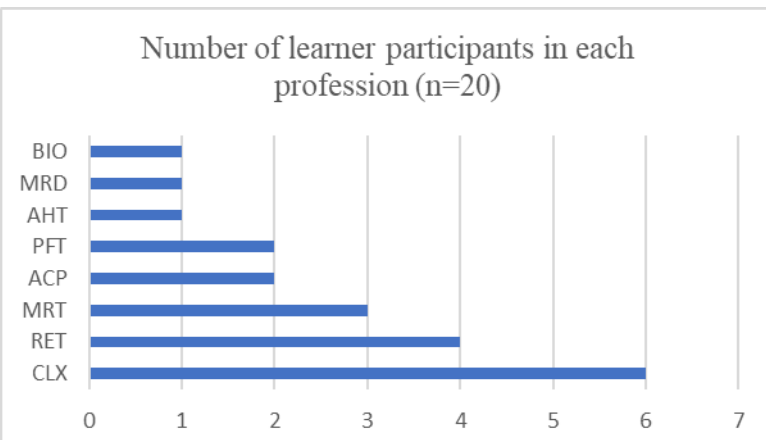
Learner Results

Professions within the Learner Sample

The study's recruitment process yielded twenty-three learner participants from a variety of health professions. Within the first two weeks of the study, during the theory portion of the course, three learner participants had requested withdrawal, and upon their request their data were removed from the study (pre-study questionnaires). From that point onwards twenty learners completed the study. As reported by learners on each questionnaire, Figure 6 below reflects the number of learners in each of the eight health professions within this final sample: Biomedical Engineering Technology (BIO), Magnetic Resonance Diploma (MRD), Animal Health Technology* (AHT), Personal Fitness Trainer (PFT), Advanced Care Paramedic (ACP), Medical Radiologic Technology (MRT), Respiratory Therapy (RET), and Combined Laboratory and X-Ray Technology (CLX). *To note: the AHT participant was eligible for the study due to previous nursing credentials and experience, however, identified as AHT when completing the questionnaires.

Figure 6

Number of Learner Participants per Profession



Note: Data from excerpt from questionnaire reports (Appendix M6)

With respect to the health professions in the study sample, the eight professions are further described and compared from the lens of their eligibility criteria: 1) ultrasound naïve, 2) familiar with human anatomy, and 3) prior experience with patient interactions. With respect to the first criterion (ultrasound naïve) one-half of participants entered the study from a diagnostic imaging (DI) profession, however not from the DI discipline of ultrasound. The DI composition of the sample group was examined to distinguish those with 'imaging' backgrounds from those without, due to anecdotal misperceptions in the researcher's workplace that a background in imaging, e.g. X-ray may have an advantage in learning the discipline of ultrasound imaging, misperceptions that could (and did) surface in learner and/or instructor comments. Despite these misperceptions, all learner participants entered the study as ‘ultrasound-naïve’, a criterion reflecting a lack of knowledge and skills in the operator-dependent hands-on ultrasound practice prior to the training intervention. With respect to the second and third criteria for study eligibility, knowledge of human anatomy and experience with patient interactions/care are common to all allied health professions as well as general medicine. The elements of a DI background and nature of patient care experience are compared in the sample profession descriptions below, presented in four groups:

- ten professionals (50% of sample) *with* DI and human patient care experience, e.g., medical radiological technology (MRT), combined laboratory and x-ray (CLX) and magnetic resonance imaging (MRD),
- six professionals (30% of sample) *not* from DI and experienced in direct human patient care, e.g., advanced care paramedic (ACP) and respiratory therapy (RET),
- two professionals (10% of sample) from the personal fitness training (PFT) profession *not* from DI and trained with direct human contact with their clients who are predominantly healthy and sometimes injured and/or sick, and
- two professionals (10% of sample): one individual from animal health technology/veterinary medicine (AHT) with a previous nursing background, and the other from biomedical engineering technology (BIO). These two professions are *not* from DI - the former with human patient contact (as a former nurse), and the latter with some but little human patient care experience.

Appendix P provides a brief description for each profession reflecting participant eligibility for inclusion in the study sample, as retrieved from the NAIT (n.d.) website on program information. As described earlier, learner participant data were evaluated within the four NWKM levels: reaction, learning, behaviors, and results, as presented in in the following section.

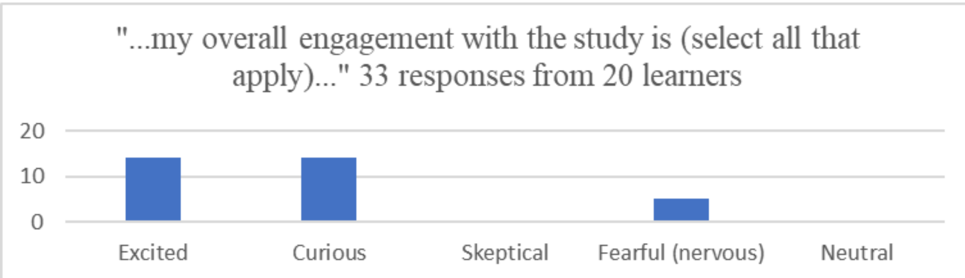
NWKM Level 1 – Reaction

Inquiry into level 1, as described by Kirkpatrick and Kirkpatrick (2010-2019), assesses the degree to which participants find the training favorable, encompassing the elements of engagement, relevancy, and satisfaction. Engagement with the training is “the degree to which the participants are actively involved in and contributing to the learning experience [and is] directly relate[s] to the level of learning that is attained” (Kirkpatrick & Kirkpatrick, 2010-2019, p. 9). The dimension of relevance refers to “the degree to which training participants will have the opportunity to use or apply what they learned in training on the job” (Kirkpatrick & Kirkpatrick, 2010-2019, p. 9). Further description of a favorable reaction involves the participant’s satisfaction with the training. Data which address level 1 are presented in the following three participant areas: engagement, relevance, and satisfaction.

Participant Engagement. In the NWKM, learner engagement explores how involved participants are, and how do they actively contribute to their learning experience. One pre-study question investigated levels of engagement by asking participants how they felt about the study: Were they excited, curious, skeptical, fearful (nervous), and/or neutral? The chart below (Figure 7) reflects a high level of excitement and curiosity with a few feelings of nervousness.

Figure 7

Overall Pre-Study Learner Engagement



Note: Data from pre-study questionnaire report, question #6 (Appendix M1)

Another indicator of learners' degree of engagement was their active involvement and contribution to their learning experience beyond the pre-study phase, reflected in the 100% attendance record of learners at all remote hands-on scanning labs and f2f OSCE assessments, as well as full completion and submission of all online questionnaires. From a learning domain lens, data in Figure 7 reflect the emotional response of learners in their immediate reaction to the study and proposed training, indicators to how they were 'receiving' and 'responding', hierarchies of the affective learning domain. Overall, data reflect a high degree of participant engagement.

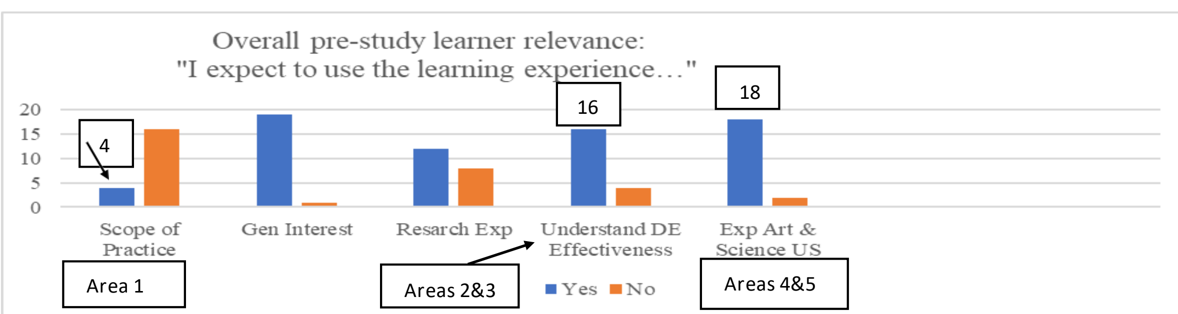
Relevance of Training for Participants. Relevance of the training was explored as per the first NWKM level, guided by the following three themes of inquiry:

1. To what degree did participants find the training relevant to their scopes of practice, general interest, and/or research experience? What was their perceived usefulness of the training?
2. To what degree did participants currently understand how DE can work to learn hands-on ultrasound skills, and the application of DE to EFAST and POCUS?
3. To what degree did learners intend to use the training?

The above themes were explored with pre- to end-study comparisons as presented in Figures 8 and 9 below. As depicted, there are five notable areas in pre- to end-study levels of training relevance. In the first area, relevance to using the training in one's own scope of practice slightly increased from four to six learners. The second and third areas depict continual strength from the pre-study theme to generally understand DE effectiveness for hands-on training (sixteen learners), resulting in end-study recommendations for DE in EFAST and POCUS training for seventeen of twenty learners; with ten learners indicating interest to further their POCUS education (Figure 9, Area 4). In the fifth area to further one's education in general (non-POCUS) ultrasound, eighteen of twenty participants indicated no interest at end-study, a complete reversal when compared to pre-study responses to experience the art and science of ultrasound. These last data reflect greater understanding of the difference between POCUS and the more detailed nature of comprehensive general ultrasound. Other pre- to end-study comparisons include minor decreases in general interest and gaining experience as a research participant. As discussed above, the charts below depict participants' degree of relevance at the onset of the study (Figure 8) compared to their reaction to relevance at the end of the study (Figure 9).

Figure 8

Overall Pre-Study Relevance

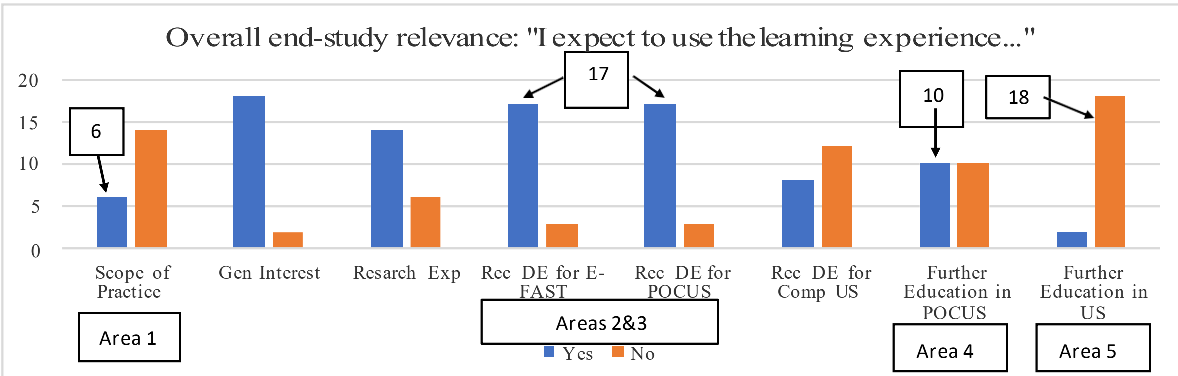


Note: Data from pre-study questionnaire report, question #5 (Appendix M1)

N=20: Area 1: 95%CI (1.6-1.99); Areas 2&3: 95%CI (1.01-1.39); Areas 4&5: 95%CI (.96-1.24)

Figure 9

Overall End Study Relevance (in Comparison to Pre-Study Areas)



Note: End-study questionnaire report, question #3 (Appendix M3)

N=20: Area 1: 95%CI (1.49-1.91); Areas 2&3: 95%CI (.98-1.32); Area 4: 95%CI (1.27-1.73); Area 5: 95%CI (1.75-2.04)

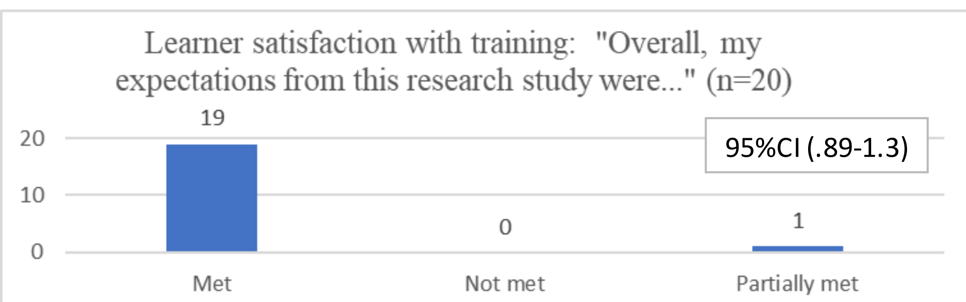
Data from Figure 9 above reflect an overall increase of relevance from pre- to end-study in the areas of: 1) participants' scope of practice, 2) their understanding of DE for hands-on ultrasound training, and 3) end-study recommendations for DE for EFAST and POCUS after participants' experiential learning. The increase of relevance in these training areas indicates learners' perceptions of the usefulness of the training, noting its worth and value for them, feelings related to the 'valuing' level of the affective learning domain. This increase in training relevance also engages the cognitive and psychomotor learning domains in learners' greater understanding of DE in the context of their experiential learning in hands-on scanning skills.

Participant Satisfaction. Learners' satisfaction levels were investigated to assess the degree of participants' appreciation of their learning event and value of training content. Open-ended comments on the mid-study questionnaire reports include participant satisfaction at the completion of the training and prior to their OSCE experience (Appendix M2, question #14). These comments include: "Great experience, learned a lot, and I am happy to have taken part of this research project!", "That was fun!", and "I really enjoyed participating in the study and learning the E-FAST scan!" One participant opined: "My EFAST training works well with the uninjured patient, but it may be quite different, and more difficult with patients who may be in pain, etc., and potentially have injuries and fluid". The first two comments indicate these participants liked the training. The third comment indicates appreciation beyond feelings of "liking" to reflections on training content and recognition of its application in the clinical field, a statement reflecting higher shifts in the affective and cognitive domains.

An additional metric to identify learner satisfaction explored the area of learner expectations in relation to the training they anticipated. End-study data to measure whether training expectations were met indicate that nineteen of twenty learners' expectations were met, as depicted in Figure 10 below. One learner whose expectations were partially met commented: "During the practice labs, I did NOT expect to find fluid, on my healthy partner, so things may be different and more difficult if the patient MAY have blood or free fluid…" (Appendix M3, question #10). This comment is common in the field of ultrasound where incidental findings are often discovered in both teaching and clinical environments, a common expectation to be forewarned about.

Figure 10

Learner Satisfaction with Training (Expectations)

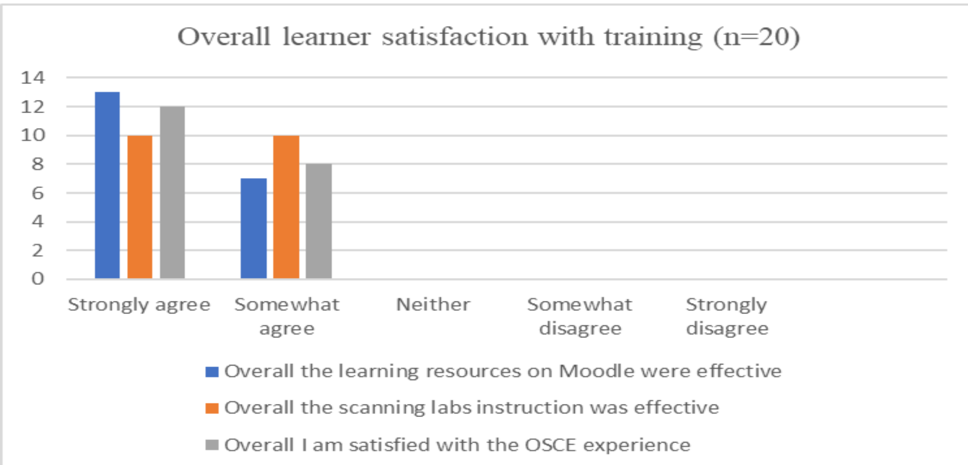


Note: Date from end-study questionnaire report, question #8 (Appendix M3)

To gauge overall learner satisfaction the three phases of training were investigated: 1) Moodle course for theory, 2) scanning lab instruction for practical training, and 3) the OSCE experience. As shown in Figure 11 below, all twenty participants agreed (strongly or somewhat) with the effectiveness of the Moodle learning resources and scanning lab instruction; all were satisfied with their OSCE experience.

Figure 11

Learner Satisfaction with Training (Overall)



Note: Data from end-study questionnaire report, question #4 (Appendix M3)

As presented above, learner data indicate overall strong levels of satisfaction from five points of view: 1) liking/enjoying the training, 2) appreciating the value/usefulness of the training, 3) statements that expectations were met, 4) effectiveness of learning resources and instruction, and 5) satisfaction with the assessment phase (OSCEs). These data engage the learning domains in feelings of satisfaction/appreciation/value of the training event (affective), and effectiveness of training resources for acquisition of knowledge, skills, and professional behaviors (cognitive, psychomotor, affective).

In summary of the first NWKM level, study results indicate an overall favorable learner participant reaction to the training intervention indicated by their high degrees of engagement, relevance, and satisfaction. In the context of this study, learner satisfaction also reflects learner assessment of training content and learning elements, to be discussed in the next level of the NWKM – Learning.

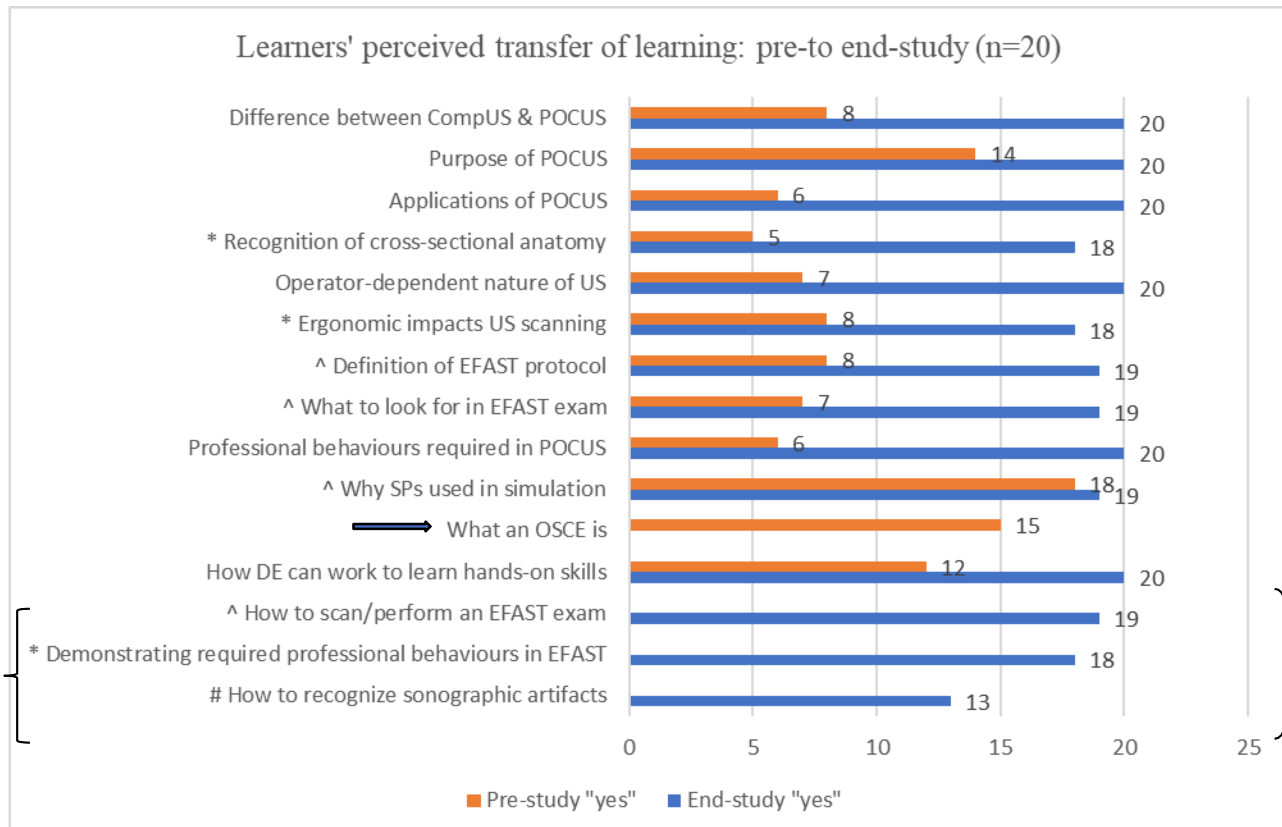
NWKM Level 2 – Learning

Level 2 of the NWKM investigates to what degree did participants acquire the intended knowledge (I know it), skills (I can do it right now), and attitudes (I believe this knowledge and training is worthwhile) based on their participation in the training. This level also captures the extent that participants acquire confidence (I think I can do it), and their commitment (I intend to do it) on the job (Kirkpatrick & Kirkpatrick, 2010-2019). In the context of this study, results relating to the second NWKM level are presented in this order: learners' perceived transfer of learning, learner evaluation of training, and learner beliefs in DE for the training.

Perceived Transfer of Learning. In the pre-study questionnaire, before access to the Moodle course was granted, learners were asked to rate their current level of knowledge on twelve different elements of the training intervention they were soon to begin. At the end of the instruction and OSCE component of the study, via the end-study questionnaire, learners were again asked to self-assess their acquired level of knowledge on all but one of the same elements, plus three additional areas. Results reflect a high degree of learner perception of acquired knowledge and transfer of learning, as follows: from a large increase in some areas such as cross-sectional anatomy (five to eighteen learners) to a small gain in why SPs are used in simulation (eighteen to nineteen learners). It is significant that all participants self-assessed learning progression in all training elements, reflecting a high degree of perceived acquisition of knowledge, skills, and attitudes, perceptions validated quantitatively via subsequent OSCE scores in the testing phase of the study. These data are depicted in Figure 12 below; to note is the one question/element included on the pre-study only (solid arrow) and the three questions/elements solely asked in the end-study (brackets). These self-reported data on perceived acquired knowledge and skills are congruent with instructor field notes on the positive transfer of learning from the instructor lens, e.g., "Very good…easy to communicate…" and one instructor's surprise at "…what parts of the EFAST scan that the students found easier to pick up and what they struggled with; [and]…the ease that most candidates had in obtaining a good view of the pleura" (Appendices O1 & O2, questions #20, respectively). Learners' perceptions of learning transfer reflect engagement of the cognitive (knowledge level) and psychomotor (performance level) domains. Most learner perceptions that learning was transferred were validated with the study's OSCE scores - a formal measure of actual acquisition of knowledge, skills, and attitudes.

Figure 12

Perceived Transfer of Learning from Pre to End Study (as Reported by Learners)



Note: Data from pre/end study questionnaire reports, questions #7/#5 (Appendices M1/M3)

End-study * 95%CI (.96-1.24); ^ 95%CI (.95-1.15); # 95%CI (1.13-1.58)

Pre-study 95%CI top-bottom: (1.37-1.83); (1.09-1.51); (1.49-1.91); (1.55-1.95); (1.43-1.87); (1.37-1.83); (1.37-1.83); (1.43-1.87); (1.49-1.91); (.96-1.24); (1.05-1.45); (1.17-1.63)

These data, as presented above indicate a strong transfer of learning as perceived and self-reported by learners from pre- to end-study, data which are congruent with instructor observations and OSCE results, to be presented in full detail later in the chapter. In addition to learner statements on areas of training progression, participants were also asked to evaluate their learning experiences.

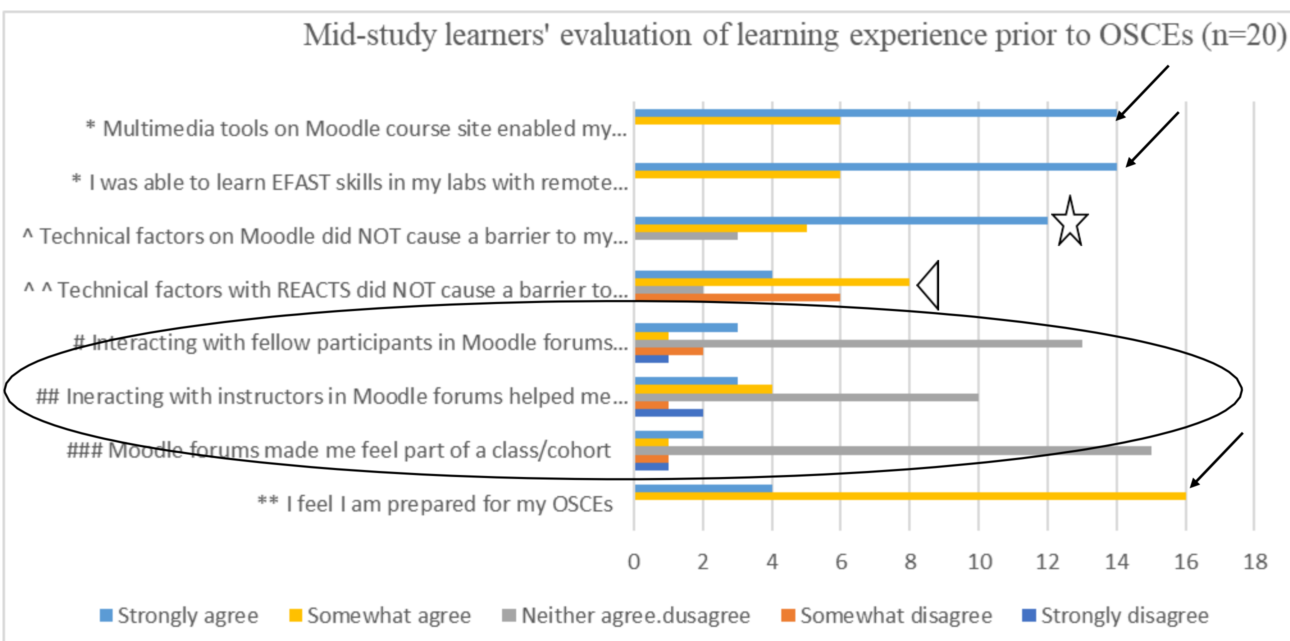
Learner Evaluation of Training. Following the instruction phase of the training (theory and labs) and prior to being tested in their OSCEs, learners completed the mid-study questionnaire. In addition to examining perceived transfer of learning as previously discussed, another area of exploration was how learners rated the effectiveness of their training elements and overall learning experience. Figure 13 is presented below to highlight how learners self-assessed the effectiveness of the training elements. It was important to the research design that learners evaluate their training prior to the OSCE testing phase as a learner's OSCE experience and score results could have positively or negatively influenced a learner's evaluation of their training. The three arrows in the chart below identify strong areas of satisfaction (agree or strongly agree) for all participants in 1) multimedia resources provided for theory learning, 2) the ability to apply theory to learn EFAST skills in the hands-on scanning labs, and 3) the level of preparation for their OSCEs.

As circled on Figure 13 below, the greatest element negatively affecting full satisfaction for several participants were the Moodle forum activities (with each other and/or with the instructors) and with fostering a sense of cohort, indicating a possible weakness in the training intervention. These data on the forums were unexpected as the training design intentionally provided a 'space' for online social presence through the discussion forums. However, most learners felt neutral, disagreed, or strongly disagreed on the ability of the forums to help them learn with each other (n= 16) or with instructors (n=13), or to make them feel a part of a cohort (n=17). As most learners' OSCE results were very good, it appears the lack of Moodle forum activity did not impact learner success as measured by OSCE scores. These findings are further discussed later in this section and again in chapter five.

As also presented in Figure 13, technical factors affecting Moodle effectiveness were not an issue for seventeen of twenty participants (star), however, as indicated by the open arrowhead, technical factors with the interactive tele-assisted DE platform, REACTS®, yielded a mixed reaction with data reporting satisfaction (n=12), neutrality (n=2), or dissatisfaction (n=6). This latter finding was not a surprise as technical difficulties were experienced in the field test and subsequently mitigated. Despite the mixed response in Figure 13, the technical difficulties with REACTS® were *not* a significant barrier as most learners were successful in their OSCE scores, suggesting *feelings* of a learning barrier versus an actual impediment to attaining outcomes and success.

Figure 13

Mid Study Learner Evaluation of Learning Experience (Prior to OSCEs)



Note: Mid-study questionnaire report, question #3 (Appendix M2)

*95%CI (11.49-11.91); ^ 95%CI (11.10-11.79); ^^ 95%CI (9.97-11.02); # 95%CI (9.7-10.6); ## 95%CI (9.7-10.76); ### 95%CI (9.7-10.49); ** 95%CI (11.01-11.39)

The three areas of strength depicted by the solid arrows in Figure 13 above (strongly agree or agree) prior to OSCEs were further compared with individual learner end-study data and OSCE scores, to glean a sense of congruence with how learners perceived their training outcomes at mid-study and how they actually performed and demonstrated those learning outcomes on their OSCEs. Data for individual learners are presented in Table 1 below. To note: OSCE data are presented and further discussed in detail in the next NWKM level.

Data presented in Table 1 below reflect a strong correlation with perceived training strengths, as cited by learners' ratings of feeling knowledgeable/able to learn at mid-study, their feelings of ability at end-study, and their OSCE performance scores, with three exceptions. For two learners, L10BIO and L13PFT, data indicate positivity about their learning at mid-study, yet both did not feel positive about their ability to demonstrate professional behaviors at end study, despite scoring very well on the OSCEs (scores of 77% and 83% respectively). The third exception is L19MRT who also felt positive at mid-study, however, in contrast to L10BIO and L13PFT, maintained feelings of ability to demonstrate professional behaviors, with a change in response, from yes to no, in the ability to scan EFAST, a shift which is understandable given L19MRT's low OSCE outcome for most competencies (37%). For most learners, data in Table 1 reflect learner degrees of confidence in knowledge and skills of the cognitive and psychomotor domains, and emotions/feelings of the affective learning domain.

Table 1

Training Strengths Cited in Mid Study Evaluation of Learning Experience Compared to End Study Data

	Mid-Study Data: Learner Evaluation of Training			End-Study Data	
Learners	Multi-media tools enabled learning	Feeling able to learn EFAST skills in labs [including behaviors]	I feel prepared for my OSCEs	Feeling able to: Scan EFAST/ Demonstrate required professional behaviors?	% OSCE average scores
L10BIO		SA or A		Yes/No	77
L18MRD		SA or A		Yes/Yes	97
L05AHT		SA or A		Yes/Yes	74
L15PFT		SA or A		Yes/Yes	57
L13PFT		SA or A		Yes/No	83
L08/16ACP		SA or A		Yes/Yes	63/91
L03/14MRT		SA or A		Yes/Yes	83/86
L19MRT		SA or A		No/Yes	37
L01/09/14/21 RET		SA or A		Yes/Yes	91/94/86/83
L06/07/12/17/20/22CLX		SA or A		Yes/Yes	94/88/71/91/63/83

Note. SA = strongly agree, A = agree

Data derived from mid/end-study questionnaire reports, questions #3/#5 (Appendices M2/M3), individual Qualtrics reports; OSCE scores (Appendix N1)

As with training strengths, training weaknesses cited in Figure 13 were also compared with learner end-study data and OSCE scores, as presented in Table 2 for Moodle forum activity, and Table 3 for the technical difficulties experienced with REACTS®. To note: OSCE data are presented and further discussed in detail in the next NWKM level, later in this chapter.

As presented earlier, study results indicate significant lack of interactivity in the Moodle forums with most learners stating neutrality or disagreement with the ability of the forums to help them learn. Despite this negative feedback on the effectiveness of the Moodle forums, data in Table 2 below show mid to high level OSCE scores for most learners, thereby reflecting learner success despite the lack of learner interactions and social presence via the forums. These findings engender the following question: Are online discussion forums and social presence necessary for learning success in a training event such as the study's course design? Discussion on this question ensues in chapter five.

Table 2

Training Weaknesses of Moodle Forums Cited in Learner Mid Study Evaluation of Learning Experience Compared to End Study OSCE Outcomes

Learners	With peers	With Instructors	Sense of cohort	% OSCE average score(s)
L10BIO	neutral	neutral	neutral	77
L18MRD	neutral	agree	neutral	97
L05AHT	agree	agree	agree	74
L13/15PFT	1 disagree 1 neutral	neutral	neutral	83/57
L08/16ACP	2 neutral	1 agree;1 neutral	2 neutral	63/91
L03/04/19MRT	1 agree 2 neutral	1 agree;1 disagree 1 neutral	3 neutral	83/86/37
L01/09/14/21 RET	2 disagree 2 neutral	1 agree 2 disagree;1 neutral	2 disagree 2 neutral	91/94/86/83
L06/07/12/17/ 20/22CLX	2 agree 4 neutral	2 agree;4 neutral	2 agree 4 neutral	94/88/71/91/63/83

Note: Responses relate to effectiveness of Moodle forums

Data derived from mid-study questionnaire report, question #3 (Appendix M2), individual Qualtrics reports; OSCE scores (Appendix N1)

The other notable training weakness was the sporadic performance of the REACTS® platform creating technical difficulties for some learner-instructor interactions. As presented in Figure 13 on the statement: "Any technical factors with the REACTS platform did *not* cause a barrier to my learning", twelve learners strongly agreed/agreed. The remaining responses recorded neutral feelings (two learners) or disagreement with the statement (six learners), the latter datum indicating feelings of a barrier to their learning. Individual learner narratives pertaining to technical difficulties included: "the software had some technical issues", "connectivity issues with Reacts losing voice and call dropping", and "the video stream of the instructor would frequently freeze.

This was problematic when they were trying to demonstrate how I should be adjusting the probe position" (Appendix M2, question #9). Despite the technical difficulties or feelings of neutrality for some learners, data in Table 3 below reflect passing OSCE scores (⩾70%) for sixteen learners indicating learner success and an ability to learn scanning skills despite the technical problems experienced.

Table 3

Training Weaknesses of REACTS® Cited in Learner Mid Study Evaluation of Learning Experience Compared to End Study OSCE Outcomes

Learners	Responses	% OSCE average score(s)
L10BIO	disagree	77
L18MRD	strongly agree	97
L05AHT	agree	74
L13/15PFT	agree	83/57
L08/16ACP	agree	63/91
L03/04/19MRT	strongly agree, neutral, disagree	83/86/37
L01/09/14/21RET	strongly agree, agree, disagree	91/94/86/83
L06/07/12/17/20/22CLX	strongly agree, agree, disagree, neutral	94/88/71 91/63/83

Note: Responses relate to effectiveness of REACTS®

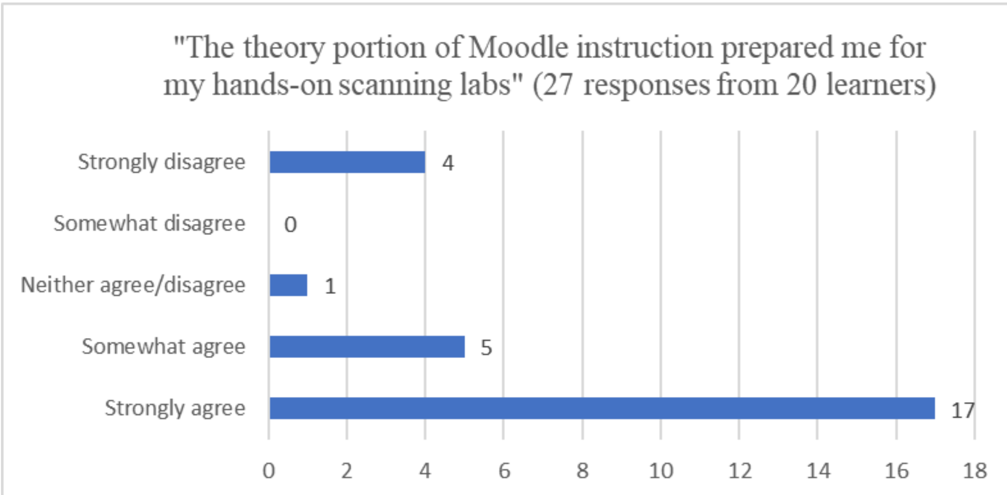
Data derived from mid-study questionnaire report, question #3 (Appendix M2), individual Qualtrics reports; OSCE scores (Appendix N1)

Learners' ability to learn scanning skills, as reflected in their OSCE scores, despite cited technical problems with the tele-assisted platform, correlates with another study result when learners were asked if they would recommend the REACTS® method for learning pocket ultrasound and to explain why or why not. From this question nineteen of twenty learners reported they would recommend REACTS® with rationales such as:: "user-friendly", "[a]llowed instructor to see what you were doing and redirect", "more effective than I anticipated", "it would be a valuable tool in assessing trauma", and "[s]eemed effective, and I feel I grasped the main concepts with understanding that mastery may take more time" (Appendix M2, question #10). Cautionary comments were expressed as: "I would not feel comfortable scanning without a mentor without more experience", access to the instructors as a "crucial piece", "when it was working well, it was effective", a recommendation to have a "backup communication method for when the video call is having problems with connectivity", and "this can definitely work in certain contexts" (Appendix M2, question #10). The comment from the one learner who would *not* recommend REACTS was expressed as "…it was frustrating as the video would freeze, or the audio would be choppy…When it was working the tool was great and I learned, but the technical glitches were a barrier" (Appendix M2, question #10). In reviewing individual learner data the last comment was derived from a learner who attained an OSCE average score of 86%, a finding that is notable in that this mid-study comment may have been different had the learner already completed their OSCEs and known their OSCE score, strengthening the study's intention to assess learning experiences prior to the OSCE step of the study. The recommendation for REACTS® to learn scanning skills with a PUD, is further discussed in this chapter (NWKM level 4).

Another area to investigate participants' evaluation of their learning was the effectiveness of the online, asynchronous self-paced theory portion of the training and its ability to prepare learners for their real-time interactive hands-on scanning labs. Data in Figure 14 below are somewhat difficult to interpret due to the twenty-seven responses from twenty learners indicating more than one choice for some learners, however, twenty-two of the twenty-seven choices indicate learner agreement that the theory component of training prepared them for their hands-on scanning labs. These data speak to the degree of confidence that the second level of the NWKM seeks (I know it). Another measure of confidence and commitment was 100% attendance for all scanning labs as reported by the participants (mid-study question #4) and verified by the research administrative assistant's records**.**

Figure 14

Learner Evaluation of Theory to Prepare for Hands-on Scanning Labs

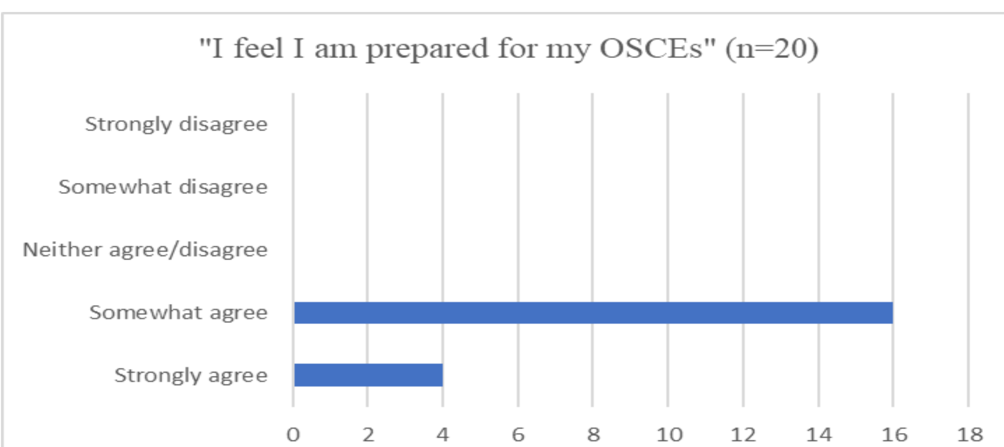


Note: Data from mid-study questionnaire report, question #5 (Appendix M2)

In addition, data presented below in Figure 15 indicate that all twenty learners felt (agreed or strongly agreed) that the scanning labs (remote training with REACTS®) prepared them for their OSCEs, also reflecting degrees of confidence (I think I can), and commitment (I intend) elements of the second level of the NWKM.

Figure 15

Learner Evaluation of Feeling Prepared for Their OSCEs



Note: Data from mid-study questionnaire report, question #3 (Appendix M2)

In the mid-study questionnaire prior to their OSCEs, participants were asked if they experienced any surprises in their learning experiences. Their narratives reflected the following: "[h]ow quickly I could learn this skill in 3 short labs", "how effective the remote system was for learning. I began as a bit of a skeptic", "[h]ow easy was the very first lab" and "I found it surprising that someone without sonography experience could learn the E-FAST scan so quickly". Another area of surprise was "how thorough the content was before the labs began…I expected to feel more blind heading into them" and the "[a]mount of videos available to see technique". On an imaging theme, participants reported "I was surprised how easy it was to find the correct anatomy" and "how easy it actually was with the right instruction". Despite the clear instructions in the pre-study consent information one learner was surprised at "[h]aving to be a patient also". (Mid -study questionnaire, question #12, Appendix M2)

In the mid-study questionnaire participants were also asked if there was anything that did *not* surprise them in their learning experiences. Narratives included no surprise with "routine patient care principles [which are] quite standardized", the ability to "learn the theory component of E-FAST through Moodle – distance delivery", the "quality of instruction", and, "that the learning could be effective if technology was used effectively (and if there were no technical issues)" (Mid-study questionnaire, question #13, Appendix M2).

As presented thus far, learners' perceived transfer of learning and their evaluation of the learning event itself engaged the cognitive learning domain in learners' analyses of their learning progress such as reporting on perceived gains in knowledge areas, assessing what was most and least helpful in their learning experience, and further in evaluating REACTS® to learn PUD scanning skills. Learners also engaged the hierarchies in the psychomotor domain as they applied theory to practical learning, a notable shift from being ready to scan ('set') to the 'doing' of hands-on skills ('imitation'). The affective domain was also active with learners' expressing feelings about their cognitive and psychomotor learning, e.g., being surprised at how quickly they could learn without prior ultrasound experience, how easy it was to learn, and feeling prepared for the OSCEs, expressions of 'valuing'. Learners were also engaged in another area of the affective domain, that of their beliefs.

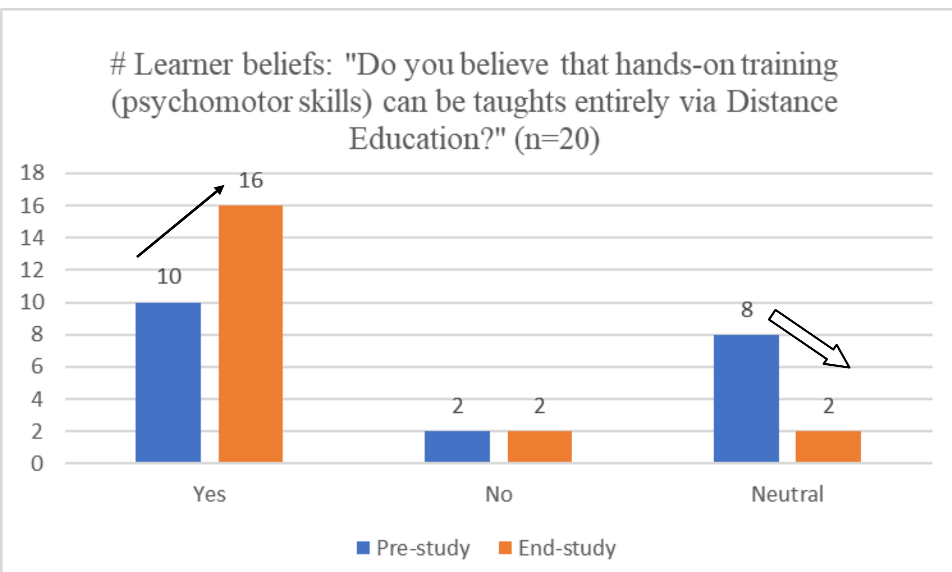
Learner Beliefs in DE for the Training. The degree of confidence and commitment within the second level of the NWKM was further investigated by measuring learner participant beliefs prior to the study compared to their beliefs at the end of the study. Learner beliefs selected for exploration were if they believed that the core skills of ultrasound imaging competency, that is, the synthesis of scanning ability (application of cognitive knowledge to psychomotor skills) and the demonstration of professional behaviors (affective skills) could be attained through DE alone. The synthesis of these core skills directly addresses the primary research question: Can allied health practitioners attain ultrasound imaging skills/competency with a PUD in DE learning environment? Learner data on these beliefs are presented below, first for psychomotor skills, and secondly for required professional behaviors.

Beliefs in Psychomotor Skills by DE. Learner data identifying their pre and end study beliefs that psychomotor skills can be taught entirely by DE are presented in Figure 16 below. Data analysis reflects that learner beliefs increased from a pre-study "yes" for ten learners to an end-study "yes" for sixteen learners (solid arrow). Pre-study beliefs in the study's DE training were captured in learner narratives (Appendix M1, question #10), as follows: "I am very excited for this research project…I am hesitant though to see how some skills that require fine detail will be taught from a distance". Further pre-study doubts on the learning of psychomotor skills entirely by distance were expressed by several participants in the following representative example: "unsure that distance delivery alone would have the same effect as face to face". Another pre -study narrative reflected curiosity on how psychomotor skills, taught by distance "would transfer to real patients in a clinical environment".

Also in reference to data in Figure 16, the 'no' responses remained unchanged at two learners each, with end-study narratives as follows: "need hands on learning" and "[t]here's not a way to sufficiently assess ergonomics…nor the patient's reaction to things that the scanner does or says" (Appendix M3, question #6). Pre- to end-study data in 'neutral' responses identify a shift in beliefs from eight to two learners (open arrow) with end-study narratives as follows: "Yes, but not as efficiently as in-person training…the instructor was limited to a small field of view, and couldn't see my posture", and this training "depends on the type of hands-on skills you are trying to teach" (Appendix M3, question #6).

Figure 16

Pre and End Study Learner Beliefs in Psychomotor Skills via DE



Note: Data from pre/end study questionnaire reports, questions #8/#6 Appendices M1/M3)

Pre-study: 95%CI (1.46-2.3); End-study: 95%CI (1.01-1.6)

In addition to examining learner beliefs at a group level, review was also focused on those individual beliefs that changed from pre- to end-study, to better understand the role a learner's belief may have played in that learner's hands-on skills OSCE performance. In this examination, data were compared to learner OSCE data (scores and missed competencies). Data for the group are detailed in Appendix R with notable changes in beliefs presented in Table 4 below.

Data in Appendix R identify no change in beliefs for twelve learners. For the remaining eight learners with belief changes in Table 4, all reported a greater belief in DE for psychomotor skills with exception of one learner (L06CLX), whose belief changed from neutral to no despite attaining a 94% OSCE score. This last finding is curious and requires further analysis on why this learner who acquired the skills of EFAST entirely by DE, with only two competencies missed, would not believe in DE. This area will be further discussed in chapter five.

Table 4

Individual Learners Who Changed Beliefs, from Pre to End Study, in DE for Psychomotor Skills

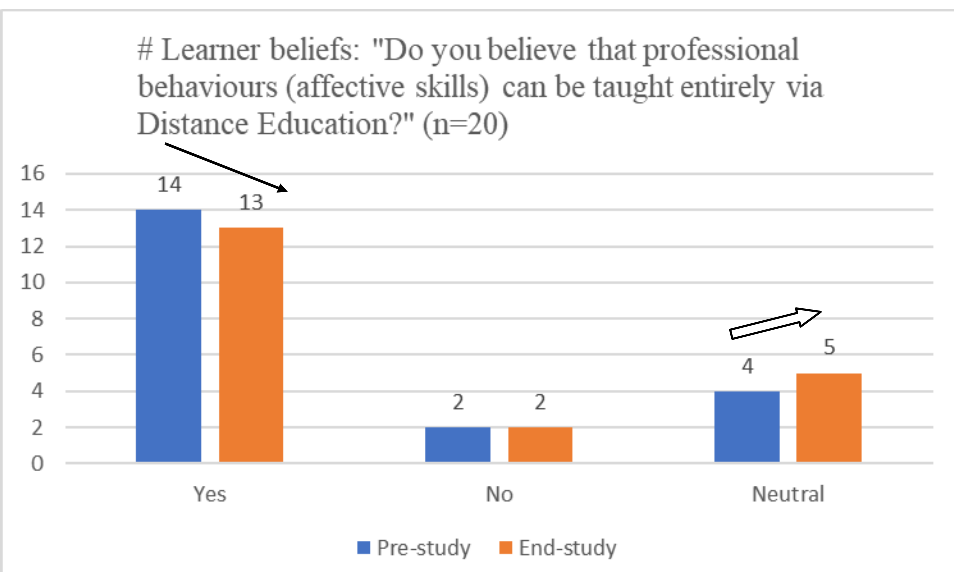
Learners	Change in belief	Direction in belief	OSCE average score	Psychomotor competency areas missed
L10BIO	No to Neutral	greater	27/35=77%	Imaging, artifact, end tasks
L16ACP	Neutral to Yes	greater	32/35=91%	Artifact
L04MRT	Neutral to Yes	greater	30/35=86%	Ergonomics, imaging, artifact
L03MRT	No to Yes	greater	29/35=83%	Ergonomics, imaging, artifact
L01RET	Neutral to Yes	greater	32/35=91%	Imaging
L09RET	Neutral to Yes	greater	33/35=94%	End tasks
L17CLX	Neutral to Yes	greater	32/35=91%	Ergonomics
L06CLX	Neutral to No	lesser	33/35=94%	Instrumentation

Note: Data derived from pre/end-study questionnaire reports, questions #8/#6 (Appendices M1/M3), individual Qualtrics reports; OSCE scores (Appendix N1); Competency performances (Appendices T1-T7)

Beliefs in Affective Skills by DE. Learner data identifying their pre- and end-study beliefs that affective skills can be taught entirely by DE are presented in Figure 17 below. Data analysis reflects a small decrease from a pre-study "yes" for fourteen learners to an end-study datum of "yes" for thirteen learners (solid arrow). Beliefs that professional behaviors could be taught by distance were captured in the pre-study questionnaire (Appendix, question #10), expressed as follows: "I put neutral…as I'm skeptical professional behaviours can be taught at all, whether face to face or distance. I think they are something you have, or you do not". The "no" responses remained unchanged at two learners each from pre- to end-study with related narratives as follows: "need hand on practice" and "I think this course assumed I had basic professional behaviours, they were not taught" (Appendix M3, question #7). A slight increase by one (four to five learners) is noted in the pre- to end-study "neutral" responses (open arrow), with related end-study narratives to include: Yes, "if the headphones were off and the facilitator could hear what the patient was indicating (pain, questions, etc.)", and "I think that attitudes and professionalism can only be taught to a limited extent regardless of whether it's in person or by distance. I think they are intrinsic qualities". Other comments were conditional, e.g. "if combined with prior experience in healthcare", and it "depends on the students you have" (Appendix M3, question #7).

Figure 17

Pre and End Study Learner Beliefs in Affective Skills via DE



Note: Data from pre/end study questionnaire reports, questions #9/#7 (Appendices M1/M3)

Pre-study: 95%CI (1.12-1.88); End-study: 95%CI (1.2-2.0)

As with the study of individual beliefs in the psychomotor domain, a similar review was also conducted in relation to those individual beliefs that changed from pre- to-end study in the affective domain, to better understand the role a learner's belief may have played in that learner's OSCE performance in professional behaviors. In this examination, data were compared to learner OSCE data (scores and missed competencies). Individual learner data identifying their pre and end study beliefs that affective skills can be taught entirely by DE are detailed in Appendix S with notable changes in beliefs presented in Table 5 below.

Data in Appendix S identify no change in beliefs for thirteen of learners. For the remaining seven learners presented in Table 5 below, three learners' beliefs were greater with the remaining four (circled) reporting a lesser belief, despite positive OSCE results and no missed competencies in the professionalism category. These last findings for four learners require further examination; the correlation of learner beliefs and their performance are further discussed in chapter five.

Table 5

Individual Learners who Changed Beliefs, from Pre to End Study, in DE for Affective Skills

Learners	Change in belief	Direction in belief	OSCE average score	Professionalism competency areas missed
L10BIO	Neutral to Yes	greater	27/35=77%	None
L18MRD	Yes, to Neutral	lesser	34/35=97%	None
L05AHT	Yes, to Neutral	lesser	26/35-74%	None
L03MRT	Yes, to No	lesser	29/35=83%	None
L01RET	No to Yes	greater	32/35=91%	None
L17CLX	Neutral to Yes	greater	32/35=91%	None
L06CLX	Yes, to Neutral	lesser	33/35=94%	None

Note: Data derived from pre/end-study questionnaire reports, questions #9/#7 (Appendices M1/M3), individual Qualtrics reports; OSCE scores (Appendix N1); Competency performances (Appendices T1-T7)

Overall, pre-, and end-study data depicted and described above indicate that beliefs in psychomotor skills training by DE were enhanced while beliefs in the DE delivery of affective skills were slightly lessened. Also, with the exploration and comparison of learner beliefs to their OSCE outcomes it does not appear that learner beliefs had a significant impact on learning outcomes. In addition, the findings identify that some learners' beliefs in DE decreased from pre- to end-study despite attaining good to great OSCE performances and scores with few missed competencies, a curious phenomenon for further examination.

In summary of this second level of the NWKM, data reflect a high degree of learner perception in a positive transfer of learning from theory lessons in Moodle to the application of theory to hands-on skills in the scanning labs. In addition, learners stated that they felt prepared for their OSCEs. Learners' evaluation of their training provided insights into training strengths and weaknesses, including unexpected findings sparking further discussion, namely: the necessity and value of online discussion forums for learner success, and, the influence or impact of learner beliefs on learner performance in knowledge, skills, and attitudes. The next NWKM level examines the application and validation of the training to the testing environment, the OSCEs, to demonstrate if learning outcomes were acquired, as manifested in desired behaviors because of the learning experience.

NWKM Level 3 – Behaviors

As aligned with level 3 of the NWKM this research phase assessed how learner participants applied what they learned during the training when they were 'back on the job' (Kirkpatrick & Kirkpatrick, 2010-2019). In the context of this study, 'back on the job' was designed as simulated on-the-job POCUS EFAST experiences utilizing a PUD in scenarios with ultrasound models acting as SPs. Each learner completed three consecutive EFAST examinations on three different SPs, while being observed by a different assessor each time, according to an OSCE grading rubric for EFAST (Appendix F1). Each OSCE was timed to a maximum of fifteen minutes; this time applied to simulate the real-world POCUS environment in performing targeted EFAST examinations in a short time frame. A research assistant was responsible for regulating this maximum time-period whether the learner was finished or not. The overall average score (average of three OSCE scores) per participant provided the primary criterion to ascertain if there was a positive behavior change as a result of the training, that is, did the acquisition of knowledge, skills, and attitudes of the training result in an observable behavior change, determined by the average OSCE score which reflected EFAST competency?

The third level of the NWKM also delves into those "critical behaviors…which, if performed consistently on the job, will have the biggest impact on the desired results" and "required drivers [described as] processes and systems that reinforce, monitor, encourage, and reward performance of critical behaviors on the job (Kirkpatrick & Kirkpatrick, 2010-2019, p. 7). In the context of this study, critical performances were identified as the required competencies of the EFAST protocol (Montoya et al., 2016), framed in the learning outcomes and OSCE grading rubric (Appendices F2 & F1, respectively). The processes and systems to reinforce, monitor, and encourage performance of critical EFAST behaviors entailed learner awareness of 'on the job' expectations and how they would be tested, with access to the testing tool (grading rubric) from the onset of the study to the OSCE experience. Instructional strategies in the three scanning labs also provided OSCE practice in mock scenarios of desired critical behaviors. Reward of critical behaviors were the OSCE scores themselves, indicating whether behaviors had been successfully applied in simulated on-the-job settings, because of the training.

Study results for this third NWKM level are presented in two areas: 1) the OSCE scores, and, 2) a review of the thirty-five OSCE competencies: fully attained, partially attained, and those that were missed entirely by some learners.

OSCE Scores. The OSCE scores were the primary data to determine behavior change because of the training at a quantitative level. As outlined in the OSCE evaluation grading rubric for EFAST (Appendix F1) a maximum score was thirty-five (35) per OSCE representing pre-identified competencies which encompassed EFAST learning outcomes (Appendix F2). After completing their theory and practical training, and their mid-study questionnaire, each learner was scheduled for their OSCE rotation. Each completed three consecutive OSCEs (fifteen minutes each) within a one-hour time frame with an ultrasound model and assessor per OSCE station. The competencies were marked as completed (checkmark) or not (an “x” or left blank). Each assessor submitted their completed grading rubrics (paper) to the research administrative assistant who then recorded all scores and calculated the average per learner on an Excel file (Appendix N1); these data are presented in Table 6 below. To note: Each learner received their average OSCE score prior to completing their end- study questionnaire.

Overall OSCE Success by Average Scores. There are several ways to determine OSCE success at the quantitative level, and minimum ‘pass’ marks will vary across schools and provinces. One view of the study’s OSCE results was attaining a minimum score of twenty-four and a half of the thirty-five competencies (24.5/35), equaling seventy percent (70%), a common minimum standard in Canada’s program accreditation process for entry-level competency. This national accreditation standard requires program adherence to allied health professions’ respective published benchmarks of annual graduate pass rates (Health Standards Organization, 2018). An example of a benchmark for the allied health profession of magnetic resonance imaging can be found in program correspondence, such as a letter to the Chair of NAIT’s magnetic resonance imaging programs from the Canadian Association of Medical Radiation Technologists (CAMRT) advising NAIT that “…should an annual pass rate of lower than 70% occur twice within 3 consecutive years” the program may be subject to non-compliance with Accreditation Canada (C. Bru, personal communication, March 5, 2018). Given this criterion of a minimum 70%, sixteen of the twenty learner participants were successful with the other four attaining scores below 70% as circled on

Table 6. With application of the 95% confidence interval ±6.4 from the mean, two scores on the cusp of the 70% standard (open arrows) would be failures rendering overall results of fourteen of twenty learners achieving the minimum national pass, indicating that 70% of learners achieved success, a metric that still meets Canada's minimum standard for allied health programs.

Another perspective to gauge the study's OSCE results is a minimum score of twenty-two of the thirty-five competencies (22/35) based on NAIT's minimum course pass criterion in its health programs where a course grade of minimum 63% or standard C is required for academic progression, as published in several of NAIT's course outlines in the School of Health and Life Sciences (NAIT, 2020). In this latter metric, eighteen of twenty learner participants achieved OSCE success with only two below this criterion as indicated by the two solid arrows on Table 6.

Table 6

OSCE Scores and Averages

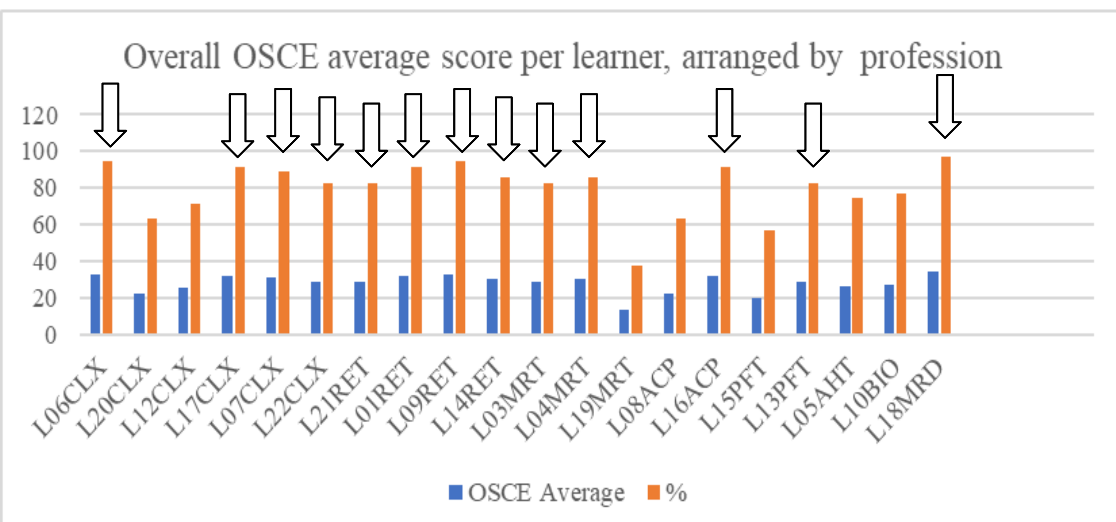
Learner Number & Profession	OSCE Score by Assessor			OSCE Averages: Score & Percentage		Rounded up/down results
	OSCE A01	OSCE A02	OSCE A03	Score	Percentage	% Rounded up or down
L06CLX	32	34	32	33	94.2	94
L20CLX	15	24	26	22	62.8	63
L12CLX	19	28	27	25	71.4	71 ⇐
L17CLX	28	35	34	32	91.4	91
L07CLX	31	32	31	31	88.5	88
L22CLX	24	32	30	29	82.8	83
L21RET	28	30	30	29	82.8	83
L01RET	31	32	32	32	91.4	91
L09RET	32	32	34	33	94.2	94
L14RET	32	29	30	30	85.7	86
L03MRT	26	28	33	29	82.8	83
L04MRT	29	29	32	30	85.7	86
L19MRT	9	17	14	13	37.1	37 ↙
L08ACP	24	19	24	22	62.8	63
L16ACP	29	32	34	32	91.4	91
L15PFT	14	28	17	20	57.1	57 ↙
L13PFT	29	27	32	29	82.8	83
L05AHT	20	30	29	26	74.2	74 ⇐
L10BIO	23	33	25	27	77.1	77
L18MRD	35	34	33	34	97.1	97
[a]**AVERAGE**	**26**	**29**	**29**	**28**	**79.6**	**80**

Note: [a] Group Means. Data from OSCE scores (Appendix N1). 95%CI (73.2-86.0) ±6.4

Data presented above indicate that the training enabled the desired behavior change sought by level three of the NWKM for eighteen of twenty learners, according to current NAIT academic standards (>63%) and for sixteen of twenty learners with a national accreditation entry-to-practice criteria (>70%). The value of presenting quantitative data for individual participants in Table 6 above supports further qualitative analysis of individual competency performances. Individual learner analyses sought to identify which competencies were strong and weak to glean further information behind their quantitative OSCE scores, such as the low score for L19MRT (37 .1%), a score significantly lower than the group average of 79.6%, to the top score of L18MRD (97.1%). These qualitative data on competency performances are presented later in this chapter. A depiction of individual OSCE average scores per learner is presented in Figure 18 below (note the arrows are explained in the following paragraph):

Figure 18

Overall OSCE Average Score per Learner



Note: Data derived from Excel file of OSCE scores for group: n=20 (Appendix N1)

With multiple professionals volunteering for the study the opportunity to discover any learning/competency differences between the professions existed, findings which could inform the transferability potential or unique training needs of the training intervention for other allied health/medical disciplines. From this lens, those learner average scores above the group average of 79.6% were reviewed, as identified in Figure 18 (open arrows). It is notable that these scores represent individuals from six of the eight different professions in the study and suggest the importance of the aptitude of the individual learner versus the profession they come from. These findings could also suggest potential transferability of the training intervention for multiple allied health disciplines; however, the study's small sample size does not provide any evidence to support conclusions on training transferability, and further research in this area is recommended.

As earlier presented in Table 6, data identify a sixty-point range of learner performance from a low of 37.1% (L19MRT) to a high of 97.1% (L18MRD). The low performance of L19MRT is considered a failure and with such results it would be important for the learner to repeat the training with important academic support to identify learning barriers. In this case, there is insight in L19MRT's narratives offered at mid-study which included needing "more practice scanning labs", and the comment "I was not surprised at my clumsy handling of the transducer" (Appendix M2, question #11 & #13, respectively). At end-study, when asked what one thing the learner would change, L19MRT responded "I would be more attentive in how to use the transducer. I was lost without the 'voice in my ear' [during the OSCEs]" (Appendix M3, question #9). This end-study comment is helpful, suggesting the incorporation of a 'mock OSCE' with opportunity to practice without the instructor's guidance and 'voice in one's ear' prior to a formal assessment such as an OSCE. With the removal of L19MRT's average score the group's low-to-high range is still large at forty points (L15PFT to L18MRD). Given these wide ranges in OSCE average scores it was important to review any variations between the assessors and their grading patterns to ascertain potential impacts to OSCE results.

Assessor Profiles and Impact to OSCE Scores. A review of assessor performance was conducted to understand any inter- or intra-assessor variability. OSCE assessors were coded as

A01, A02, and A03 on their OSCE assessment grading rubrics. An excerpt of the OSCE scores from Table 6 above is presented below in Table 7, highlighting those individual OSCE average scores less than 70%, to explore assessor congruency/incongruency and its potential impact on these learner results. The data below identify four learners where one of their assessor scores is significantly lower or higher than the other two by six to fourteen points, either by Assessor 01 for two learners or Assessor 02 for the other two learners. The data reveal that although four of twenty learners were impacted by variable scoring by a single assessor, thereby affecting their OSCE results of less than 70%, there was congruency with the other two assessors. This finding of some scoring variability validates the value of learners being tested on a minimum of three OSCEs versus one or two, due to the inherent subjectivity of assessment procedures which include human observation methods, a notation for future training evaluation plans and research.

Table 7

Assessor Variations for OSCE Scores and Averages

Learner Number & Profession	OSCE Station by Assessor Code			Variable Points from low to high	OSCE Average & %	
	A01	A02	A03		Score	Percentage
L20CLX	15	24	26	-11	22	62.8
L08ACP	24	19	24	-6	22	62.8
L19MRT	9	17	14	-8	13	37.1
LL15PFT	14	28	17	+14	20	57.1

Note: Data from Excel file of OSCE scores (Appendix N1)

Summary of OSCE Score Analysis. In summary, OSCE scores demonstrate success rate for sixteen of twenty learner participants when measured against the national health industry standard of a minimum 70% 'pass'. In the context of the current NAIT standard of a minimum course pass of

63% for academic progression, eighteen of the twenty students 'passed'. The quantitative results of learner OSCE scores presented thus far were further reviewed from a qualitative approach by reviewing learners' individual grading data (Appendices T1-T7) to analyze the 'performance' of the competencies themselves.

Analysis of OSCE Competencies. In addition to OSCE scores further analysis of the thirty-five individual OSCE-tested competencies was conducted to identify those competencies that were easily attained by learners and those that were not. In turn, this analysis reflects where the training may have been strong or weak. Each competency was attempted and assessed three times, with each assessor checking off those elements as completed or not, as per the example provided in Appendix N2. The researcher conducted a review of each individual OSCE assessment paper record to identify which competencies were attained by participants on all three attempts, on two and above, only once, or not at all. Appendices T1 to T7 present the results of this competency analysis.

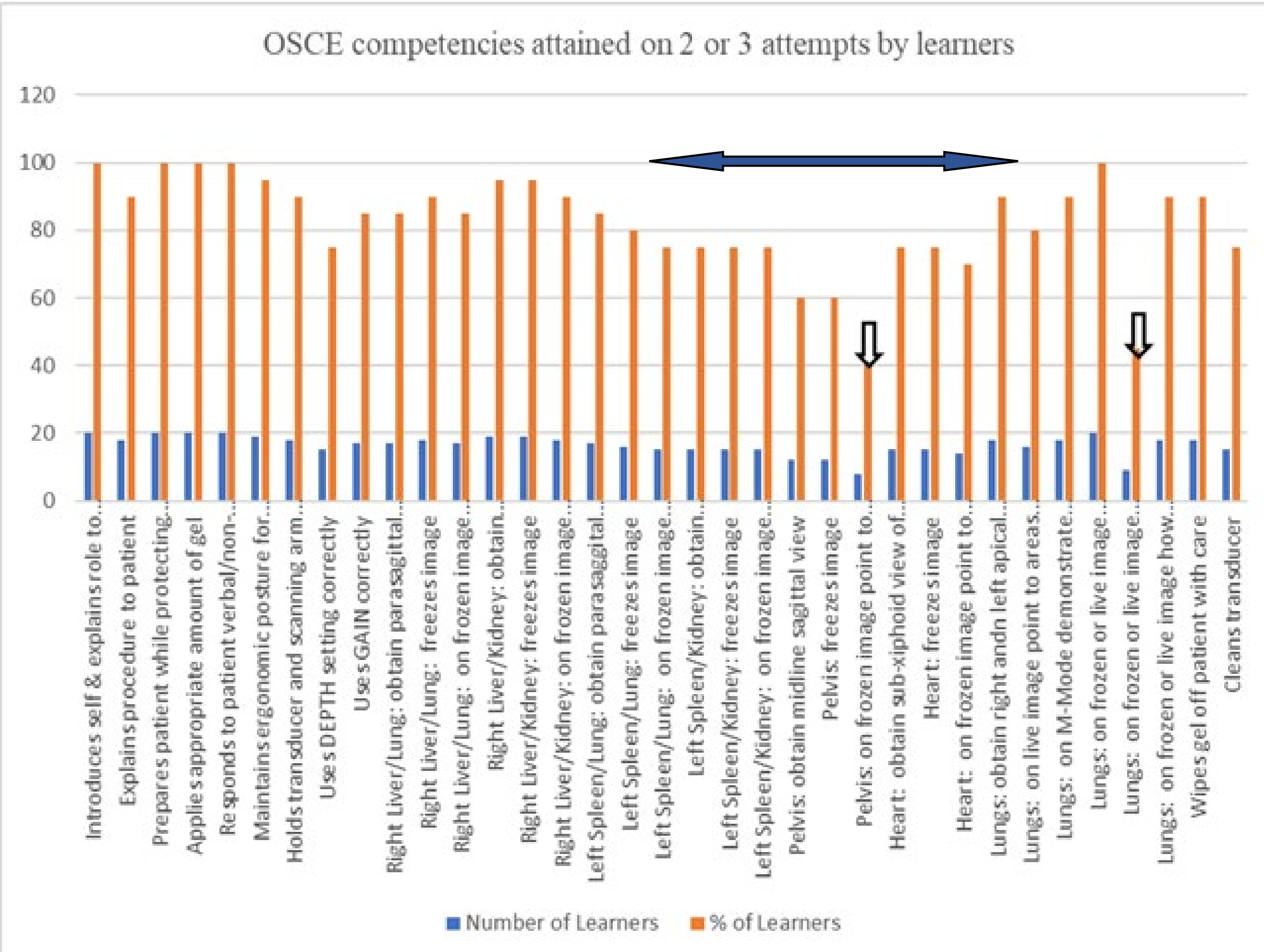
OSCE Competencies Attained 100% (all 3 attempts). In a review of competencies not missed by any learner, two were successfully attained on all three attempts, both from the professional behaviors category occurring at the start of the OSCE examination: 1) introduces self & explains role to patient, and 2) applies appropriate amount of gel. The first success is logical given the previous professional patient-care experiences of the learner participants and their familiarity with this important professional behavior. The second competency, unique to ultrasound, is notable as too little gel is critical, as this will affect image quality, whereas too much is simply inefficient (Sanders & Winter, 2007).

OSCE Competencies Attained at least 66.6% (minimum of 2 attempts). Given the caveats that: 1) attaining a competency a minimum of two out of three attempts (minimum 66.6%) indicates learner success according to certain academic standards, and 2) these data reflect effective training, the following depiction (Figure 19) represents competencies successfully attained by participants and indicates those elements to reinforce in future training designs. Data identify two weaker areas of performance (vertical arrows) as follows: 1) pelvic imaging (40%), specifically in pointing to where fluid would be, and 2) identification of reverberation artifacts on an image of the lungs (45%). With pelvic imaging identified as a weak area, considerations of study design emerged in data analysis, as scanning labs were planned with same-gender partners where possible. This same gender element could have been a disadvantage for male participants in the testing phase, given that all three OSCEs had a female SP in each scenario. As the research study methodology did not require gender information, and cannot be illuminated after the fact, it compels the researcher to advise future researchers, and future instructional designers to implement different gender partners for scanning lab instruction, advocacy that is corroborated by learner and instructor feedback, to be discussed later in the chapter.

The next areas of some struggle, depicted by the horizontal arrow on Figure 19 for some learners (between 60-80%), involved imaging of the left side of the abdomen, the heart, and one of the lung views (sliding). All other competencies reflect a strong performance, attained by greater than 80% of learners at least two out of three attempts

Figure 19

OSCE Competencies Attained on 2 or 3 Attempts by Learners



Note: Data derived from Excel files (Appendices T1-T7); 35 competencies

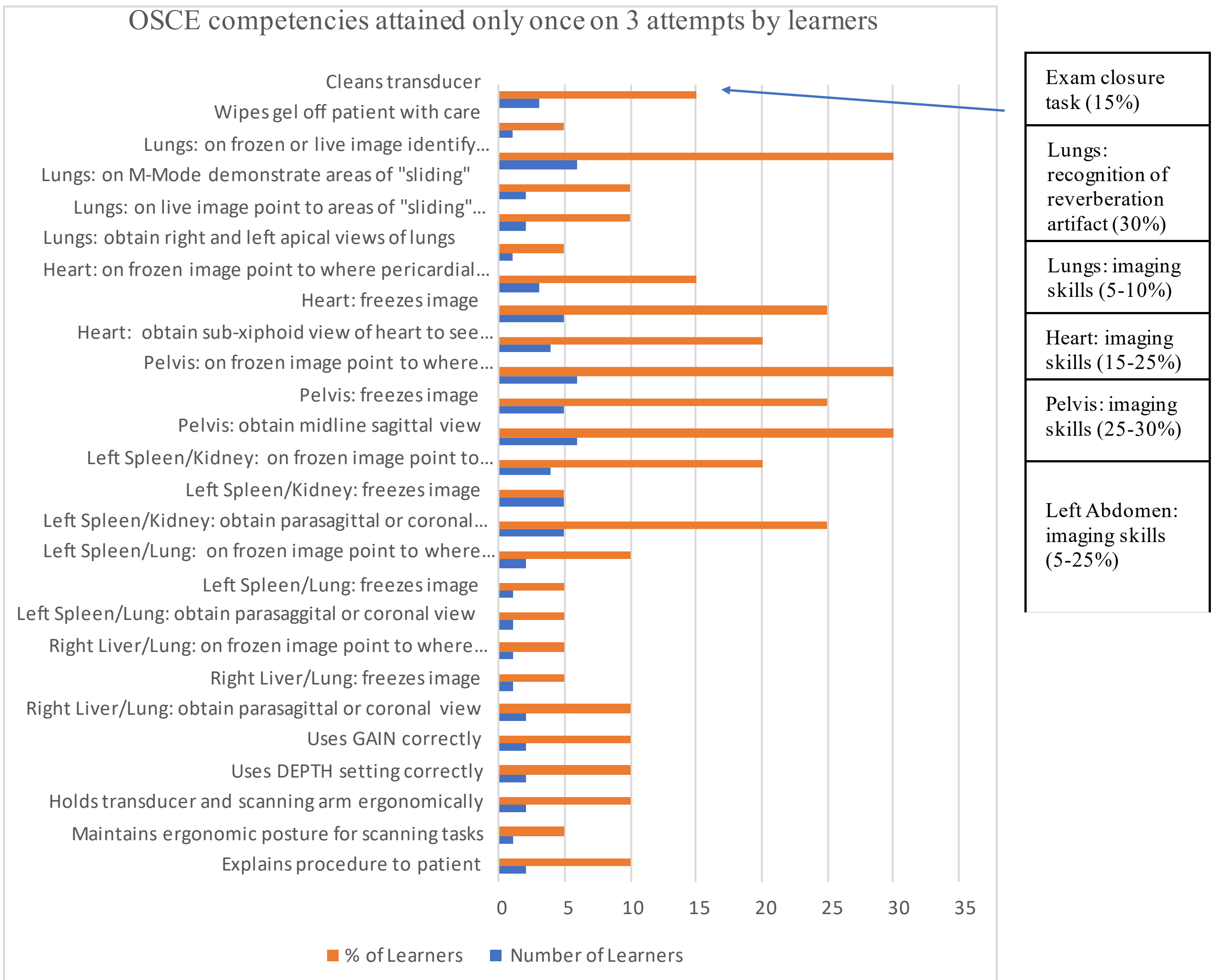
For further insight into competency performance and to assist in the evaluation of training effectiveness for future design, those competencies only passed once on three attempts by some learners were identified.

OSCE Competencies Attained Only Once on 3 Attempts. As presented in Figure 20 below data are consistent with previously identified weaker areas of competence, e.g., lungs, heart, pelvis, and left abdomen. As pelvic imaging skills were only attained once by 25-30% of learners, and, as this anatomical area is best imaged with a full urinary bladder (Sanders & Winter, 2007), grading rubrics were examined for indications of inadequate bladder filling by the ultrasound models.

Appendix U1 is an example of such a case and may explain the difficulty for some learners in pelvic imaging. This finding demonstrates the need for proper patient preparation in an OSCE scenario to test pelvic imaging competencies. An additional area only attained once by 15% of learners (arrow on Figure 20), represents one of the competencies in exam closure, that of cleaning the transducer, a relatively easy task, however critical to prevent the spread of infection. Review of some assessor grading sheets in the 'exam closure' area demonstrated no check mark on this competency, some with the notation "ran out of time", as provided in Appendix U2, a finding to inform adequate timing for future OSCE sessions, and to stress the importance of infection control.

Figure 20

OSCE Competencies Attained Once on 3 Attempts by Learners

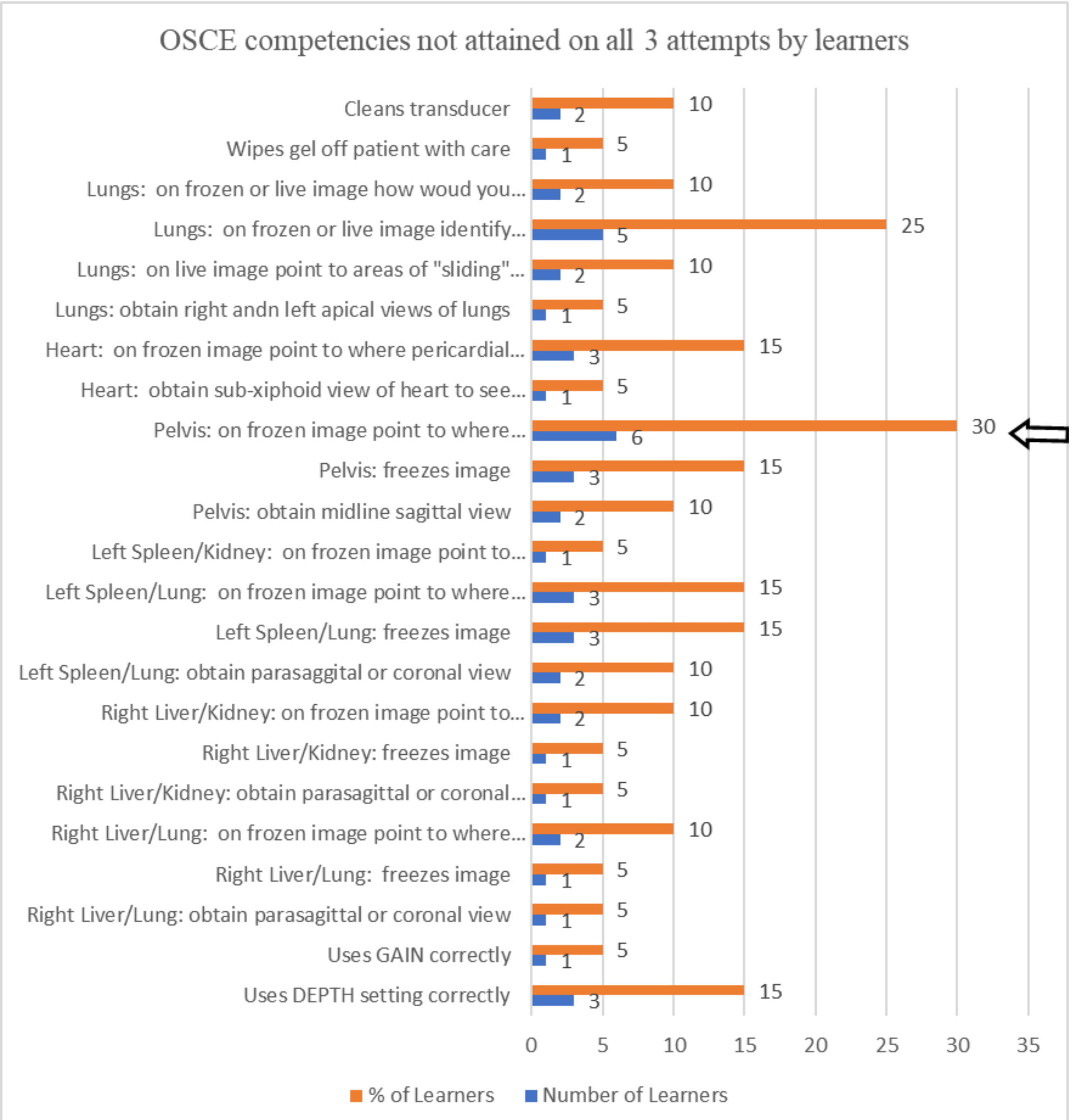


Note: Data derived from Excel files (Appendices T1-T7); 35 competencies

OSCE Competencies Not Attained (missed on all attempts). In keeping with data analysis thus far, the last areas of competency review were those competencies that were completely missed by some learners, that is, learners failed on all three attempts. As presented in Figure 21 below, one of the pelvic imaging skills was missed on all three attempts by six learners (30%) specifically, the identification ('point to'…) of possible fluid location (open arrow). The next areas of weakness for learners were the previously cited areas of left side abdomen, heart, identification of reverberation artifact on the lungs, and the inaccurate or lack of use with the 'depth' function in ultrasound instrumentation. Other areas missed by one or two learners (<10%) represented variable competency areas of imaging skills and the tasks for exam closure. A significant finding in the theme of missed competencies is that the majority are missed in the skill of 'pointing to' the area where fluid could be, a notable finding in future course design which indicates the need for stronger theory and practice recognition of ultrasound pathologies and image patterns, cognitive objectives in course content.

Figure 21

OSCE Competencies Not Attained on All 3 Attempts by Learners



Note: Data derived from Excel files (Appendices T1-T7); 22 competencies

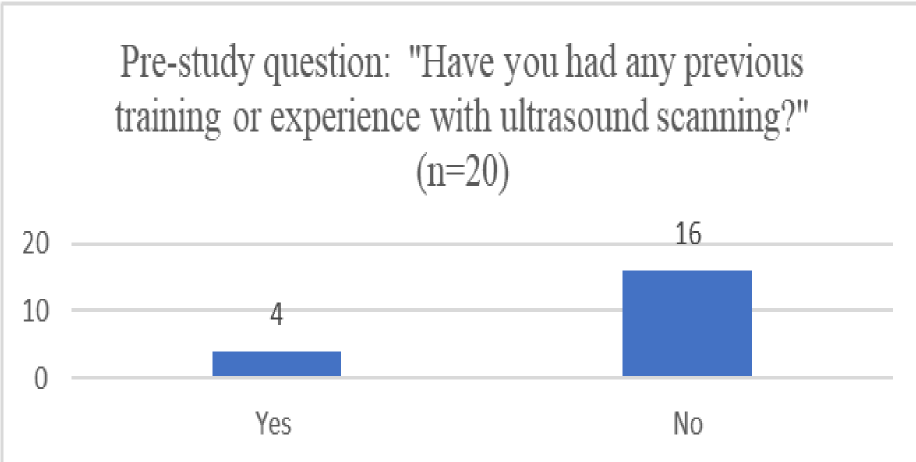
Summary of OSCE Competency Review. In summary, the review of which competencies were fully attained, and which were missed once, twice or all three times, informs recommendations for future instructional design and are brought forward for discussion in later chapters. Now that performances of the OSCE competencies have been presented, a review of any influencing factors will be discussed such as previous ultrasound experience or an imaging background.

Previous Training/Experience in Ultrasound. In the analysis of OSCE data, it was important to present any factors which may have influenced learner change of behavior (OSCE performance) in the context of the third NWKM level. In the pre-study questionnaire, all learners were asked if they had any previous ultrasound training or experience and if yes, to describe that experience (Appendix M1, question #4). The graph below (Figure 22) indicates that four learner participants identified previous ultrasound exposure. These four learners described their previous training or experience in the following ways: "modeled as an [ultrasound] patient", "imaging of geometric phantoms", measuring blood flow velocity, and using a built-in ultrasound transducer to localize "radiopaque calculi" (Appendix Q).

In consideration of each of these four cases, the researcher determined that all four participants still maintained the criterion of 'ultrasound naïve' for the study. In the first case, modeling as an ultrasound patient is passive providing no actual hands-on activity in the operator-dependent manipulation of the transducer. In the second example, imaging static geometric phantoms does not give adequate hands-on experience of scanning live human anatomy. The third scenario of measuring blood flow velocity does not include two-dimensional real-time ultrasound imaging skills, rather, it is related to one-dimensional graphics and doppler sounds (Sanders & Winter, 2007). And finally, for the fourth declaration, a built-in transducer would not give the participant any advantage in the hand-held operator-dependent skills of a PUD for the EFAST study. In addition, the respective OSCE scores of these four cases were: 82.8%, 77.1%, 82.8% and 97.1%. These scores, when compared to the group OSCE average of 79.6% do not reflect significant advantages for the four examples of perceived previous experience described above, as other participants achieved equal or higher scores.

Figure 22

Previous Training or Experience in Ultrasound (Pre-Study Question)



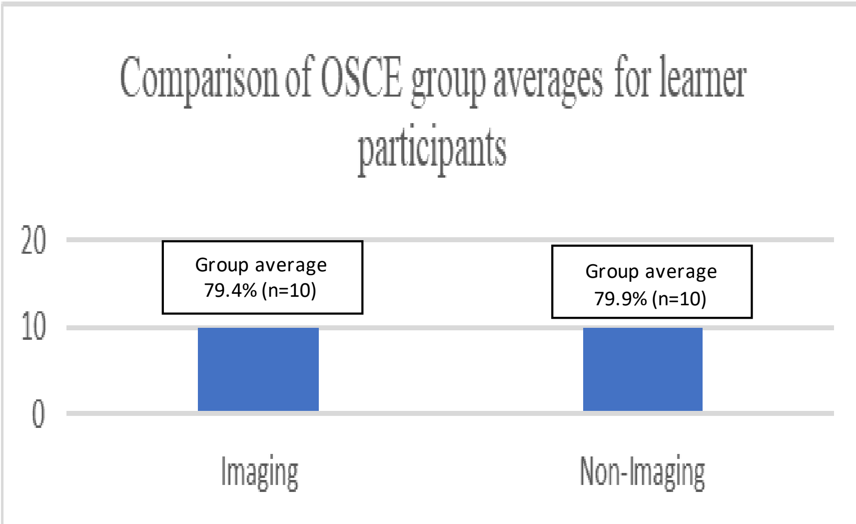
Note: Data from pre-study questionnaire report, question #3 & #4 (Appendices M1 & Q)

95%CI (1.6-1.99)

Entering the Study from an Imaging Profession versus a Non-Imaging Profession. Another potential influence on learner behavior change and performance was whether one's prior professional training was more amenable to attaining ultrasound imaging competency than another, for example, those with imaging versus non-imaging backgrounds. The researcher investigated if learner participants with imaging backgrounds would have an advantage in the study. Figure 23 below represents a group OSCE average of 79.4% for the ten participants from imaging professions (CLX, MRT, MRD), and the other group of ten with non-imaging backgrounds (RET, ACP, PFT, BIO, AHT) scoring a group average of 79.9%. These data indicate a very small difference (< 1%), between the two groups and identify no advantage of one group over the other in this study.

Figure 23

Comparison of OSCE Average Scores between Imaging and Non-Imaging Professions in Sample



Note: Data derived from Excel/Word files (Appendices M6/P)

The possibility of an advantage for imaging over non-imaging professional backgrounds was also raised by one of the instructor participants in their field notes as: “I guess the participants with an imaging background (X-Ray or CLXT), may have been a bit more familiar with cross-sectional anatomy…”, this same instructor commenting for all learners: “I found that some people seemed to have a natural aptitude for controlling the transducer and being able to manipulate the image and patient to get the image required.” (Appendix O2, question #21). From these instructor comments the researcher examined prior cross-sectional anatomy education as a potential learner advantage in the context of the instructor’s observation of a “natural aptitude” in manipulating the transducer to get an image. To explain, a course in cross-sectional anatomy is learning to view ‘slices’ of human anatomy in two- and three-dimensional images, a common course in the curricula of imaging professions (The Michener Institute, n.d.). Cross-sectional imaging requires cognitive visuospatial abilities to mentally construct three-dimensional anatomy from two-dimensional images (Sanders & Winter, 2007). In ultrasound performance, visuospatial skills are simultaneously combined with visuomotor skills as the ultrasound operator continuously views human anatomy in cross-sectional format while manipulating the probe subtly and differently for each view/slice of anatomy to create a diagnostic image. As cited in Bowra et al. (2015, p. 24) these psychomotor skills are referred as "open, because there are variations each time the skill is performed…e.g. the task is not identical each time" (Melniker et at., 2006). This ability to synthesize psychomotor and cognitive skills (hand-eye coordination) is noted by the instructor's comment that participants demonstrated "natural aptitude" in creating a diagnostic image, which is performing required hand-eye coordination with visuospatial *and* visuomotor skills. Data in Table 8 below examine if the lack of prior cross-sectional anatomy knowledge was a potential disadvantage to the non-imaging professions in attaining their imaging skills. As presented, all professions in the sample already possessed some degree of hand-eye coordination skills from their background scopes of practice, however, not all had received specific cross-sectional anatomy education. To note: the hand-eye coordination skills for ultrasonography are included as well for reference. From these data (stars), it can be stated that the lack of cross-sectional anatomy education in the non-imaging fields did not present a disadvantage to learners when one views their successful OSCE scores (circled) of greater than 70%.

Table 8

Professional Backgrounds: Elements of Education and/or Practice with Potential Influence on Competency Performance in the Study

Profession (n) & %OSCE average scores of learners within the profession	Medical imaging profession?	Formal courses/education in cross-sectional anatomy?	Are hand-eye coordination skills required on the job?	Relevant examples of hand-eye coordination from scope of Practice
	Yes/No	Yes/No	Yes/No	
ACP [a] (n=2) 63, 91	No	No	Yes	Frequent intubations/airway management
AHT [b] (n=1) 74	No	No	Yes	With surgical procedures
BIO [b] (n=1) 77	No	No	Yes	Small instrument adjustments
CLX [c] (n=6) 63, 71, 83, 88, 91, 94	Yes	Yes	Yes	Phlebotomy (taking blood) and x-ray positioning
MRD [c] (n=1) 97	Yes	Yes	Yes	Computer adjustments to MRI imaging planes
MRT [c] (n=3) 37, 83, 86	Yes	Yes	Yes	X-ray positioning
PFT [b] (n=2) 57, 83	No	No	Yes	Adjustments of physical body technique
RET [d] (n=4) 83, 86, 91, 94	No	No	Yes	Adjustments of small ventilator technology/airway management
Ultrasound [e] (n=n/a)	Yes	Yes	Yes	Continuous and subtle hand-eye imaging skills

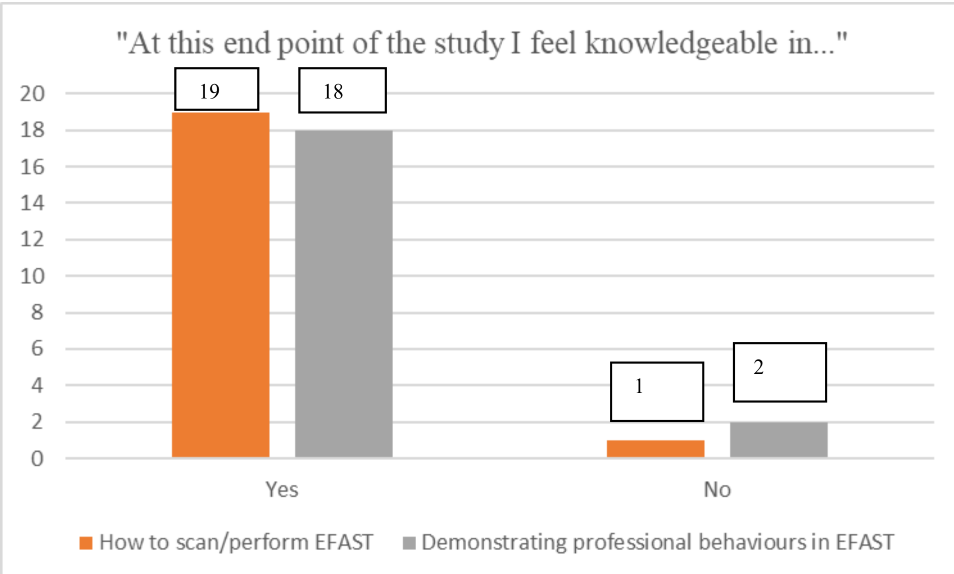
Note. [a] Government of Newfoundland and Labrador (n.d.); [b] Williams (2017); [c] Medical Imaging Overview (n.d.); [d] Canadian Society of Respiratory Therapy (2020); [e] Layne (n.d.). Data derived from Excel files of OSCE scores (Appendix N1); Profession descriptions (Appendix P)

Competency Analysis of Individual Learners in Core Skills of the Study. In addition to reviewing the overall attainment rate of competencies by the participants as a group, the researcher analyzed how individual learners performed on their competencies (Appendices T1 to T7) and their OSCE scores in comparison to their stated beliefs in the effectiveness of DE training with a PUD for the EFAST examination. These data are captured in the context of the two core skills of the study: how to scan/perform EFAST and how to demonstrate the required professional behaviors in EFAST.

Core Skills of the Study. Data analysis included focus on the core skills of the study directly related to the primary research question to investigate attainment of hands-on skills and professional competencies required of POCUS via the OSCE scores of EFAST performances. At end study, after their OSCEs, learners were asked if they felt knowledgeable in how to scan/perform EFAST, and in demonstrating the required professional behaviors. As presented in Figure 24 below, study results indicate that nineteen of twenty learners reported feeling knowledgeable in scanning/performing EFAST, and eighteen of twenty learners felt they were able to demonstrate the required professional behaviors in EFAST.

Figure 24

Learner Statements (Feelings) on Achieving Core Skills at End Study



Note: Data from end-study questionnaire report, question #5 (Appendix M3)

How to scan/perform: 95%CI (.95-1.15); Demo. professional behaviours: 95%CI (.96-1.24)

The three participants who responded "No" to feeling knowledgeable in the chart above were further examined for deeper understanding if their beliefs impacted their self-assessment of their ability to 1) perform an EFAST exam and/or 2) demonstrate the required professional behaviors of an EFAST exam. Analysis for results in Table 9 below examines the relationship of these three learner beliefs to their self-evaluations of feeling knowledgeable, their average OSCE score, and those OSCE competencies they missed. The focus of this exercise was conducted to better understand the role of participant beliefs, and, if these beliefs may or may not have affected respective performances regardless of their feelings of being knowledgeable.

Of the three learners with "no" responses in Figure 24, two (L10BIO and L13PFT) believed in DE, felt knowledgeable in their ability to perform (scan) the EFAST exam, and had very good OSCE scores with some missed competencies primarily in the psychomotor imaging skills.

However, in relation to professional behaviors they both believed in DE but did not feel knowledgeable in this area (rectangles). One of these learners, L13PFT, did not miss any OSCE professional behaviors (star) yet still did not feel knowledgeable. On the other hand, the other learner, L10BIO, did miss professional competencies on his OSCE (cross). In this latter case, despite not feeling knowledgeable the learner maintained a personal belief in DE for acquisition of professional behavior skills, a finding emphasized by the learner's increase of belief from pre -to end-study (oval). To note is the professional background of L10BIO, one of the professions in the sample with the least amount of patient interactions.

The relationship of feeling knowledgeable and belief in DE is also tested with data for the third learner in Table 9. In the case of L19MRT, beliefs in DE for psychomotor and affective skills were maintained (solid arrows) despite a very poor OSCE score and multiple competencies missed; in this case the learner did not feel knowledgeable in scanning ability with the opposite feeling for professional behaviors (circles).

These three examples offer a favorable case for DE as a viable method to acquire the core skills of EFAST where learners believed in DE, despite not *feeling* knowledgeable. The data for L10BIO and L13PFT may indicate low levels of confidence despite achieving very good OSCE results. For L19MRT with a failed OSCE score of 37% there is understanding with not feeling knowledgeable in performing EFAST, however, there is non-congruency in feelings and possible false confidence with demonstrating professional behaviors. The degrees of confidence are elements of the second level of the NWKM where transfer of learning occurs; the researcher postulates that some learners need more time to build confidence despite early academic success. To note, beliefs were discussed earlier in the chapter (Appendices R and S; Tables 4 and 5, respectively).

Table 9

Comparison of Learner Beliefs in DE for Psychomotor and Affective Skills and Their Feelings of Knowledgeability to OSCE Data for L10BIO, L13PFT, L19MRT

	Participant		
	L10BIO	**L13PFT**	**L19MRT**
Pre to end study: Beliefs in DE for learning hands-on training (psychomotor skills)	Neutral to Neutral	Yes, to Yes	Yes, to Yes
At End-Study: Feel knowledgeable in performing EFAST?	Yes	Yes	No
Pre to end study: Beliefs in DE for professional behaviors	Neutral to Yes	Yes, to Yes	Yes, to Yes
At End-Study: Feel knowledgeable in demonstrating professional behaviors in EFAST?	No	No	Yes
OSCE Average Score	27/35 (77%)	29/35 (83%)	13/35 (37%)
Competency Areas Missed	Some imaging skills and Professional behaviors (patient interactions)	Ergonomics and some imaging skills	All areas missed including professional behaviors
Analysis Notes & Conclusions	*Note:* Increased belief in DE for professional behaviors but stated NOT feeling knowledgeable despite a good OSCE score, however, to note is missed professionalism competencies **Conclusions:** Belief in DE maintained post-OSCE despite not *feeling* knowledgeable	*Note:* Belief in DE for professional behaviors but stated NOT feeling knowledgeable despite a high OSCE score above average **Conclusions:** Belief in DE maintained post-OSCE despite not *feeling* knowledgeable	*Note:* Belief in DE for hands-on despite not being able to pass imaging skills; Belief in DE for professional behaviors despite areas missed in professionalism and a low OSCE score **Conclusions**: Belief in DE maintained post-OSCE despite not *feeling* knowledgeable

Note: Data derived from pre/end-study questionnaire reports, questions #8&9/#6&7 (Appendices M1/M3), individual Qualtrics reports; OSCE scores (Appendix N1); Competency performances (Appendices T1-T7)

In summary of the third NWKM level, analysis of OSCE scores indicate positive learning outcomes with resultant change in behaviors which demonstrate desired results. Additional analysis of competency attainment highlights those strong and weak areas which inform future training design. Within these data some learners maintained their beliefs in DE for EFAST training despite personal reports of not feeling knowledgeable, data which strengthen the value of DE for acquiring skills, in particular, hands-on skills (psychomotor) and professional behaviors (affective), in addition to knowledge (cognitive). All data presented in this third level of the NWKM indicate that training was effective, and learners were successful when tested in simulated EFAST settings with models behaving as patients. In the fourth and final level of the NWKM (results) training effectiveness was evaluated in its ability to be sustainable 'on the job'.

NWKM Level 4 – Results

In the real world setting of workplace education, the fourth NWKM level applies to evaluation of the training once the trainees are back on the job. This level aims to determine to what degree did targeted learning outcomes transfer to the workplace as a result of the training. Leading indicators of this level are "short-term observations and measurements that suggest that critical behaviors are on track to create a positive impact on desired results" (Kirkpatrick & Kirkpatrick, 2010-2019, p. 6). This NWKM level also includes the degree of support, retention, and sustainability of the training with attention to leading indicators such as continued engagement of employees, sustained quality of performance, and satisfaction of workplace customers, and in the case of healthcare, the patients. The last indicator, customer satisfaction, is an important element in its connection to organizational goals rather than 'results' being measured at a single unit or department level. In other words, level four of the NWKM encompasses training that is successful for both trainees and the organization overall. In the context of this study, a review of 'results' was modified.

Upon completion of the research study, learner participants did not use their training 'on the job' as they all returned to their own non-ultrasound professional practices as faculty members of NAIT. Thus, the researcher re-framed this level to explore how participant feedback on the training could support and reinforce future instructional design for EFAST and POCUS workplace training, a parallel to the leading indicators reflected in level 4 of the NWKM. From this lens, the researcher believes that effective instructional design will contribute to reinforced and sustainable training, training reflecting the 'results' level of the NWKM, where critical behaviors continue to be on track in the performance of EFAST and POCUS fields of practice, for patient satisfaction, and for broader organizational benefit. Within this frame, learner and instructor feedback were analyzed for their recommendations for future design, including sustainable strategies in the post-training period.

Learner Evaluation of Training for Recommendations for Future Instructional Design. Mid- and end-study online questionnaires were designed to capture learner participant feedback on their learning and assessment experiences. The deployment of the mid-study questionnaire was timed to capture participant feedback *after* completion of theory and practical training (Moodle course and scanning lab instruction with REACTS®), and *before* the OSCEs, with the end-study gleaning further data once the learners had completed their OSCEs and learned of their average score. As earlier described, learner feedback *before* their OSCEs was critical to receive learner feedback on their learning experience first, without their reflections on the OSCE phase of testing.

Theory (Moodle) Component. Mid-study questionnaire results capture learner narratives on the *most* and *least* helpful elements of their learning experience in the theory (Moodle) portion of the training (Appendix M2, questions 6 & 7).

From learner narratives, feedback on the Moodle course experience identified the following resources as *most* helpful: guided (narrated) PowerPoints, YouTube videos on performing the EFAST examination, and the inclusion of ultrasound images within both the PowerPoints and videos. As reported by one learner: "The YouTube videos were extremely helpful. I'd recommend that students watch those first before tackling the PowerPoint presentations, as it provided some visual clarity to the content" (Appendix M2, question #6; Appendix V3). These narratives correlate with the number of favorable responses to the question: "The multimedia tools (PowerPoint and YouTube) on the Moodle course site enabled me to learn the theory of ultrasound principles" (Appendix M2, question #3). Learner response to this statement "somewhat agree" for six learners and "strongly agree" for the remaining fourteen learners, findings which indicate a very strong element of the training design.

Learner feedback on the *least* helpful elements included nine of twenty narratives citing the online discussion forums, with comments such as "The forums were not used by the group very much", "I didn't use any discussion forums or watch most of the videos", and "[t]he forums were not really utilized by the students. If there were more questions, there would have been more of a use…didn't really get to the point of needing the forums". Interestingly, the other eleven narratives did not mention forums (Appendix M2, question #7; Appendix V3). This omission from more than half of learner narratives correlates with quantitative data where learners responded "neither agree or disagree" to the following statements: 1) "Interacting with my fellow participants in the Moodle forums helped me to learn course material" (thirteen responses), 2) "Interacting with my instructors in the Moodle forums helped me to learn the course material" (ten responses), and 3) "Participating in the Moodle forums made me feel a part of a class or cohort" (fifteen responses) (Appendix M2, question #3). Quantitative and qualitative data clearly indicate that the forums were a weak and/or low-value training area and do not indicate participant recommendations to include online discussion forums into future POCUS training designs.

Other areas noted as least helpful include reference to the multimedia resources where four learners suggested tips for improvement such as less narration. One learner reported non-use of the "glossary", which was provided as a resource on Moodle and identical to the list of nomenclature and acronyms in this dissertation. Six learners reported no negative experiences when asked what was least helpful, with examples of these narratives expressed as "[n]othing. Everything was helpful", or "[n]othing comes to mind" (Appendix M2, question #7; Appendix V4).

Data in Table 10 below summarize learner narratives on the *most* and *least* helpful elements of theory training (ovals), with multimedia resources rated highly by all twenty learners (100%); in contrast, the poor results of Moodle forum discussions, commented by nine of twenty learners (45%), in the forums' ability to facilitate learning or enable a sense of cohort.

Table 10

Learner Narratives on the MOST and LEAST Helpful Elements in Theory Training (at Mid Study)

What was MOST and LEAST helpful for your learning experience in the Moodle course site?	
MOST = Multimedia resources* (100%) 20/20 comments *tips for improvement (see #2 in Least helpful column)	**LEAST = Forums** (45%) 9/20 comments
1. **PowerPoint slides**: narrated slides including images – great explanation and tips (7/20=35%)	1. **Forums**: did not use; not helpful; if there were more questions there would have been more use but didn't get to the point of needing them, didn't find instructors answers helpful
2. **Videos**: videos (YouTube) with audio within showing whole scan; how EFAST scan is done; videos of ultrasound image and hand/probe placement at same time (6/20=30%)	2. ***Multimedia aspects**: too much narration on PowerPoint slides; need more markers on Images, variances of technique on videos but sorted out in labs (4/20=20%)
3. **Both PowerPoint slides and videos**; including multiple examples of good/bad pathology (7/20=35%)	3. **List of Nomenclature and Acronyms (Glossary)**: did not use (1/20=5%)
	4. **ALL was helpful**: no negative experiences (6/20=30%)

Note: Data derived from mid-study questionnaire report, questions #6 & #7 (Appendix M2; Appendices V3 & V4)

Practical (REACTS®) Component. Mid-study questionnaire results captured learner narratives on the *most* and *least* helpful elements of their learning experience in their practical scanning labs (Appendix M2, questions 8 & 9).

Learner narratives indicate the following themes as the most helpful training elements in their hands-on scanning labs: instructor competencies and instructor number (five responses), real-time instructor interaction (eight responses), the interactive features of the REACTS® technology and the course design itself (five responses each), a design providing one-on-one hands-on labs with remote guided instruction. These themes of most helpful elements are further supported with comments on the labs: “Getting the hands on and one on one instruction”, “real time instructor feedback” and “[h]aving the instructor confirm what I was seeing and being able to see the instructor demonstrate how to manipulate the probe to get a better image”. Learners also cited instructor characteristics and competence as “helpful and knowledgeable”, including appreciation for instructor number: “The instructors were great, and having two of them was beneficial, because they each stressed different points.” (Appendix M2, question #8; Appendix V5). These narratives match quantitative data in learner response to the statement: “I was able to learn ultrasound hands-on skills of E-FAST in my labs with remote instruction” yielding data of “somewhat agree” (six learners) and “strongly agree” (fourteen learners) (Appendix M2, question #3). The active hands-on learning in the labs was a key element of the training intervention, primarily accelerating hierarchical shifts in the psychomotor learning domain, as learners advanced from being ready to scan (’set’) to scanning performance in a ‘guided response’ or imitative ‘mechanism’ stratum. Cognitive and affective learning domains were also engaged as learners strived to learn and practice the requirements of an EFAST scan in a holistic performance. Further discussion on learning domains is provided later in this chapter.

In reference to what was least helpful in the scanning labs, one-third of learner narratives cited technical issues with connectivity and one-fifth commented on the design of the technology platform. Connectivity issues created interruptions for some learners and the instructor team. Technology design issues related to the small field of view of the monitor and inability for instructors to properly assess the ergonomic positions of the learner. Four learners cited course design issues including same-person and single-gender scanning partners, lack of variety in partners (body habitus issues), insufficient lab time, and the desire for more self-directed labs. One quarter of learners reported that all was helpful, or, did not respond to the question. Learner narratives related to the REACTS® platform included: "[c]onnectivity issues with Reacts losing voice and call dropping", and "screens were small and it was hard to see the screen and scan at the same time at certain points of the labs", and "[t]he video stream (of the instructor) would frequently freeze [while demonstrating] how I should be adjusting the probe position". A notable comment from one learner related to their position of receiving the scan versus performing it, reporting "I couldn't hear the discussion due to the headphones" – the discussion being that of the learner and instructor. Narratives relating to non-technical issues included single gender scanning for the labs: "I only had female patients, so I'm not as confident scanning a male patient for the pelvic portion" and a comment on ergonomics assessment stated as: "There was no way for the instructor to properly assess my ergonomics while scanning and I felt like I was constantly readjusting when I'd feel pain in my shoulder" (Appendix M2, question #9; Appendix V6). The narratives above correlate with quantitative data in response to the question: "Any technical factors with the REACTS platform did not cause a barrier to my learning" with the following findings: strongly disagree (zero learners), disagree (six learners), neither agree nor disagree (two learners), somewhat agree (eight learners), and strongly agree (four learners) (Appendix M2, question #3). From these data it appears that six learners felt that technical difficulties in the labs were a learning barrier and two learners were neutral on the question. The researcher notes that although OSCE scores do not reflect a significant learning barrier in the training for the majority of learners it is important to note that learners *felt* there was a barrier in their ability to learn and mitigating any f actors that affect learner perception of progress and confidence is key to instructional design.

Data in Table 11 below summarize learner narratives on the *most* and *least* helpful elements of practical training (ovals), citing real-time instructor interactions as most helpful, and technical connectivity issues as most problematic.

Table 11

Learner Narratives on the Most and Least Helpful Elements of Practical Training (at Mid Study)

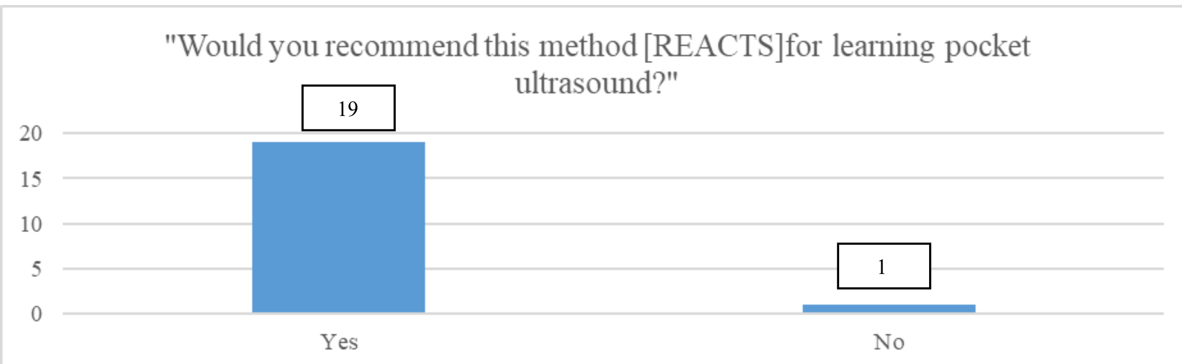
What was MOST and LEASTH helpful for your learning experience in the scanning labs?	
MOST: Instructor Competence& Effectiveness, Instructor Interactions	**LEAST: Technical Issues**
1. **Instructor competencies:** knowledgeable, patient, helpful (3/20=15%)	1. **Technical connectivity**: poor connection, video stream of instructor would freeze, difficult to hear instructor and information lost, experienced dropped calls when computer would freeze (7/20=35%)
2. **Number of instructors:** two helpful, each a stressed different point (2/20=10%)	2. **Technical – design**: no way for instructor to assess my ergonomics while scanning, trying to position camera for instructor to see, and maintain my ergonomic position, screens were small…hard to see screen and scan at same time, not being able to learn from partner – couldn't hear discussion due to headphones (4/20=20%)
3. **Real-time interaction with instructors**: screen-sharing, video chat with instructor, real-time guidance and feedback, able to see my pointer, help with scans, teach proper anatomy 8/20=40%	3. **Course design**: only had female patients so not confident with male patients, would have liked variety in partners and more self-directed labs, e.g. in 3rd lab, would have liked more time, difficult to know what was meant by some verbal directions…not used to terminology (4/20=20%)
4. **Interactive technology:** instructor guidance to position probe, adjust gain and depth, point out anatomy, demonstrate how to manipulate probe to get a better image, able to see what images are produced based on my hand/probe placement, able to see my pointer, having instructor confirm what I'm seeing, able to see instructor, remote instructor can see your monitor…able to turn camera so they can see your transducer position (5/20=25%)	4. **No problems**: all was helpful or no response to the question (5/20=25%)
5. **Course design**: being able to scan, hands-on labs and hands-on instruction one-on-one, back-to-back labs – then try again when information is fresh (5/20=25%)	

Note: Data derived from mid-study questionnaire report, questions #8 & #9 (Appendix M2; Appendices V5 & V6)

Despite the technical issues in the scanning labs cited above, nineteen of twenty participants stated they would recommend REACTS® as a method for learning pocket ultrasound as depicted in Figure 25 below (Appendix M2, question #10).

Figure 25

Mid Study Learner Statements on Recommendation of REACTS to Learn Pocket Ultrasound



Note: Mid-study questionnaire report, question #10 (Appendix M2)

Data in Table 12 below present why the majority of participants highly valued the technology, citing ease of use and their ability to learn with the tool (ovals), including the one participant (L19MRT) with a very low OSCE average score (37.1%), 42.5 points below the group average of 79.6%. In contrast, the one participant who would *not* recommend REACTS® attained an OSCE average score of 94.2%, citing the following comment: "Even with IT support right there it was frustrating…When it was working the tool was great and I learned, but the technical glitches were a barrier" (Appendix M2, question #10). This last comment calls the question: What was the barrier for this learner since the learner reported that they "learned"? The researcher attributes the *feeling* of a barrier (frustration while learning) despite other feelings of success. Advice to offset technical issues was included in other learner narratives in their recommendations such as: "having a back-up communication method for when the video call is having problems with connectivity", "there needs to be parameters worked out (such as ergonomics)", and, "I was nervous… but with other medical knowledge it was not bad" (Appendix M2, question #10). The last participant's comment o previous medical knowledge reflects the value of pre-requisite knowledge as a healthcare practitioner for the short-targeted nature of POCUS training and practice.

Table 12

Why Learners Would Recommend REACTS® to Learn Pocket Ultrasound by DE

"You learned how to scan using REACTS as a distance education method. Would you recommend this method for learning pocket ultrasound? If yes, why…?"
Reasons why learners stated Yes: 19/20 (95%).

Ease of Use	Ability to Learn
1. User-friendly 2. Easy to use when working well 3. Access to mentor easy which is crucial – I would not feel comfortable scanning without a mentor 4. Easy and at your own pace 5. Very practical way to learn 6. One-on-one with instructor effective 7. Allowed instruction to see what you were doing and redirect	1. Good learning tool 2. I was able to learn via this method 3. I grasped main concepts and understanding mastery may take more time 4. Wouldn't be my preferred choice but I was able to adequately learn how to scan 5. Need more practice with an injured person 6. More effective than I anticipated 7. worked well, variety of teaching modalities 8. effectiveness with no geographical limitation; can work in certain contexts (physicians, nurses, remote rural) 9. great way to learn ultrasound basics 10. [a] valuable tool to assess trauma

Note. [a] participant with 37% OSCE average

Data derived from mid-study questionnaire report, question #10 (Appendix M2; Appendix V7)

The high recommendation for REACTS® as a tele-assisted method to learn EFAST, despite its sporadic performance, indicates that learners felt they were still able to learn hands-on skills vie DE.

Learner Advice and Recommendations. At mid-study point participants were asked for their advice for future DE instructional design for remote skill acquisition, and, later at the end of the study they were asked: "If you could change one thing in your learning experience what would it be?". With learners' mid-study advice, recommendations were themed as follows: multimedia resources (more and shorter in length), more scanning practice/labs, ensuring "perfect connectivity" in the technology, and the use of additional cameras for ergonomic assessment to show one's scanning hand. One participant stressed the importance of breaking down any communication barriers when learning is not f2f asserting that "[t]rying to communicate how one should hold a probe is difficult at a distance". Another learner's insight on the value of their DE experience cited the benefit for remote areas, expressed as: "I think this form of remote skill education should be focused in environments where it is appropriate (…such as northern rural hospitals)" (Appendix M2, question #11; Appendix V8).

When participants were asked if they could change one thing in their learning experience at end-study the following themes were reported: lab practice with both genders and a variety of patients, more labs/more lab time, a mock OSCE during the last lab focused on improvements, less "outright direction in labs 2 and 3 [to] let me make my mistakes and correct me as I go", and less "glitchy technology". (Appendix M3, question #9; Appendix V6).

Table 13 below presents dominant themes of learner feedback at mid- and end-study points. Consistent themes are the need to secure reliable technology connections, and attention to variety of scanning partners in scanning lab design. These data form a basis upon which study recommendations can be offered in contribution to future instructional design. Most notable recommendations include assurance that :1) technical issues do not occur with the remote instructional tool utilized, 2) learning resources are multimedia, 3) more hands-on learning/lab practice is provided with less direction as labs progress, and 4) multiple lab models of both genders with diversity of body habitus are provided for learning. Of interest is the omission of advice for online discussion forums.

Table 13

Narratives from Mid Study Learner Advice and End Study Elements They Would Change

Mid Study Question (prior to OSCEs) What is your advice for future distance educational instructional design for remote skill acquisition?	End Study Question (post OSCEs) If you could change one thing in your learning experience what would it be?
Dominant Themes: **Technology, Multimedia resources, Scanning Lab Design, Ergonomics**	**Dominant Themes:** **Technology, Scanning Lab Design**
Interactive technology • Ensure good connection • Have option to call instructor usinga regular phone (if REACTS fails) • Use separate camera to focus on ergonomic techniques • Better video capture devices	**Variety in body habitus for hands-on learning** • different partners to see variety of anatomy
Instructional resources • Multimedia very helpful • Shorter videos and PowerPoints • Include practice quizzes	**Both genders for hands-on learning & OSCE preparation** • need both male and female to learn
Scanning labs • more and longer labs to learn and practice • more exam practice time • more labs for equipment and settings	**More time and more labs for hands-on learning** • more exposure to really feel confident • have a mock OSCE for practice
Remote Instruction • these remote skills needed in environments where appropriate (rural hospitals) • trying to communicate how to hold a probe is difficult - future studies need to break down barriers of instructor not being able to physically interact with students	**Instructional design** • less outright direction in last labs • more time to learn Moodle material **Technology** • less glitchy technology • no headphones so I [as a patient] can hear instructor

Note: Data derived from mid/end-study questionnaire reports, questions #11/#9 (Appendices M2/M3; Appendices V8/V12)

Learner Surprises/No Surprises. Another approach to further understand participant learning experiences and to explore recommendations for future instructional design was to ask the participants if anything surprised them, or not. To this question, thirteen learners responded with the following comments: surprise in their ability to learn the EFAST examination quickly and without ultrasound experience, and the thoroughness of theory content before labs (Appendix M2, question #12; Appendix V9). These comments indicate a satisfactory timeframe for the study design of three hours for theory and three hours for practical scanning lab time. On the question of no surprises, one half learners responded, citing three areas: that distance learning could work when there were no technical issues, and no surprises in the learning of patient care principles, nor with the quality of instruction (Appendix M2, question #13; Appendix V10). The latter two comments are understandable in this research sample, and in the case study design, as learner participants all had prior patient care education with full awareness of the instructional expertise of their colleagues who were the two instructors in the study. Data in Table 14 below capture participant responses on these mid- and end-study questions.

Table 14

Narratives at Mid Study of What Did and Did Not Surprise Learners

Were there any surprises in your learning experience in this research project?	Did anything NOT surprise you in your learning experience?
Yes [a]	I was NOT surprised that [c]
• How quickly I could learn in 3 short labs	• Routine patient care principles are standardized
• That someone without sonography experience could learn an EFAST scan so quick~~ly~~	• I could learn theory by Moodle
• How quickly I became familiar with anatomy on the ultrasound image	• Quality of instruction
• How thorough Moodle content was before labs	• Learning could be effective with no technology issues
No [b]	Nothing surprised me [d]
• No surprises	

Note. [a] n=13/20 (65%); [b] n= 7/20 (35%), [c] n=10/20 (50%), [d] n = 10/20 (50%).

Data derived from mid-study questionnaire report, questions #12 & #13 (Appendix M2; Appendices V9 & V10)

Open Comments, Concerns, Questions. Another approach to collect participant data on their learning experience from the onset of the study to the end was in the unstructured open comment sections of questionnaires. These data yielded a pre-study position of excitement, curiosity, or uncertainty for eight learners with no comments from the remaining twelve (Appendix M1, question #10; Appendix V2). At mid-study point, nine learners expressed satisfaction, one comment on improvements for the PowerPoint slides, with ten learners choosing not to comment (Appendix M2, question #14; Append V11). At end-study, learner satisfaction was again noted for four learners, with no concerns, questions, or comments from thirteen in the group. Other comments at end-study included suggestions for improved course design, e.g. robust image critique, and one learner's comment on being surprised to find fluid on their lab partner (Appendix M3, question #10; Appendix V13). In this last comment it is common to find unexpected findings with ultrasound scanning of the human body. On the recommendation to include more instruction on artifacts, it is notable that OSCE results identified recognition of reverberation artifact as a weak area for several learners (Figures 19-21).

Data on open comments from learners from pre- to mid- to end-study are summarized in Table 15 below. Most notable is the level of learner satisfaction from mid-study through to end study (arrows) with a 65% majority (thirteen learners) with no concerns, issues, or comments at end-study (circle).

Table 15

Pre-Study, Mid Study, and End Study Learner Comments, Concerns, Questions

Pre-Study (prior to training) Do you have any concerns, questions or comments?	Mid Study (prior to OSCEs) Do you have any other comments to share?	End Study (post OSCEs) Do you have any concerns, questions or comments? If none, enter "not applicable"
Excitement (5%) → • very excited about research project & opinion that DE will have great positive impact for future learning	Satisfaction [a] (45%) →	Satisfaction [d] (20%) • thank you, fun opportunity, enjoyed it, truly a pleasure
Hesitancy, Curiosity, Uncertainty, Skepticism (35%) ↗ • uncertainty in effectiveness of DE forhands-on skills and/or professional behaviors	Course Design [b] (5%) • embed narration into PowerPoint slides	Course Design [e] (15%) • include more robust image critique • during labs did notexpect to find fluid on my partner • more instruction on artifacts
No comments or no response (60%)	No Comment [c] (50%)	No concerns, questions, or comments [f] (65%) Other[g] (5%) • Make timer on surveys longer [research design] Nothing surprised me [h] (50%)

Note: the Mid Study Satisfaction cell also contains: • great, interesting, enjoyed it, fun experience

Note. [a] n = 9/20, [b] n = 1/20, [c] n = 10/20, [d] n = 4/20, [e] n = 3/20, [f] n = 13/20, [g] n = 1/20, [h] n = 10/20. Data derived from pre/mid/end-study questionnaire reports, questions #10/#14/#10 (Appendices M1, M2, M3; Appendices V2, V11, & V13).

Learner narratives were a rich source of data in their authenticity for qualitative analysis in understanding what worked and what did not work with the training intervention, with some unexpected and curious findings inviting further analysis on their meaning for future instructional DE design. These data also provide insight into learner engagement of learning domains, with narratives reflecting certain hierarchical levels in the taxonomies and insights where significant shifts occurred in the training intervention. This qualitative analysis of learning domain progressions, combined with other qualitative and quantitative data analyses, enabled address of the study's sub-research question to answer *how* learners 'learned' in order to perform an EFAST scan with a PUD as a result of their DE training.

In summary of the fourth NWKM level (results), modified for this study, data analysis of learner narratives provided rich data from which to shape recommendations for effective and standardized learning outcomes in future instructional design for EFAST and POCUS fields of practice. These recommendations, as summarized in Tables 10-15 above, were derived from companion documents in Appendices V2 to V13. It is in these companion documents where individual narrative analysis and co-coded results were recorded to an assigned NWKM level, and a learning domain with its respective hierarchy.

Learning Domains

The study's research sub-question reads: "*how* can the cognitive, psychomotor, and affective operator-dependent skills of POCUS with a PUD be taught and learned in a DE format"? Guided by this question, learner narratives were analyzed to investigate signs of progression within the taxonomies of the learning domains from pre- to end-study. These narrative analyses followed pre-determined guidelines (Appendix L) as agreed by the researcher and co-coder, to categorize data (words and/or phrases) into learning domains and their hierarchies. The following discussion is presented in the context of learners' engagement with and within the domains. To note: the taxonomies are arranged from simple to complex, in a hierarchical framework for the three learning domains: affective, cognitive, and psychomotor.

The affective or feeling domain attends to participant emotions arising from attitudes, interests, values, appreciation, enthusiasm, and motivations (Anderson et al., 2001; Wilson, 2020). The five levels of the affective taxonomy, in the context of the study's learner participants, are presented as follows:

1. Receiving (awareness, willingness): Learners were aware and willing to participate in the research study upon recruitment and informed consent.
2. Responding (motivation to learn): Learners readily engaged in the study with completion of the first pre-study online questionnaire and theory learning.
3. Valuing (appreciation, learner beliefs, attitudes of worth): Learners expressed training relevance, satisfaction, and their beliefs in the effectiveness of DE at pre and end-study points.
4. Organizing (formative internalization of values and beliefs): As learners progressed through the study phases, formative values were organized and expressed in end-study comments on learner beliefs in the effectiveness of DE.
5. Characterization (further internalization of values): Data did not reflect this element. As this level is refinement of the previous taxonomical level, the researcher views this as a long-term measure and advocates future research in continuing to evaluate affective learning after a training intervention.

The cognitive or thinking domain hierarchies reflect intellectual, critical thinking, problem solving, and creative skills (Anderson et al., 2001; Wilson, 2020). The taxonomy of six cognitive hierarchies are presented in the context of the study, as follows:

1. Remembering (recognizing/recalling knowledge): With a pre-requisite professional background of allied health education and practice, this hierarchical level for learners was assumed at the onset of the study.
2. Understanding (constructing meaning from knowledge): Learners began the study at this level in their understanding of the study's purpose and first instructional activities in the Moodle theory component (learned material).
3. Applying (learned material is applied, e.g., simulated practice): Learners were able to apply theory knowledge to practice in their hands-on scanning labs.
4. Analyzing (breaking down and differentiating concepts): Learners reflected and provided feedback on their learning experiences via their online questionnaires.
5. Evaluating (making judgments and recommendations): Questionnaires were constructed to allow participants to go beyond analysis to evaluating their learning experiences including feelings, thoughts, and ideas.
6. Creating (constructing elements into a new way): The study design did not overtly ask participants to re-construct the training activities/design, however, they were asked at end-study to comment on the one thing they would change in their learning experience.

With the emphasis of essential operator-dependent hands-on skills acquisition of POCUS with a PUD via DE for the study, the psychomotor learning domain is most relevant for analysis of learner success. As described by Wilson (2020) psychomotor (or kinesthetic) objectives "are concerned with the physical encoding of information, with movement and/or activities where the gross and fine muscles are used…[also referring] to natural, autonomic responses or reflexes" (5th page). For discussion of the psychomotor learning domain Simpson and Illinois Univ.'s classification of educational objectives (1966) are best aligned with the study's methodology to learn hands-on skills with DE. The seven hierarchical levels within this taxonomy of the psychomotor domain are described below in the context of the research study:

1. Perception (awareness): As with the cognitive domain, with a pre-requisite professional background of allied health practice, awareness levels of study objectives and required learner contributions were assumed at the onset of the study.
2. Set (mindset of readiness to act): With a willingness (affective domain) and an understanding (cognitive domain) of study goals and methods, learners' mindsets to physically engage and interact were set and ready.
3. Guided response (imitation): With multimedia resources (YouTubes & PowerPoints) to demonstrate EFAST performances, and with active learning in hands-on labs, learners had opportunity to imitate the EFAST examination with instructor guidance.
4. Mechanism (basic proficiency, learned response): As scanning labs progressed with ultimate testing of scanning skills at the OSCE phase, learners were able to demonstrate basic proficiency in EFAST performances.
5. Complex overt response (expert, quick & accurate performance): With some OSCE scores in or near the mastery level, e.g., 80% or above, some learners demonstrated hierarchical progression to a quick & accurate performance of the EFAST examination.
6. Adaptation (able to modify skills): With the time frame of the study, learners were not expected to adapt learned skills to an external framework.
7. Origination (creative): As with adaptation, the framework of study methodology did not provide opportunity for this highest psychomotor level.

Data included in Appendix V1 present an overview of co-coded results from analysis of learner narratives from pre-to end study (Appendices V2 to V13), with a summary provided in Table 16 below.

In the affective domain, learners progressed from ‘receiving’, ‘responding’, ‘valuing’ to ‘organizing’ levels within the hierarchy in the following stages: 1) pre-study willingness to engage in the research (receiving/responding), 2) mid-and end-study satisfaction with their learning experience (valuing), and 3) mid-and end-study learner appreciation of their training (perceived valuing) and reflections on their beliefs in DE effectiveness (organizing of values).

Progression in the cognitive learner domain followed a similar gradual path from ‘understanding’ theoretical concepts to ‘applying’ and ‘analyzing’ these concepts with scanning practice in the labs at mid-study point, including their advice and recommendations for future design. Following their OSCEs, learners continued to shift into the ‘evaluating’ element of the cognitive hierarchy with their overall reflections and feedback upon completion of their OSCEs and knowledge of their OSCE results.

A more dramatic hierarchical shift occurred in the psychomotor learning domain from a ‘set’ level of readiness to act, to ‘guided learning response’ and ‘mechanism’ levels at mid-study point, as learners gained basic proficiency in their scanning labs. These data indicate the importance of hands-on or practical learning to advance psychomotor skills. For some learners a ‘complex overt response’ was identified beyond a basic proficiency level, reflected in their high OSCE scores, another indication of the importance of experiential learning and the ‘doing’ of learning.

The co-coded narrative analyses to identify learning domain data were also aligned to one or more of the NWKM levels (Appendix L; Appendices V2-13). Learning within the affective domain (feelings and emotions), aligned with all four NWKM levels as follows: positive and favorable learner reaction (level one), perceived transfer of learning and expression of beliefs in DE (level two), successful demonstration of affective behaviors in OSCE performances (level three), and level four learner recommendations for future POCUS training where learners expressed their feelings and emotions on their learning experience.

In the cognitive domain, learners commenced their training in theoretical concepts with progression to applying them (level two - learning). Learners continued to practice and progress to demonstrated behavior change in their OSCE performances (level three), behaviors that reflected the effectiveness of the training intervention. Learner advice and recommendations (analysis and evaluation) for future training contributed to level four of the NWKM in results for sustainable training.

In the psychomotor domain, data reflected learner readiness for active learning in the scanning labs with positive self-assessments and perceived transfer of hands-on learning (level two). Level three of the NWKM (behaviors) was learner demonstration of hands-on proficiency in the OSCEs.

From discussion of learning domains above, a significant finding is rapid progression in the psychomotor learning domain from a ‘set’ (readiness to act) position, to guided response (imitation) and mechanism (basic proficiency) in labs and OSCE performances (levels two and three of NWKM), For some learners high OSCE performances reflected increased advances into the ‘complex overt response’ level of the psychomotor taxonomy. This finding is notable to ensure hands-on training in future POCUS DE design. A summary of the discussion above is presented in Table 16 below with supporting detailed documentation provided in Appendices V1 through V13.

Table 16

Learning Domain Taxonomical Progressions (Reflected in Learner Narratives) and Points of Shifting in Study

Learning Domain	Taxonomical Progression: Hierarchies	Points of shifting	NWKM
Affective	Receiving to Responding to Valuing to Organizing	Gradual shift: To *Valuing* at mid-study as learning progresses; to *Organizing* at end-study with reflection on beliefs	Levels 1-4
Cognitive	Understanding to Applying to Analyzing to Evaluating	Less gradual shift: To *Applying* and *Analyzing* at mid-study after scanning labs; to *Evaluating* after OSCEs at end study	Levels 2-4
Psychomotor	Set to Guided Response to Mechanism to Complex Overt Response	Rapid shift: To *Guided Response* and *Mechanism* at mid-study with scanning labs; to *Complex Overt Response* in OSCE performances	Levels 2&3

Note: Data from summary data in Appendices V1-V13

Learner participant results have thus been presented, framed in the four levels of the NWKM and elements of the three learning domains. As with most learning and teaching environments, learning experiences of the study participants were influenced by instructor participants, especially in their progression of practical learning in the real-time interactive scanning labs. It is now time to present the study's instructor results, based on the voice of the instructors themselves through their summative field notes.

Instructor Results

Data collected from the two instructors' field notes are provided in Appendices O1 and O2. Instructor results were not evaluated within the NWKM, rather, the researcher reviewed the respective field note narratives to: 1) evaluate inter-instructor and instructor-learner alignment, 2) ascertain overall themes from instructors' teaching experiences, and 3) capture instructor recommendations for future instructional design.

Inter-instructor and Instructor-learner Data Alignment

Data in this area depict strong alignment between instructors and learners, in both theory and practical training components. Both data groups identified training strengths in the multimedia resources for theory, PowerPoints, and videos, with an instructor comment on their "good information on ultrasound in general as well as the steps to performing an [E]FAST scan" (Appendix O2, question #9).

Both groups were also in synchrony on the underutilization of Moodle forums. As previously discussed, most learners were neutral on the effectiveness of the forums citing lack of use or providing no comment. Instructor comments included "I checked fairly frequently to see if there were posts on the forums and did not see any (therefore I had no Moodle Forum interaction)" (Appendix O1, question #5) and "[t]here were only 2 questions posted in this forum…I was able to answer both…and there was no further conversation with either one" (Appendix O2, question #14). It appears that instructors were prepared to react to learner forum activity and awaited learner-led questions. Conversely, it could be that learners expected instructor-led questions, as reflected in one comment: "If there were more questions, there would have been more of a use, but we all just worked through the material and didn't really get to the point of needing the forums" (Appendix M2, question #7). Although the study's data collection tools did not probe deeper into *why* Moodle forums were not helpful, instructor and learner comments cited above provide some insight into the study's course design, indicating lack of direction for optimal use of forum discussions. Although this one insight helps to understand the lack of satisfactory forum interactions for a few learners it does not adequately explain the neutral/ambivalent feelings of most learners; one would think it would engender clear negative ratings instead, if that is what learners expected. As to learner expectations, data indicated a high degree that overall training expectations were met for nineteen learners (Figure 10). Having expectations met, coupled with a large neutral response on forum effectiveness, begs the question: Were the Moodle discussion forums necessary and/or valued for this training intervention? There is added significance to this question given data on overall participant satisfaction with the training. The question of necessity and/or value also assumes importance due to lack of recommendations from instructors or learners for Moodle discussion forum improvement. This omission is notable as learners and instructors were generous in their advice and recommendations for future DE instructional design, as summarized in Tables 10 -15 and Appendix O3. To further expand upon this curious finding, despite a clear lack of forum interaction and sense of cohort (online social presence) for most learners, it appears that learning transfer did not suffer, as most learners applied theory learning to demonstrate practical learning success over the course of their three scanning labs, success that was validated by good to great OSCE scores. It appears that learning outcomes were not negatively affected by underutilization of the forums. Another potential reason for lack of forum questions was offered by one instructor: " Based on how few questions there were, I am guessing that the candidates felt that they had enough background information before participating in the scanning portion of the study" (Appendix O2, question #16). This last instructor comment reflects effective course design and resources in the theory portion possibly lessening the 'need' for online discussion forums as a learning resource, however, was social interaction also not needed? Was social presence achieved via an alternate way? As cited by both instructors and learners, positive strengths of the training were the real-time, interactive, one-on-one hands-on sessions in the scanning labs, and perhaps the 'strength' of this strength mitigated the lack of social presence and related learning in the forums? With a working hypothesis that strong learning in the interactive scanning labs may have compensated for lack of asynchronous forum interactivity, the following question emerges: What is the necessity and value of online discussion forums in asynchronous course components when paired with synchronous activity? Further discussion on this question ensues in chapter five.

Instructors were also aligned with learner comments on the *ability to learn* with interactive REACTS® sessions, and instructors reflected on their *ability to teach* with REACTS®, as stated by instructors: “[it served its purpose well”, “ I think REACTS is a very effective tool for this type of learning”, and “I like the fact that you are interacting with the participants in real time and are able to observe their scanning as well” (Appendices O1 & O2, question #18). In the scanning labs, similar challenges were expressed by both groups, such as a learner’s difficulty to understand what the instructor was conveying, as per a learner’s comment: “Trying to communicate how one should hold a probe is difficult at a distance” (Appendix M2, question #11). One instructor described this same difficulty as: “I struggled with being able to describe subtle hand movements in order to optimize images”. This same instructor changed tactics to “explanation of these hand movements before the actual scanning began and then guide the participants through the scan” (Appendix O2, question #20). With connectivity issues of REACTS® there was strong instructor/learner alignment on their frustrations with the technology and congruence that these difficulties were not barriers to learning, despite the frustrations.

In addition to evaluations of their experiences, both groups were aligned in their recommendations and advice for future training, further discussed in chapters five and six. There were two notable areas of non-alignment. The first was in the evaluation of the REACTS® platform where one instructor did not highly recommend REACTS® as the remote technology of choice despite rating it as effective (Appendix O1, question #26), whereas the second instructor and all but one of the learners were positive in this recommendation (Appendix O1, question #18; Appendix M2, question #10). The second area of note, a training gap noted by learners only, was the inability of instructors to properly assess learner ergonomics during scanning instruction, exemplified in one learner’s comment: “the instructor was limited to a small field of view, and couldn’t see my posture" (Appendix M3, question #6). Table 17 below presents alignment data as discussed above, including the two areas of non-alignment (circles).

Table 17

Comparative of Instructor Field Notes and Learner Data

Instructor and Learner Feedback on Course Components: Was there alignment?		
Training (course) components	Feedback on course elements	Aligned?
Theory component		
Effectiveness of Moodle course activities and resources	Strength of multimedia	Yes
Technical factors with Moodle as a teaching tool	No barrier to learning	Yes
Transfer of knowledge, skills, and professional behaviors in general & among professions	Positive transfer for most learners	Yes
Effectiveness of interactions via the *Moodle* Forums	Indifference and low use of forums	Yes
Effectiveness of Forums to foster sense of cohort [community of learning]	Not attained	Yes
Other comments	Theory prepared learners for hands-on labs	Yes
Practical component (hands-on labs)		
Effectiveness of REACTS® platform for teaching ultrasound scanning	One instructor suggests use of other platforms; other instructor and nineteen (95%) learners recommend REACTS	Mixed
Technical factors with REACTS® as a teaching tool	Multiple difficulties but no barrier to learning	Yes
Transfer of knowledge, skills, professional behaviors in general & among professions	Imaging struggles with left abdomen; most agreed on transfer of professional behaviors	Yes
Instructor-Learner Interaction via REACTS®	Strength of training	Yes
Assessment of Ergonomics	Weak area (identified by learners only)	No
Overall		
Impressions	Overall positive experiences; struggles in communications with subtle hand movements	Yes
Differences or similarities amongst the professions	No significant differences	Yes
Significant questions or comments	Unexpected findings	Yes
Recommendations	Itemized in Appendix O3	Yes

Note: Data summarized from comparative analysis of instructor field notes to learner data (Appendix O3)

Overall Instructor Themes from a Teaching Experience

The training was delivered in a two-instructor team-teaching model, where both instructors had access to all learners, and, vice versa, all learners were taught by both instructors in the Moodle course site (instructor facilitation of self-directed learning) and scanning labs (direct interactive hands-on teaching and learning). As presented in Table 17 above, data from instructor field notes indicate overall satisfaction with their teaching experience. Instructors commented on the effectiveness of Moodle course activities and resources, e.g. “I do think that it [Moodle course] provided the necessary resources needed for participants to prepare for the practical component” (Appendix O1, question #2). Instructor evaluation of their scanning lab instruction experiences included their evaluation of the REACTS® platform, describing their appreciation to interact “with the participants in real time [and] observe their scanning” with additional comment that it was “very effective and for the most part, easy to use”. (Appendix O2, question #18)

Instructors also highlighted their struggles with the remote technology citing the “biggest technical factor in using this platform is the loss of connection while trying to teach…frustrating, both for the learner and the instructor” (Appendix O2, question #19). The loss of connection was also unpredictable and variable creating further frustration as follows: “it was difficult to tell when the connection cut out fully versus when it was merely weak” (Appendix O1, question #19).

As previously noted in the challenge to remotely communicate hands-on skills and the subtle movements to manipulate the ultrasound transducer properly, an adaptive measure was introduced early in the scanning lab instruction phase to provide the instructors with a probe themselves, rather than relying on the sole use of their hand. This was accomplished by creating a mock plastic ultrasound transducer (3-D printed) used by each instructor to demonstrate probe movement more effectively, a recommendation for future instructors of remote hands-on teaching of ultrasound skills.

Instructor Recommendations for Future Instructional Design

Data analysis of instructor field notes contributes to future instructional design of EFAST and POCUS training. In this data set instructor narratives were examined for their teaching insights and what worked/did not work in the design and delivery of the training. As previously discussed, instructor evaluations of training strengths and weaknesses are well aligned with learner data. Instructor recommendations included suggestions on multimedia resources such as specific videos, and the importance of a stable internet connection for an interactive platform such as REACTS®. As previously noted, instructor recommendations were in full alignment with learners, with exception of one instructor's doubt that REACTS® is necessary, as other technologies may also suffice, e.g., Skype or Messenger (Appendix O1, question #18).

In their teaching experiences with a mixture of allied health professionals in the study, instructor recommendations did not include accommodations for specific professions, asserted as: "I did not notice any significant differences between the professional groups" (Appendix O1, question #4). One instructor expressed an assumption that participants with an imaging background, e.g., X-ray, may have more familiarity with cross-sectional anatomy, however, further reflected to add "but just like with our ultrasound students, I found that some people seemed to have a natural aptitude for controlling the transducer and being able to manipulate the image and patient to get the images required" (Appendix O2, question #21). Instructor comments above also speak to equal opportunity for imaging and non-imaging categories, as previously noted earlier in the chapter. The lack of any notable teaching accommodations for any profession suggests potential transferability of the training to other healthcare professions, which forms the basis to recommend training to a mixed group of professionals.

Of interest in examining instructor field notes is the lack of data on teaching professional behaviors, despite the question being directly posed in the instructor field note template. The only datum relating to this question (indirectly) is one instructor's reflections on participant "motivation" and perception that "[s]ome [professions] seemed very interested into learning and a few (small part) seemed somewhat less invested" (Appendix O1, question #4). The researcher notes that this instructor's reflection on participant motivation is not interpreted as a comment on professionalism, however, relates to engagement and relevance, elements of the first level of the NWKM (learner reaction).

Summary

In summary, chapter four first presents the approach to data analysis followed by presentation of study results. Learner results ensue, framed in the four levels of the NWKM - reaction, learning, behaviors, results. With the fourth 'results' NWKM level, learner feedback, advice and recommendations inform future instructional DE POCUS design. Also applied to learner data analysis is examination of learning domain activity (affective, cognitive, psychomotor), highlighting hierarchical progression in the respective taxonomies from pre- to end-study for insight into *how* learners 'learned'. The chapter concludes with presentation of instructor field notes in their alignment within the instructor team and with learner data, instructor teaching themes, and instructor recommendations for future instructional design of EFAST and POCUS training. These quantitative and qualitative study results will now be discussed in relation to the research questions in chapter five.

Chapter 5. Discussion

Chapter five will discuss emergent themes from data analysis of study results presented in the previous chapter. The discussion is framed from the lens of the four NWKM levels, with related discussion on the three learning domains, and aligned to the study's research questions.

Research Questions Revisited

The primary research question asks if allied health practitioners can attain ultrasound imaging skills/competency with a PUD in a DE environment. Analysis of learner OSCE results provides an affirmative quantitative response as follows: Based on a learner participant sample of twenty ultrasound-naïve allied health practitioners, sixteen participants were able to attain scores above the minimum standard of 70% to demonstrate ultrasound imaging skills/competency of EFAST with a PUD upon completion of their DE training in a simulated environment. To expand, learner success was determined in an f2f OSCE format according to a grading rubric, with scores aligned to NAIT's academic standards as well as national industry metrics for entry-to-practice in the allied health professions of Canada. These OSCE results fall within the third NWKM level where desired and critical behaviors were demonstrated 'on the job' in performing an EFAST examination upon completion of training (simulated 'on the job' for the study). Further quantitative and qualitative analyses of OSCE and other study data provide deeper understanding of the primary research question and address the study's sub-question to investigate *how* the cognitive, psychomotor, and affective operator-dependent skills of POCUS with a PUD can be taught and learned in a DE format. This sub-question is served with quantitative and qualitative analysis of learner and instructor results, as identified in chapter four, to be expanded upon in the next section of this chapter.

To address the research questions, the study's data analysis evaluation framework (Appendix D) utilized the NWKM levels to evaluate the effectiveness and impact of the training intervention

(Kirkpatrick & Kirkpatrick, 2010-2019). Data were also analyzed to capture learner progressions within the taxonomies of the three learning domains and their relation to study phases, primarily through learner narratives, utilizing the classification of educational objectives offered by Anderson et al. (2001) for the cognitive and affective domains, and Simpson and Illinois Univ. (1966) for the psychomotor domain. Summary results of narrative analyses (researcher and co-coder), presented in Tables 10-15, were based on learner participant questionnaire results with detailed data provided in Appendices V2-V13.

NWKM Level 1 Reaction

Study data to assess learner participants' reactions to the training from pre-to end study were analyzed in learner degrees of engagement with the training, relevance of the learning experience, and overall satisfaction.

Engagement

Data indicate a favorable degree of engagement, from pre- to end-study, demonstrating active participation and learner contributions to their training experiences. Study results on participant engagement also indicate an upward movement in the affective learning domain, from pre-study levels of 'receiving' (willingness), to mid- and end-study levels of 'responding' (motivation) and 'valuing' (appreciation, beliefs, finding worth). The engaged reaction of learner participants demonstrates that the training was meaningful to/for them. As asserted by Kirkpatrick and Kirkpatrick (2010-2019) "[e]ngagement levels directly relate to the level of learning that is attained" (p. 9), an assertion congruent with the study's positive transfer of learning as demonstrated by OSCE success. The high engagement of learners reflected: 1) their pre-study emotions of excitement, curiosity and fear/nervousness and their willingness to embark upon the proposed training, 2) their motivation to continue and embrace all activities to the end, and 3) assertions that the training was appreciated and worthy. The researcher notes the importance of positive learner engagement and its connection to supporting the learning experience and its role in future instructional designs.

Relevance

Study data on the second aspect of learner reaction explored training relevance, to examine learner interests and/or opportunities to use the training in their professional careers. Pre- and end-study data indicate significant increased learner understanding in the role of DE for targeted training in EFAST and POCUS environments, compared to a decreased role in the wider field of comprehensive ultrasound. These findings demonstrate effectiveness of the training with learner assessment, at an experiential level, to recognize DE's suitability for POCUS and not necessarily for comprehensive ultrasound, a recognition engaging all three levels of the learning domains (affective valuing, cognitive evaluating, psychomotor mechanism). These findings do not mean that DE cannot be used for comprehensive ultrasound education, rather, it demonstrates an evolution of learner understanding, from pre- to end-study, on the differences between the two forms of ultrasound practice. Another shift in relevance from pre- to end-study for a minority of learners was increased intention to use their POCUS training in their own scopes of practice, indicating increased perceived value on the usefulness of the training. Perceived usefulness of training has a strong influence on overall training satisfaction, as concluded by Giangreco et al. (2009) who investigated trainees' reactions to training and factors that affect overall satisfaction.

In the context of training relevance, pre- and end-study comparisons identify progression within the three learning domains. In the cognitive taxonomy, learners advanced from early 'understanding' through to higher 'evaluating' within the hierarchy, as they assessed and reflected upon their DE training experience in relation to their learning goals, professional careers and healthcare applications. Progression within the psychomotor learning domain identified a taxonomy shift from being prepared ('set') through to higher levels of 'guided response' and basic proficiency ('mechanism'), and for some, advances to quick and accurate performance ('complex overt response'). This rapid progression of psychomotor skills was rapidly achieved over three hours of hands-on experiential learning, thereby impacting learner perceptions of training relevance and what it meant for each of them; for some, the opportunity to apply the training in their scopes of practice. In the affective domain, data analysis of relevance was like learner engagement, advancing from 'receiving' to 'valuing' in perceiving worth in the training. In their learning experience, learners formed their perceptions on the usefulness of the training and its value for themselves. In summary, data indicate that relevance of training for learners was maintained with certain changes in some areas, a reaction to training that has influence on training satisfaction.

Satisfaction

In the third dimension of learner reaction to assess learner satisfaction with their training, data were analyzed from an overall perspective as well as a review of selected elements of training. Mid study data collected at the completion of training and prior to the OSCEs indicate strong majority satisfaction with the effectiveness of multimedia resources for theory, and hands-on interactive practical sessions for application of theory in scanning labs. In contrast, mid-study data are mixed, from feelings of satisfaction, neutrality, or dissatisfaction with the Moodle forums, a sentiment similarly reported by instructors. Despite this lack of forum activity and dissatisfaction in an online social presence, a strong percentage positively rated overall Moodle effectiveness at mid-study, with no negative effects on their subsequent OSCE scores. This mixed reaction from participants on Moodle forums warrants further investigation, however, did not appear to influence positive overall training satisfaction.

In the context of theory learning, participants were asked if Moodle course resources prepared them for their hands-on scanning labs. Responses to this question were multiple, as some participants chose more than one category. Of those that only chose one category, 65% reported that they felt prepared for their labs, an important milestone for the study, as success of the hands-on scanning labs was dependent on learners' ability to quickly apply their knowledge to practice, given the study design of three, and only three, one-hour labs with their instructors.

Learner satisfaction with the practical course component, hands-on scanning labs, was significantly high (ten agree; ten somewhat agree) as was satisfaction with feeling prepared for their OSCEs (four strongly agree; sixteen somewhat agree). The major area of dissatisfaction with scanning labs, for some learners and both instructors, was difficulty with the REACTS® technology in the episodic loss of connectivity, and therefore loss of instructor-learner interaction. Despite their dissatisfaction with the technology, mid-study learner data report a high recommendation (nineteen of twenty) for utilizing REACTS® for hands-on training, another sign of satisfaction and positive learner reaction to the training. The high recommendation of REACTS® as a remote training tool, despite reported learner and instructor frustrations with its technical difficulties, is curious data. The researcher interprets this dichotomy to the strong effectiveness of the interactive nature of REACTS® for teaching and learning, as identified by learner success and instructor feedback. Mitigation of technical difficulties to avoid negative factors, e.g., instructor/learner frustration and real or perceived barriers to learning, is key to future instructional design with REACTS® or any other remote tele-assisted platform.

End-study data identify that nineteen of twenty learners' expectations were met with similar numbers of overall satisfaction with: multimedia resources in Moodle, scanning labs, and the OSCE experience. These data on learner satisfaction also reflect progression in the taxonomy levels of learning domains as follows: 1) to affective 'valuing' (appreciation and perceived value of the training), 2) cognitive knowledge shifts from 'understanding' to 'evaluation', and 3) psychomotor progression to 'mechanism', or 'complex overt response' (basic & advanced proficiency) in their passing OSCE scores, learning progressions that influence learner satisfaction. On average for the group, the 'mechanism' hierarchy of the psychomotor taxonomy was achieved by most learner participants with a smaller number achieving a lesser 'guided response' (imitation) category, or a higher complex overt response (expert) level with OSCE scores above 90%. From a customer satisfaction lens, the degree of satisfaction reported by learners and instructors was high, with alignment to positive shifts in each of the learning domains, thereby contributing to learner success.

In summary, results of learner reaction to the training identify advantages in attending to learner engagement, relevance, and satisfaction in future instructional designs to support and promote learner success. Although there is no evidence that a favorable reaction to training is directly connected to positive outcomes in learning transfer and behavior change, it "would be rash to assume that positive training experiences have absolutely no beneficial effect on trainees" (Giangreco et al., 2009, p. 100). The researcher asserts that emotional aspects inherent in a learner's reaction to the training, immediate and throughout the training, will influence their learning experience and possibly their short, and long-term success. This comes about due to feelings that engage the intrinsic nature of the affective learning domain, specifically the 'valuing' hierarchy in the taxonomy and higher. This assertion is supported by Bolkan (2015) who writes that positivity in the affective domain draws upon the learners' inner motivation and effort, with impact on positive self-regulation. Furthermore, elements that induce 'valuing' in a learner serves them well in the short term (training success) and in the long term in *how* they will use the training, ethically and responsibly (Witt, 2015). In summary, study data indicate an overall favorable learner reaction to the training and beneficial conditions for the second level of the NWKM – Learning.

NWKM Level 2 Learning

Data analysis for this second NWKM level included review of 1) what areas of knowledge, skills, and attitudes were perceived to be transferred from pre- to end-study, 2) learner beliefs in the effectiveness of DE that may have impacted acquisition of intended learning outcomes, and, 3) learner evaluation of their learning experiences which potentially contributed to their confidence and commitment. Instructor field notes were also analyzed for comparison of teaching experiences with learner experiences. As with other areas of data discussion, learning domain taxonomical shifts during the process of learning were also analyzed.

Transfer of Learning

A comparison of pre- and end-study questionnaire data revealed strong degrees of learning transfer, as perceived by learners, for most knowledge areas in theory, applied theory (scanning labs), and in core skills to perform an EFAST examination including the required professional behaviors. These data align with data from instructor field notes rating the transfer of learning as "[a]verage to above average overall" (Appendix O1, question #3). These data also indicate that intended learning outcomes in theoretical principles were perceived to be achieved, with learners feeling like they 'knew it'. Similarly, for their scanning lab performances, data indicate that learners felt they could 'do it'. For most learners these perceptions of achievement were validated in behaviors they manifested in their positive OSCE scores, as presented in chapter four. Data also indicate a level of learner confidence (I think I can do it) in statements that the theory prepared them for scanning labs and that they felt prepared for the OSCEs. There is a connection to training relevance in this section in that six of the twenty learners perceived the value of the training, and perhaps associated confidence in using the training in their own scopes of practice (Figure 9).

To glean further insight on the transfer of learning, individual competency performances were reviewed for any patterns of weak or missed performance which would indicate why certain learning elements may not have transferred. In this analysis, competency areas of the pelvis, left upper quadrant and heart, depth (instrumentation) settings, and identification of reverberation lung artifact were more commonly missed, a finding in alignment with one instructor's field notes who stated "I found most of the students had a hard time getting a good view of the Left Upper

Quadrant" (Appendix O2, question #20). Further analysis of missed competency areas identified a common learner theme of inability to identify or 'point' to the area where pathology would be. This finding is significant, as it was not a difficulty with acquiring the hands-on imaging skills of the anatomical areas, rather, once an image was attained and frozen, the learner struggled with identification of the image pattern, a cognitive skill of evaluation in discerning normal from abnormal patterns in a patient's ultrasound images. This finding calls for more pathology pattern recognition in future instructional design of POCUS, dominant in the cognitive domain of pathophysiology knowledge, supported by psychomotor skills (acquiring images of abnormalities), and affective learning (appreciating and valuing the impact of an abnormality on the patient and family).

In the study of learning domains, there was definite and rapid hierarchical progression for learners when they began to apply theory to practice. This shift primarily occurred in the psychomotor domain taxonomy, from the preparatory 'set' position, to imitation of 'guided response', upwards to basic proficiency ('mechanism'), and for some advanced levels of expert levels (complex overt response) in scanning lab performances. In this psychomotor domain, some learner data reported the challenge of learning the subtle hand movements of the transducer probe during labs, a finding aligned to instructor data as well. This challenge poses the question if this challenge is due to a technical constraint, lack of instructor expertise, and/or a communication problem. One instructor stated: "Because you are not interacting in person, you really have to be able to explain yourself well to relay the information that you are wanting to give" (Appendix O2, question #3), also citing the power of the step-by-step PowerPoints and videos to assist in that function for the instructor. In contrast, the other instructor did not experience similar difficulties and described the transfer of learning/teaching as "very good - easy to communicate when internet connection was stable" (Appendix O1, question #20). These challenges are considerations in future instructional design of remote delivery of hands-on instruction to include measures of orientation and training for teachers, as well as effective technical support.

Cognitive progression was equally realized from the hierarchical ‘understanding’ of concepts to their ‘application’, ‘analysis’ and further ‘evaluation’ levels, as learners had to decipher what they were seeing on each image in synchrony with image creation, all in rapid real-time, while making judgements on what was normal or abnormal based on each image they acquired. Progression in the cognitive domain was also apparent in learners’ discernment and perceptions of what they had learned from pre- to end-study, an activity requiring analysis and self-evaluation of what was different in their knowledge levels due to the training.

As with the psychomotor and cognitive domains, the affective domain also experienced progression within its taxonomy with learners ‘responding’ to training demands and sharing their feelings of appreciation and perceived value of the training. Unlike the direct measurement of pre- and post-tests for cognitive and psychomotor domains, changes in feelings and values were not directly measured in the study, however, learner narratives were interpreted and reflected positive engagement of the affective domain primarily in ‘valuing’ the knowledge and skills gained (statements of appreciation, finding its worth, beliefs in DE). It is important to note that feelings of appreciation were evaluated beyond a simple ‘liking’ of the training. For example, one learner opined “I found it surprising that someone without sonography experience could learn the E-FAST so quickly”, an appreciation of the training and that learner’s ability to learn (Appendix M2, question #12). Another example highlights learner perceived value of the training beyond self into the clinical field: “I would say that this can definitely work in certain contexts (ex. physicians in remote rural sites)” (Appendix M2, question #10). As affective changes will provide an effect on learning, the researcher advocates further research in this area to better understand and possibly measure ‘valuing’ and its inter-relationship with the cognitive and psychomotor areas of learning.

This view is shared by other scholars who each contributed to a forum on affective learning in 2015, in their essays to reconsider and reclaim the importance of affective learning, including studies in the field of cognitive neuroscience (Housley Gaffney & Dannels; Lane; Mottet; Myers & Goodboy; Thweatt & Wrench). Progression through the affective learning domain in analyzing the transfer of learning process was also viewed in context of learner beliefs in two aspects: 1) Did pre-study beliefs in DE to learn hands-on skills and professionalism change once training was completed and OSCE scores known?; and 2) what impact did learner beliefs in DE have on learner confidence?

Learner Beliefs

Learner beliefs that hands-on learning (psychomotor skills) and professional behaviors (affective skills) could be attained entirely by DE were explored in the pre- and end-study questionnaires. To the question/belief that psychomotor skills can be taught entirely via DE, the pre-to-end-study group response of "yes" shifted upwards from a pre-study ten to sixteen learners. With further examination of individual results, twelve learners maintained the same beliefs, with seven learners shifting to a greater level, from "no" to "neutral", "no" to "yes", or "neutral" to "yes". There was one learner who lessened their belief from "neutral" to "no" (Appendix R).

In minor contrast, on the question/belief that affective skills can be taught entirely by DE, the pre- to end-study response of "yes" decreased by on learner (fourteen to thirteen). Although this later datum is only a downward shift by one factor in the "yes" group response, examination of individual data indicates decreased beliefs for four learners, three from "yes" to "neutral" and one from "yes" to "no", with the remaining thirteen learners maintaining their beliefs with no shift from pre- to end-study (Appendix S).

As previously presented in chapter four (Tables 4 and 5) data analysis of shifts in individual participant beliefs were explored in relation to respective learners' OSCE scores and their areas of missed competencies. This comparison of beliefs to OSCE results was undertaken to provide in sight on the impact and subsequent potential shift of learner beliefs once the training was completed and their OSCE results were known. Findings indicate that beliefs in psychomotor or affective skills by DE did not change for most learners (twelve, thirteen, respectively), however, there were shifts in beliefs for some learners, with these learners attaining 'passing' OSCE scores from 77% to 97%. These data offer a mixed interpretation, as it appears that learner beliefs were not impacted (changed) for some learners, and for others the training and OSCE scores may have influenced learner beliefs. For most of these shifts, learner beliefs were increased which is understandable given their attainment of 'passing' OSCE scores and feelings of success. However, this understanding is in question considering those learners where beliefs did not change, regardless of their high or low OSCE scores, for example the very low failing score of 37% (L19MRT). Equally curious are those learners whose beliefs lessened despite very high OSCE scores, for example: L06 who achieved a 94% OSCE average score and lessened their belief in DE for psychomotor skills (neutral to no) and affective skills (yes to neutral). From these data, it appears that learner beliefs were not influenced by OSCE scores, and further analysis may be related to the process of learning, learning effectiveness, and learner confidence, versus a single 'passing' score. As beliefs and learner confidence are entrenched within the affective learning domain, further discussion ensues in this area.

The shift in beliefs for some learners may reflect their advancement in the affective learning domain from 'valuing' the learning (determining perceived worth) to the 'organizing' actions of categorizing and prioritizing upon completion of the DE training and knowledge of their OSCE average score. As offered by McQueen and Webber (2013), the question is posed: Is an effective learner someone who does well, or someone who is good at learning? In the context of this study, did the learners effectively learn and/or did they just do well? This is an important distinction in the context of this study as learners may have attained an acceptable or high score, yet perhaps may not have *felt* they learned? In pursuit of this question, individual learner beliefs in DE for learning were also compared with their end-study statements of *feeling* knowledgeable in performing EFAST, including required professional behaviors. For most learners their feelings of ability correlated with their beliefs in DE, with data review further focused on three exceptions: learners who believed in DE despite their feelings of inability in their acquired hands-on skills (psychomotor) and/or professional behaviors (affective) learning (Table 9). Although these three examples represent a small number of three learners, this finding speaks to the level of confidence (I think I can do it), an element of the second NWKM level. To further explain, although two of these learners stated beliefs in DE, for affective skills (intrinsic value), with related successful OSCE scores (L10BIO at 77%; L13PFT at 83%), they may have lacked inner confidence and therefore did not *feel* knowledgeable at the end of the training. The third learner presents interesting data in their belief in DE for both affective and psychomotor skills, with feelings of ability for the former and not for the latter, despite a failed score of 37% and several missed competencies (L19MRT), potentially indicating confidence in the affective learning domain and not in psychomotor skills. It could be said that because L19MRT entered the study with an acquired confidence in professional behaviors, as MRT is a profession with ample patient interaction, poor performance in the study did not shake that confidence. This theory or interpretation is congruent with the other two learners (L10BIO and L13PFT) who, in contrast to L19MRT, did *not* enter the study with as much patient interaction and professional development as L19MRT, and the study possibly amplified an already weak area of confidence for them. Within this interpretation the researcher notes the value for future training design in properly assessing what skills learners enter with upon POCUS training, with efforts to fill any gaps warranted for full success and *feelings* of success by learners. In addition to exploring learner beliefs, learner reflections on their learning experience were investigated.

Evaluation of Learning Experience

Learners were asked to evaluate their learning experience at mid-study upon completion of their scanning labs just prior to their OSCEs. For evaluation of their teaching experiences, instructors commented on the same areas as learners: effectiveness of learning resources (Moodle and REACTS®), transfer of learning, overall reflections, and recommendations. An additional area of data collection for instructors was inquiry into any differences amongst the learners or professions that may have needed unique teaching accommodations or instructional strategies. These data inform future course design in EFAST and POCUS and provide insight into the efficacy of learning elements and the role they play in the learning process.

Training Strengths. Both learner and instructor data indicate training strengths in the effectiveness of multimedia resources for theoretical principles, and hands-on scanning labs. Advocacy of multimedia resources aligns with Mayer and Moreno's cognitive theory of multimedia learning (2003) where the combination of words and pictures are meaningful in the learning process versus one mode. Both learner and instructor data indicate that the study's theory resources were effective for learning progression to the next phase of applying theory to practice. Learners placed high value on the design of the scanning labs in their guided hands-on instruction, and, as discussed previously, learner progression in the psychomotor domain was rapid due to the experiential hands-on component. This discussion of training strengths points to effective course design, where efficient targeted course content in EFAST outcomes prepared learners for immediate application of theory in the labs. The overall training design of asynchronous instructor-facilitated theory delivery quickly followed by synchronous remote hands-on labs with direct instructor interaction is recommended for POCUS training.

Instructors' teaching roles were more active in the scanning labs and they found learners to be fully prepared. A review of training strengths reveals high learner appreciation for instructor competence in their knowledge and supportive measures to address learner needs. In addition, the highly rated effectiveness of real-time instructor-learner-interaction via the REACTS® technology platform was a key element in the positive transfer of learning facilitated/observed by instructors and perceived by learners.

In the context of the REACTS® system, its evaluation data are curious in respect to both learners and instructor experiences, rated as a training strength *and* weakness. The primary strength lay in its ability to enable remote teaching and learning of hands-on skills in a short amount of time, its major weakness due to sporadic connection problems. As stated previously, despite the intermittent disruption of the teaching-learning interaction for participants, nineteen of twenty learners stated they would recommend REACTS® for DE instruction of scanning skills with a PUD. From these data the researcher interprets that negative critique of the technology lay in sporadic technical difficulty, and not in its ability to deliver effective remote education. This speaks to the importance of stability of internet connections regardless of the remote technology used, and a major requirement to maintain the fluidity of remote teaching and learning. The researcher attributes the effectiveness of instructors and the pedagogical features of live, interactive, tele-assisted technology as key elements to enable positive transfer of learning in the scanning labs. This assertion is supported by one learner response when asked what was least helpful in the scanning labs: “All instruction and information was helpful. Least helpful was the technical issues that came up” (Appendix M2, question #9). The above discussion helps to understand why most learners recommended REACTS® for future DE with pocket ultrasound, despite its reported technical weakness. However, despite this high recommendation for REACTS® from study participants, reliability of the internet connection in DE is important for both learners and instructors in the pedagogical process.

The rationale for mitigating technical issues in future instructional POCUS DE design is both practical and pedagogical, the latter to eliminate or reduce frustration levels for both teachers and learners. Both instructor participants described feelings of frustration as “I was not too impressed with REACTS. It was merely ok, but the freezing made it increasingly frustrating” (Appendix O1, question #26), and “the loss of communication during a sessions…was frustrating for both myself and the participants, and I felt that it disrupted the flow of my explanations” (Appendix O2, question #27). From learner perspectives, commentary on technical difficulties was exemplified as: “Even with IT support right there it was frustrating as the video would freeze, or the audio would be choppy” (Appendix M2, question #10). These narratives identify the need to be proactive in managing potential technical problems to avoid subsequent negative emotions, despite instructor competence and a learner’s ability to perform. As advocated by Belli (2018) there is need to recognize the potential social unrest that online technical difficulties can cause in collaborative forums. In the case of this study the frustrations reported by instructors and learners could have negatively impacted learner-instructor collaboration, despite the learner’s ability to learn the skills, and the instructor to teach them. To offset a potential situation of social difficulty with technical problems, the researcher advocates expecting and planning for emergent technical problems in DE, with proactive measures to mitigate these problems at initial course design phase and during instructional activities. Other areas for improvement are illuminated, as reported by learners in the context of training weaknesses.

Training Weaknesses. A non-effective training element identified by multiple learners and both instructors was the lack of Moodle forum interactivity. This finding was unexpected given the study’s intent to create online social presence in course design. This intent is well-founded given that online discussion forums in DE has been a standard practice to engender social interaction and social presence, which in turn promotes student learning by fostering critical thinking and self-efficacy (Pate et al., 2009). With most learners in the study reporting indifference regarding forum effectiveness to help them learn or feel a sense of cohort and instructor reports of low activity, the question of the necessity, purpose, and/or perceived value of online discussion forums emerges. In the context of the study's design, a related question emerges on the value of discussion forums for those asynchronous online courses with substantial interactive synchronous delivery elements. These questions are significant given the successful learning outcomes and OSCE scores of the training intervention despite underutilization of the online discussion forums and potential lack of social presence. Further inquiry on the matter focuses on the following questions: 1) Are discussion forums necessary to foster online social presence? 2) What is the correlation with online social presence and learning outcomes? 3) What role did the study's course design play in the lack of forum interactivity? 4) Are online discussions and social presence evolving in DE with synchronous online learning, with or without asynchronous elements?

In their inquiry on the effects of online discussion on community of inquiry, learner time, satisfaction, and achievement, Cho and Tobias (2016) compared three online course conditions: 1) no discussion forums, 2) discussion forums (student postings) without instructor presence, and 3) discussion forums with active instructor presence (student and instructor postings). Study findings yielded no statistical difference for cognitive presence and teaching presence however, social presence was significantly higher with the inclusion of discussion forums, and even higher with added instructor involvement. Within their study, Cho and Tobias further present data on three elements of social presence: affective expression, open communication, and group cohesion. Their findings reveal that affective expression was significantly higher with instructor-facilitated discussion groups, and there were no differences with the other two elements (open communication and group cohesion). The salient findings of Cho and Tobias demonstrate that online discussion forums with instructor presence foster social presence and its element of affective presence (affective expression). With their other findings Cho and Tobias conclude that online discussion forums did not influence learner time, satisfaction, or achievement with two caveats: online instructor presence (e-mail, grading, feedback) and a well-designed online course.

The findings of Cho and Tobias above hold meaning for the researcher as follows: 1) low participation and ambivalence towards the Moodle forums could signify a lack of social presence for learning and may have negatively affected learners' affective presence (affective expression), and in contrast, 2) due to the study's effective course design overall, the underutilization of Moodle forums did not negatively impact learner achievement, learning outcomes, or course satisfaction. This does not mean that course design was near-ideal, however, inclusion of online discussion forums was not a necessary element for learning transfer and a successful training intervention. This engenders the question of what is best practice for online discussion forums?

According to Pate et al. (2009), best practice design of online discussion forums includes combining and balancing academic and social elements into one (versus creating a space solely for socialization), thereby enabling synthesis of socializing, interacting, and collaborating. In addition, learner readiness and the importance of a clear understanding on the purpose and value of the forums cannot be overstated: "If learners do not see the value of collaborative learning, they will focus only on achievement and will not engage effectively in collaborative ideas" (Tu & Corry, 2003, p. 57). Given the assertion of Tu & Corry in the context of this study, the researcher recognizes that lack of direction or promotion on best use of the Moodle forums in the study may have resulted in their low use and perceived value, with the consequence of learners only focused on acquiring their EFAST skills and *not* in collaborative learning. Time may also have been a factor given the 'short life' of the three-week training intervention; learners may have not perceived the need or value in online discussions due to constraints of time. As asserted by Aloni and Harrington (2018), advantages of asynchronous online discussions include responding to questions at one's own pace with time to respond and reflect. Reflection time for study participants may have felt limited in this short training intervention and/or using the forums may not have been necessary given the clear training goals with specific learning objectives and outcomes for immediate subsequent OSCE testing. In other words, in the nature of POCUS training, online discussions may not be appreciated, accessed, or necessary due to dominant motives of POCUS trainees to learn the material and 'move on'; engaging in a perceived 'nice to have' discussion forum may not be efficient in the short and targeted world of POCUS training. In addition, the close real-time instructor-learner or learner-learner interactions of one-on-one scanning sessions, necessary for remote DE POCUS training, may serve the element of socialization for the learner.

In the advocacy of effective course design, Blair and Serafani (2016) conclude that not all learners use online forums for the same reason, citing the needs of self-directed theory (SDT) for learner autonomy (intrinsic motivation), competency (process of learning), and relatedness (to feel understood). The authors recognize the challenge to meet all three needs of SDT, possibly complicated by expectations of today's students who also use social media and other avenues for learning and socialization. Within SDT it is possible that underutilization of the forums in the study was related to lack of motivators (intrinsic and/or extrinsic) and/or misunderstanding on their purpose for learning, and/or learners already felt the element of relatedness as colleagues within the study's research design.

The studies cited above reflect the importance of online course design that meets the needs of learners to socially engage *in and with* their learning and progression, including an understanding of what learner needs are and the different roles students and instructors play. In their study on the effects of online discussion, Cho and Tobias (2016) present the argument that:

> …not all online courses should include discussion as a mandatory learning activity and not all instructors should necessarily actively participate in discussion. Instead, the inclusion of

> discussion should be decided with the considerations of various factors including teaching philosophy, course content, embedded learning outcomes, and learner characteristics…discussion should be utilized when there is a clear learning objective through their inclusion ((p. 136).

The argument of Cho and Tobias cited above compels designers of online instructional to carefully consider the purpose of online discussion forums to suit the purpose of course outcomes and to consider their necessity towards overall learner outcomes.

In response to the question on the purpose and necessity of online discussion forums in the context of this study, study findings do not support the need for online discussion forums for the attainment of POCUS learning outcomes in a short training intervention with a live hands-on synchronous component. For future DE training of POCUS protocols, the researcher: 1) advocates reliable online communication for instructors to facilitate basic learner needs (progress, learning support), and 2) should discussion forums be considered, the researcher suggests them to be optional with purpose to connect learners with each other to promote collaboration, a form of peer support during and after the training. The latter point attends to post-training support and is in alignment with the 'results' level of NWKM level four where training performance is maintained and sustained; the tool of the online discussion forum amongst practitioners in this case would constitute a community of practice with an eye on evolving DE technology.

Future design of online discussion forums (and community of practice) needs incorporation of new strategies and techniques to keep up with the new generation of learners who use multiple learning resources beyond what their courses may offer. Online discussion forums continue to be a topic of discussion in 2019, questioning their over-utilization and perceived value. As presented in a blog by Lieberman (2019), both online facilitators and instructors are increasingly weary of the traditional discussion forum, calling for new approaches to engage learners' participation in new and meaningful ways, including new technology and redefinition of instructor roles.

In summary of the study's adjudication of the Moodle forums, and given the discussion thus far, the researcher's 'unexpected finding' on the study's underutilization of Moodle forums could be re-framed as 'expected', given a new lens on the short and focused nature of a training event where training 'relevance' is high with learners focused on achievement, and thereby negating the need and/or value for traditional online discussions. Further research is highly recommended on the purpose and value of online discussion forums in DE POCUS training.

On the topic of possible differences in teaching techniques for the professions in the learner sample, data in instructors' field notes do not report any notable strengths or weaknesses requiring accommodations by the instructors. One instructor commented that professions with imaging backgrounds (e.g., x-ray) "may be more familiar with cross-sectional anatomy" however added "some people seemed to have a natural aptitude for controlling the transducer" for image acquisition. As presented in chapter four, prior education in cross-sectional anatomy was not an advantage, rather, hand-eye coordination skills are more beneficial for success, especially in ultrasound education and practice (Bowra et al., 2015; Choo et al., 2017). Similarly, the analysis of OSCE scores and competency performances did not yield significant differences in the professions themselves, indicating that no matter what the profession, each trainee entering the learning with an inherent degree of hand-eye coordination would likely experience a positive rate of learning in the hands-on operator-dependent skills of POCUS practice. However, given the variable and small numbers of learners per profession, and the small sample size overall (<30), there were insufficient data to render conclusions on the study findings of individual or comparative professions.

NWKM Level 3 Behaviors

In the third NWKM level the degree to which participants applied what they learned when 'back on the job' was framed in how learners applied what they learned (behaviors) in three simulated EFAST OSCE scenarios with human ultrasound models, scenarios based on the 'on the job' EFAST environment. Quantitative and qualitative analyses of OSCE results are discussed in relation to learner success.

Overall OSCE Results

A quantitative view of OSCE data compares numerical scores to two current academic standards: NAIT's minimum course pass of 63% (NAIT, 2019) and the national benchmark of 70% on credentialing examinations for entry to practice, such as the criterion of the Canadian Association of Medical Radiation Technologists (C. Bru, personal communication, March 5, 2018). The latter example relates to the requirements of Accreditation Canada where programs must maintain a profession's minimum pass rate over a three-year period (Health Standards Organization, 2018). A review of the study's OSCE scores yielded an overall group average of 79.6% which exceeds the minimum 70% industry standard for health care professions. In the study sixteen of twenty participants attained the national standard of a minimum 70% ranging from 71.4% to 97.1%. With application of the confidence interval of ±6.4 two of the scores on the cusp of the 70% pass would have failed, rendering overall results to fourteen of twenty learners achieving the national standard. These data reflect a positive response to the study's primary research question from a quantitative stance. Stated another way, for most learners, the training enabled desired behavior change sought by level three of the NWKM, that is the ability to demonstrate training success at the behavioral level with synthesis of all three learning domains. Qualitative analysis of what was behind the numbers was equally important to understand how learners achieved success including progression of learning in the learning domains.

In the performance of EFAST ultrasound imaging and the performance of visuo-spatial and visuo-motor skills while caring for the 'patient' (an ultrasound model) there was synthesis of cognitive (knowledge), psychomotor (application of knowledge and hand-eye coordination), and affective (professionalism) learning domains. In analyzing OSCE averages, together with individual learner narratives, overall data indicate that most learners (OSCE averages between 70-90%) achieved synthesis of all three learning domains with the following hierarchical progressions: to 'evaluation' and critical thinking (cognitive), to 'mechanism' and adeptness at operator-dependent skills (psychomotor) and to 'valuing' with empathy for the 'patient' in responding to their needs (affective). In reviewing individual OSCE scores and narratives there was variability of performance in the group. For example, the lower OSCE scores (below 70%) for four participants reflect beginner levels of 'guided response' (imitation) in psychomotor skills, and 'analysis" in the cognitive domain. For those learners with middle scores (70-90%) the higher psychomotor hierarchy of 'mechanism' was achieved (basic proficiency) with progression to the 'evaluating' level in cognition. The higher scores for six participants (above 90%) reflect an advanced psychomotor level, of 'complex overt response', suggesting mastery of the skill. OSCE scores in the affective domain, aligned to professional competencies of behaviors and attitudes, reflect a consistent appreciation and attention to human healthcare needs, a form of 'valuing' demonstrated by all twenty learners. The researcher interprets the hierarchical progression through the taxonomies of the learning domains as evidence of effective learner reaction to the training (engagement, relevance) and successful transfer of learning, validated in the measured behavior changes of the OSCEs.

The study's OSCE results are the most compelling data in response to research questions that yes, ultrasound skills were attained via DE methodology in simulated conditions. Although these study findings reflect success of the training intervention, they must also be viewed in the context of the study's limitations, further discussed in chapter six. One of the limitations was the short period of training with learning outcomes tested on one day in a one-hour performance. Although learner OSCE performances demonstrated entry-level competency for an EFAST examination there is no measure or indicator that competency would be maintained beyond that one day, if it was necessary.

This is a common question for all medical professionals entering their respective professions, necessitating the requirement of continuing medical education/competency testing under the umbrella term of continuing professional development (CPD). Post-graduate activities of CPD continually stimulate cognitive and psychomotor learning with knowledge and performance testing. Such evaluative measures are challenging for the affective domain, however, and its level of 'valuing' or higher, given that feelings are difficult to measure (Lane, 2015) and the value and attitudinal results of training are developed over the long term (Witt, 2015). In the context of POCUS, it could be said that the long-term effect of 'valuing' may already be developed due to the medical backgrounds and practice of the trainees, however 'valuing' of their new POCUS competencies would be new territory. Another limitation recognizes that learners in the study represented some allied health professions but not all; in some professions there was only one representative. The study has insufficient data for conclusions on the different professions in the sample or the transferability of the training intervention to other allied health professionals. A last limitation is the small study sample of twenty learners (<30), a limitation for quantitative analysis, however adequate for qualitative analysis within the study's non-probability purposive sampling with fit to purpose.

Individual Learner Competency

Data analysis included a review of sixty OSCE assessments (three per learner) to seek any patterns of missed competencies, data which could possibly explain a low OSCE score, or an external factor affecting learner performance. The results of this review did not identify unique patterns however, external factors were noted in two areas. In review of competencies attained only once (missed two or more times) as presented in Figure 20 (chapter 4) data indicate difficulties in pelvic scanning and further identified potential external factors affecting these results, e.g. an empty urinary bladder for one of the ultrasound models. Another external factor impacting some OSCE scores was in the end task of cleaning the transducer. With respect to this end task, some assessors noted that some learners "ran out of time" (Appendix U2), which may account for the difficulty in performing the final task of cleaning the transducer. These external factors are of importance to future OSCE management, i.e., adequate preparation of SPs or patients, and considerations of appropriate time allowed for competency testing. It is important to note, however that the case of an empty urinary bladder for the one ultrasound model, and the notation of running out of time by an assessor at another OSCE station, are factors that were present for all learners in an equitable manner and attained by most learners. These areas are notable for future assessments in course design to attend to external factors such as those in this study, e.g., the adequate preparation of all patients or models and adequate testing times.

Level three of the NWKM also indicates the importance of "required drivers…those processes and systems that reinforce, encourage and reward performance of critical behaviors on the job" (Kirkpatrick & Kirkpatrick, 2010-2019, p. 7). In the context of this study and its simulated on-the-job EFAST scenarios, access to the OSCE rubric at the onset of training reinforced the learning outcomes that were driving the training process, also representing the critical behaviors (competencies) required for the EFAST examination. The researcher postulates that this clarity of training purpose within a short timeframe may be one reason most learners felt they did not need the discussion forums for critical reward of behaviors, especially during their scanning labs. With easy access to the instructor and clear training objectives, online discussion forums to advance learning may not have been necessary. Reinforcement of critical behaviors could also be attributed to those learners who indicated increased relevance to use the training in their own scopes of practice, seek further POCUS applications, and/or further their career paths into general ultrasound. The OSCE scores, possible rewards of performance together with the general positive learner reaction to training (NWKM level 1), and the successful transfer of learning perceived by learners (NWKM level 2), also reflect the required drivers of NWKM level three, empowering learners to apply what they learned to their OSCE performances, a measurement of actual transfer of learning. How learning success and the parameters of the training intervention would be used beyond the study is discussed in the context of level four of the NWKM.

NWKM Level 4 Results

In this final NWKM level of training evaluation, results seek to answer if targeted learning outcomes are effectively transferred into the workplace or environment where behavior change is occurring (as a result of the training), and if these results are on track (Kirkpatrick & Kirkpatrick, 2010-2019). Within this NWKM level, adapted for the study, the targeted outcomes and desired results of the study are directly related to the purpose of this research which is a contribution to the standardization of DE POCUS training utilizing a PUD in the example of the EFAST protocol. This contribution would embody POCUS training design where learning outcomes are effectively transferred on the job *and* remain on track, that is, are maintained in a sustainable manner. This contribution is informed from learner and instructor data in evaluation of their respective learning and teaching experiences, and in their recommendations for future instructional designs. It is important to note that the study's limitations must also be considered in recommendations for the future, limitations which do not detract from the overall contribution, rather, provide context for future instructional design and in managing expectations. These design recommendations and limitations can imbed strategies to ensure critical behaviors of the training are on track with a positive impact on desired results (competency performance) for the learner and their organization.

Participant Recommendations

Discussion for this level of the NWKM is largely derived from data analysis of learner and instructor narratives, provided in learner questionnaire reports (Appendices M1, M2, M3) and instructor field notes (Appendices O1, O2), with summary data previously presented in chapter four

(Tables 10-15 & 17). The ensuing discussion of participant recommendations is organized as follows: 1) what was most and least helpful in the training, 2) were there surprises/no surprises, 3) what was their advice for future instructional design, and 4) what concerns, comments, and/or questions did they have. Learner data were collected at mid- and end-study points, with instructor data collected after the scanning labs, upon completion of their roles in the study. Instructor and learner data, in the context of NWKM level four, provide insights, overall impressions, and recommendations from their respective teaching and learning perspectives. These data contribute to training design to ensure critical behaviors are practiced on the job of POCUS environments, that is, training results are transferred to the POCUS workplace and maintained.

Learners and instructors both cited multimedia resources as the most helpful element of the Moodle course for the theory component of training, specifically the narrated PowerPoints and YouTube videos in their audio-visual presentations on EFAST practice. Learners felt prepared for their scanning labs and instructors stated that these multimedia resources prepared learners well for the hands-on portion of their training. With the effective transfer of learning demonstrated in the OSCE scores of the study, there is strong recommendation for inclusion of multimedia resources in future instructional design, a recommendation supported by other research studies such as Hay et al. (2013) in the value of videos for clinical skills training. Additional instructor advice for course design is attention to currency of course links, e.g., YouTube.

As exemplified in this study for the asynchronous theory component, the importance of identifying set goals with instructor engagement is desirable to optimize self-guided learning, as recommended by Brydges, Carnahan, Safir et al. (2009) and self-directed theory (Blair & Serafini, 2016). Goals for learners were clear in the articulation of learning outcomes for theory and reinforced by instructors in the scanning labs, sound advice for future training design.

Course design advice also included effective collaboration between instructors and assessors prior to delivery should they be different faculty, as stated by one instructor: "I think it would be better if instructors and assessors were on the same page about what needs to be taught earlier in the study (it was very helpful to get on the same page eventually)" (Appendix O1, question #26). Alignment of instructors and assessors was accomplished via the pre-study field test, a valuable component and recommendation prior to first delivery of DE POCUS training.

The data discussed above inform the study's recommendations for future DE theory training to: 1) optimize cognitive learning for 'analyzing' and 'evaluating' via the effectiveness of multimedia tools, 2) enable affective elements of 'valuing' (appreciating, beliefs in worthiness) with favorable reaction to the training, and 3) engage the psychomotor 'set' phase in readiness for active remote hands-on learning to the 'mechanism' (basic proficiency) stage.

Recommendations for future DE instructional design of practical hands-on skills arose from participant responses as to what were the most and least helpful elements in the scanning lab portion of the training. Data were strong in the effectiveness of instructor competency, element of team teaching, and the significant role instructors played in their real-time interactions with learners. Learners found the PUD easy to use and instructors were able to visualize a learner's probe position and guide probe maneuvers via the interactive technology of REACTS®. The course design of one-on-one instructor/learner labs was cited as most effective including the real time features of REACTS® in its ability to allow the instructor to see what the learner was doing, as if they were present in the same space, as in f2f instruction. As previously discussed, the REACTS® technology was cited as a strength in its learning and teaching effectiveness and cited as a weakness in its technical difficulties which interrupted the teaching and learning process. Another reported weakness of the technology was its small field of view, thereby not allowing the learner's whole posture and ergonomic stance/environment to be fully visualized by the instructor. These are highly valuable data in the considerations of technology choices for DE of hands-on learning, especially in operator-dependent skills where adequate fields of view are desirable, and the importance of viewing ergonomic positions for workplace safety standards. To note, attention to ergonomic conditions are especially important in ultrasound due to the profession's long-standing history of problems with repetitive strain injury (Kayman et al., 1999). One learner who found the ergonomics "awkward" proposed the solution of "using a camera focused on my technique separate from the device displaying the US image" (Appendix M2, question #11), duly noted as a recommendation for future course design in equipment set-up of remote scanning labs.

As stated previously, the REACTS® technology was highly recommended as a learning tool for DE hands-on learning, with both instructors indicating the value it can provide for hands-on skills teaching and learner appreciation in their ability to learn the skills with this technology. In this recommendation for REACTS®, its valuable role in areas where remote learning is the only option was cited, assertions also indicated in current literature (Bowra et al., 2015; Weil et al., 2015) and related to the purpose of the study. In the area of remote DE learning for hands-on skills, learners and instructors were aligned on their recommendations for future training: more labs, sequencing of labs with focus on instrumentation at the beginning and more self-direction at the end, variety of models (bodies/anatomy) for practice including both genders, and the introduction of practice labs in between instructional labs. The researcher notes the learner suggestion for less instructor direction as labs progress as an indicator of growth in learner confidence, as their knowledge and skills combine towards synthesis of performance in the live scanning context.

In this live scanning context, the importance of advance protocols to manage unexpected ultrasound findings was noted, such as unexpected pathology on a scanning partner, expressed by one instructor as: "One question that came up during labs was what to do if the instructor noticed the appearance of pathology while one participant scanned the other. This created a unique challenge"

(Appendix O1, question #24). This challenge was realized in one situation as reported by one learner: “During the practice labs, I did NOT expect to find fluid, on my healthy partner” (Appendix M3, question #10). Access to policies and/or procedures to manage these emergent situations is recommended to alleviate the stress these surprises can create for both learners and instructors.

At mid-study point learners were asked to comment on any surprises in their learning experience as well as anything that did not surprise them. As presented in Table 14 in chapter four, learners were surprised with how quickly they could learn how to perform the EFAST exam with so few labs and without prior ultrasound experience. This is a key data point as it is very common that POCUS trainees are not trained in ultrasound (ultrasound naïve) before they begin to perform the EFAST or other POCUS protocols, and they must learn quickly on-the-job, often in confined settings (Dietrich et al., 2017). The ease of using/manipulating a PUD and the effectiveness of the REACTS® technology were also a surprise for learners, as well as the thoroughness of the Moodle theory content, factors promoting learner success in a short time period. One instructor noted surprise at “the ease that most candidates had in obtaining a good view of the pleura [lungs]…where artifacts can be very subtle” (Appendix O2, question #21). These study findings from both learners and instructors are important to the study’s inquiry to assess if hands-on learning is attainable via DE, providing evidence that remote education by distance is possible for psychomotor skills.

Areas that did not surprise learners included patient care principles, quality of instruction, and technical difficulties. Examining these areas will assist future instructors and researchers to manage expectations. From the open comment/question/concern areas of the questionnaires, learners reported their enjoyment of their learning experience at both mid- and end-study points, reflecting a consistent level of learner satisfaction (reaction level one of NWKM) as well as their commitment to their learning process (learning level two of NWKM). The researcher notes that learner satisfaction by itself may not indicate training success, rather it is the combination of learner engagement, relevance, positive transfer of learning and results (NWKM levels 1 to 3) that contributed to training satisfaction. Open comments from learner data at end-study also included areas of improvement for future course design, e.g., more pathology and coverage of artifacts.

As presented in the previous chapter, learner advice for future DE instructional design for remote skills acquisition (mid-study questionnaire) and data on what they would change if they could (end-study questionnaire) were analyzed. These data are aligned with instructor recommendations with minor improvements to instructional resources for theory learning, and more robust recommendations for scanning lab design such as more labs and practice, and a variety of partners for enhanced learning.

Instructors and learners recommend the assurance of stable internet connections with interactive technology to optimize the teaching and learning experience. The researcher notes the advantage to mitigate technical interruptions to promote fluid instructor-learner collaboration without barriers, as advised by Belli (2018). These participant data are rich in their contributions to future design, as they are recommendations from learners who experienced POCUS training themselves and instructors who delivered the training, thereby representing credible and authentic sources. The researcher believes this credibility promotes efficacy and sustainability of training results towards standardized training in EFAST and POCUS education. Another area examined for this fourth level of the NWKM was the performance of the EFAST competencies themselves during the OSCEs, that is, which competencies were easy or difficult for learners to attain.

Competency Training (EFAST)

With OSCE scores ranging from 37% to 97%, it is difficult to target which areas were more difficult to attain than others, as one learner struggled with most of them and another had a near-perfect score. Despite this wide range, data identified three competency areas of weakness or strength, versus individual competencies themselves. These areas encompassed the category of imaging skills in the left abdomen, heart, and pelvic region. Other than these three areas, imaging skills for the rest of the body areas were relatively strong. One aspect in the set of imaging skills was recognition of reverberation artifact and identifying potential pathology areas. Thus, it is recommended that course design include reinforcement training measures for those learners who may need more time and/or more instruction, especially for these identified weaker competency areas, and, more robust coverage of artifacts and pathology recognition. It is noted that professional interactions were a strong element of OSCE performance, not a surprise given the professional backgrounds of learners, however, still an element advocated for inclusion in learning outcomes of POCUS course design no matter what the trainee's prior medical profession entails. In summary, data discussed in this fourth level of the NWKM inform future course content towards effective and sustainable training.

Summary

In summary of chapter five, learner and instructor study results are discussed in alignment with the four levels of the NWKM and three learning domains. In the first level, immediate reaction to the training was favorable and beneficial in placing the training in a positive position at the outset (willing and ready learners), an advantage for the instructors. Learner engagement and relevance were maintained throughout the training demonstrated by learner commitment. Other elements of training reaction identified overall learner satisfaction in their learning experience. Discussion of learning, as per level two of the NWKM, highlighted forward shifts within all learning domain taxonomies, reflecting strong learner perceptions on the transfer of their learning and reflection of learning domain progressions, including those pivotal points in the learning process that ignited forward shifts. The most compelling evidence that training was effective was in level three of the NWKM with measurable behavioral change of OSCE results, to reflect and validate the effectiveness of the training - a good majority of ultrasound-naïve learners were able to perform an

EFAST exam in simulated settings according to national standards. These quantitative results demonstrate that learning occurred, as manifested in behavioral change in testing conditions. The positive transfer of learning as observed by instructors and perceived by learners, validated with OSCE scores, also indicates instructor competence and effectiveness. The chapter also presents study limitations and their importance to manage expectations in designing future training interventions. Also discussed are suggestions for future research in the context of selected study findings to inform further inquiry. The chapter closes with data analysis aligned with the study's adapted level four of the NWKM with advice and recommendations from both teaching and learning perspectives for effective future DE POCUS training. Data analysis findings discussed in chapter five provide the basis from which research conclusions, recommendations, limitations and future research are presented.

Chapter 6. Conclusions, Limitations, Recommendations, and Future Research

Chapter six will first revisit the rationale, purpose, and significance of the study which informed the research questions. The researcher's conclusions, study limitations, recommendations, and areas for future research will ensue, based on the analysis and discussion of study results in previous chapters.

Rationale for the study included four factors: 1) a global call for action to standardize POCUS training (Dietrich et al., 2017), 2) increased need for effective methods to deliver POCUS education by distance (Bowra et al., 2015; Choo et al., 2017), 3) the operator-dependent nature of POCUS requiring effective DE training in visuo-spatial/visuo-motor hands-on skills (Bowra et al., 2015), and, 4) notable gaps in the literature for POCUS training in the allied health sector. These factors were instrumental in shaping the purpose of the study to investigate if allied health practitioners, without prior ultrasound skills, could learn the hands-on skills and professional behaviors of POCUS entirely by distance education methodology, and *how* these skills could be taught and learned. The importance of recruiting ultrasound-naïve learners for the study aligns with the status of many POCUS learners who do not learn ultrasound imaging skills prior to their first POCUS practice or case (Choo et al., 2017; Dietrich et al., 2017). The significance of the study lay in its potential contribution to the wider POCUS practitioner community through standardized DE and practice. The researcher notes that since the data collection phase of this study in 2019, the call for uniform POCUS training continues, in response to growing and widespread use of PUDs due to their versatility and accessibility (Baribeau et al., 2020). The study's research questions, literature review, and methodology were structured to address the purpose of the study. Data collection and analysis ensued, in an interpretive case study research framework with mixed methods inquiry. Study conclusions, limitations, and training recommendations will inform future instructional design of POCUS education by distance to contribute to the standardization of POCUS training for the ultimate potential benefit of improved patient outcomes,

Overview of Study Conclusions

Overall findings of this interpretive case study research study demonstrate that within a sample of two instructors and twenty learner participants, sixteen ultrasound-naïve learners were able to attain the entry-level ultrasound skills/competency to perform the POCUS protocol of EFAST with a PUD, following a training intervention delivered entirely by DE. These findings address the research questions including *how* cognitive, psychomotor, and affective skills of ultrasound imaging were taught and learned in a DE format. From data analysis the researcher presents the following conclusions and related areas for future research where applicable:

1. Hands-on ultrasound imaging skills can effectively be taught and learned by DE, utilizing multimedia resources for online theory and a live interactive tele-assisted platform for practical learning in a simulated learning environment, with hierarchical progression through the three learning domains.
2. It is possible forultrasound-naïve health practitioners from different professions (imaging and non-imaging) to learn the EFAST protocol of POCUS entirely by DE.
3. It is possible for ultrasound instructors to incorporate and adapt their f2f teaching methods and pedagogical skills to deliver hands-on ultrasound imaging skills in the EFAST protocol of POCUS entirely by DE.
4. The NWKM facilitated evaluation of the study's training intervention to analyze participant data towards standardized and sustainable POCUS training via DE.
5. Favorable reaction to the training (engagement and relevance) is beneficial to positive learner perceptions in their transfer of learning, and overall satisfaction. (As 'reaction' is aligned

with emotions in the affective learning domain, further research is recommended to examine potential correlations of a favorable learner reaction to learning outcomes).

6. Learner appreciation of their training and perceived 'valuing' engages the affective learning domain in the short term of training; there is potential of continued progression in the affective domain after the training (long term). (Future research is recommended on methods to measure affective learning during and after training interventions).
7. Learner beliefs may not influence learner success, however, may have an impact on *feelings* of success and learner confidence. (Further research is recommended to examine the correlation of learner beliefs to learning outcomes and learner confidence).
8. Online discussion forums to enable learner success in the training intervention were not necessary. (Further research is recommended on the necessity and purpose of online discussion forums for effective learning and social presence in the targeted nature of POCUS education as well as why online discussion forums may not work in these settings).
9. Study results yielded data to provide recommendations for future instructional design for POCUS; training to promote standardization and sustainability of POCUS education.
10. The study's methodology and results inform future mixed methods interpretive single case study investigations, especially those studies conducted in a researcher's workplace.

The study conclusions presented above are further discussed in the next section in context of the study's research sub-question and organized by the four NWKM levels.

Research Sub-Question

In the investigation of *how* cognitive, psychomotor, and affective operator-dependent skills of POCUS with a PUD were taught and learned in a DE format, the researcher concludes that the design of the training intervention contributed to training success and learning domain progression via key elements of: 1) online multimedia resources, 2) tele-assisted interactive scanning labs, and

3) benefits of a favorable learner reaction to the training. Further details and related recommendations are presented in the context of the four NWKM levels.

Level 1 NWKM (Reaction)

Learner participants' favorable reaction to the training set the stage for a positive learning culture from pre- to end-study. Although there is no evidence that a favorable learner reaction directly impacted learning outcomes, the researcher recognizes its benefits to actively engage learners in their contributions to their learning experience, as supported by the study of Giangreco, et al. (2009) who also utilized the NWKM to evaluate training, citing the importance of attending to learner 'reaction' in training design.

From the onset of the study learners expressed feelings of engagement, a reaction that was maintained in learners' demonstrated commitment through the learning and assessment phases of the study. An equally high level of training relevance ('this is meaningful to me') was motivating as learner understanding of DE progressed to its evaluation, perceived value, and potential future application to professional scopes of practice. Research findings also demonstrated high learner satisfaction with the training at two milestone points: mid- and end-study. Factors that contributed to these satisfaction milestones resided in the activities and sequence of the training intervention which enabled: 1) positive learner perceptions in their transfer of learning, and 2) the 'reward' of learning success with positive OSCE scores for the majority of participants when their learning was validated through observable behavior change.

These study conclusions attest to the need to design workplace education where learners feel positive about the proposed training and feel its relevance to their current and future work status, prior and during the training event. With these conditions in place learners are affectively ready in their response to the training, in cognitively understanding specific learning goals, and in being prepared for the training at the 'set' level of their psychomotor learning domain. In the context of the EFAST examination and POCUS training, the researcher believes learner engagement and relevance would likely pre-exist in a favorable state, due to the learner's professional need to be proficient in POCUS as a practitioner, compelling the leaner to be naturally engaged in training that is highly relevant (useful) to their goals. Despite this potential pre-existing inherent quality, the researcher recommends that future POCUS education design intentionally engage the learner in why the training is important to them before the onset of training.

Recommendations also include course design principles that are simple with learning outcomes essential to the targeted nature of POCUS training, knowing that trainees already have foundational medical knowledge in anatomy, physiology, pathology, and basic professional behaviors. This direct targeted approach promotes high degrees of training relevance with contribution to learner satisfaction. Recommendations to evaluate learner satisfaction include monitoring the progress and feedback of trainees formatively, at theory and practical skill acquisition points and at completion of the training intervention. As learning outcomes will manifest once training is applied (back on the job) the researcher recommends post-training assessment to evaluate training relevance and satisfaction in the long term. Post-training evaluation is also beneficial in its potential to measure long term affective learning. To explain, perceived 'valuing' of the training event will continue to manifest in how the learner uses the training responsibly and ethically. Measurement of affective learning such as 'valuing' is a challenge, however, as expressed by other scholars, such a measurement stresses the importance of the affective learning domain and its contribution to long-term learner success (Lane, 2015; Mottet, 2015; Witt, 2015).

Level 2 NWKM (Learning)

Study conclusions aligned within the second level NWKM include evident progression in the transfer of learning (observed by instructors, perceived by learners, validated with OSCE scores), with increased hierarchical shifts within the learning domain taxonomies. These conclusions are based on pre- and end-study data analysis, encompassing learners' self-evaluations of their own learning experiences and beliefs in DE as a viable methodology for delivering hands-on (psychomotor) and behavioral (affective) skills. A major finding is the significant role that the tele -assisted interactive hands-on component of training played in upward shifts of learning in all domains: from a psychomotor 'set' (ready to do) to 'mechanism' (I can do it); in cognitive levels from 'understanding/analyzing' (knowing/assessing) to 'evaluating' (critique of learning experience); and an affective status of 'receiving' (willing to learn) to 'valuing' (appreciation of training that is relevant and meaningful in relation to beliefs). The researcher concludes that most learners were able to achieve their learning outcomes with engagement of all three learning domains as follows: 1) from a favorable reaction to training at the outset, 2) through effective learning resources and activities for perceived positive transfer of learning, and 3) attention to learner beliefs in harnessing motivation and commitment.

Given the study's training time of three recommended hours of online self-directed theory learning and three actual hours of DE hands-on scanning labs/practice (total over three calendar weeks), together with a positive transfer of learning validated by OSCE results, it can be concluded that training times were appropriate for DE of the EFAST protocol with a PUD. Within this time frame and course structure, it can also be concluded that ultrasound instructors, experienced in f2f teaching, were able to incorporate and adapt their pedagogical methods to a DE environment using an interactive tele-assisted platform for hands-on ultrasound imaging skills.

With exploration of learner beliefs, and the role they played with intention and commitment to online training, the researcher interprets that negative beliefs or resistance to the idea of DE efficacy (skepticism) were superseded due to the strength of experiential learning in the training design which enabled attainment of learner competency by DE and learner success. Most learner beliefs in DE were maintained from pre- to end-study indicating that beliefs may not influence learner perceptions of success, however, for some learners there was a shift in their beliefs of DE efficacy, either increased or decreased, once the training event was completed and OSCE scores known. In addition, learner beliefs matched their feelings of competency/ability with three exceptions: two learners believed in DE, had very good OSCE scores, yet did not *feel* competent; the other learner believed in DE, had very poor OSCE results and had mixed feelings of competency. From these findings the researcher recommends future research in the correlation of learner beliefs to learning outcomes congruent with learner feelings of ability/confidence.

From study conclusions of effective training design, the researcher advises efficient online theory activities directly followed by remote hands-on learning via reliable DE technology. As an alternate design, theory and practical components could be integrated, depending on logistics and course content, the primary principle being the ability to practice psychomotor hands-on skills immediately after, or in conjunction with acquired theoretical knowledge (cognitive). The researcher also advises transparency and learner awareness on how they will be assessed (testing conditions) at the outset of the training, the effect of a known ‘reward’ versus the ambiguity of an unknown surprise at the end. Clarity of learning and performance expectations will also contribute to learner confidence (I think I can do it) and commitment (I intend to do it), equally important elements in effective training. The study accomplished this element by including the OSCE rubric (the examination) at the outset of training, a rubric also used in practical instruction culminating in performance in the OSCE phase.

As conducted in the study, ongoing self-monitoring of learning and teaching experiences, during and after the training, by learners and instructors respectively, enabled evaluation of the training from the training participants themselves. From qualitative analysis of the study’s learner and instructor feedback, the researcher concludes that study data from authentic experiential learning provided rich data, enabling valid recommendations for future course design and course delivery, later presented in this chapter. Conclusions pertaining to the third NWKM level will now be discussed, that is, validation of learning transfer through demonstrable and measurable behavior change.

Level 3 NWKM (Behaviors)

Participants' demonstrable and successful behavior change (measured with OSCE scores), as a result of the training, validate that the study's course design and activities were effective, given that sixteen of twenty participants met or exceeded the entry-level industry standard of 70%, and eighteen of twenty participants attained NAIT's minimum 63% post-secondary standard for academic progression. With further analysis of competency performance, e.g. missed, weak, and strong competency attainment, the researcher concludes that most of the missed and weak imaging competencies were primarily due to deficiencies in ultrasound pattern recognition (cognitive evaluation) and not due to inabilities to acquire the images (operator-dependent psychomotor skills). This conclusion speaks to the strength of remote and interactive hands-on learning methodology, and indicates the need to include image critique, for both normal and abnormal image patterns, to future course design. In the weak area of exam closure (cleaning tasks), the researcher recommends course design fortification of the importance of completing these tasks as they are critical to infection control and safety. In contrast to these weak competency areas, study results indicate strong performances in imaging skills and professional behaviors. From these strong results, the researcher concludes overall effective theory design and scanning lab instruction from which to draw recommendations.

As the study's recruitment process randomly yielded representatives from eight different allied health professions with varying degrees of imaging/non-imaging backgrounds and experience with patient interactions in the clinical setting, there was opportunity to investigate if any profession might need a different accommodation in teaching technique, or if other study results identified any profession-specific pattern. Study results did not find any differences amongst the professions, however, there are insufficient data on this topic to make any conclusions on the generalizability of the training intervention and potential transferability to other allied health or medical professions. It is important to reiterate that study participants met three criteria no matter what profession they represented: 1) ultrasound naïve, 2) knowledge of anatomy and physiology, and 3) previous experience in patient interactions. With these criteria in mind, recommendations for future course design may differ should trainees not possess a certain degree of any one or all three of these criteria. Thus, the researcher posits that it is not the professional background that is key to training success, rather, the knowledge, skills, and attitudes of the individual practitioner, especially in the hand-eye coordination aptitude of a trainee, reflecting the operator-dependent nature of ultrasound scanning, one of its key characteristics.

Recommendations presented thus far are core to discussion of the next level of the NWKM which pays attention to results, a post-training view of how learners will continue to display behavior changes ‘on the job’, i.e. back in their regular workplaces. As previously mentioned, this study re-framed ‘results’ of NWKM level four to those study recommendations that would sustain future EFAST and POCUS practice due to effective and standardized DE training.

Level 4 NWKM (Results)

The fourth level of the NWKM in training evaluation is intended for a post-training, back ‘on the job’ application. In this study, level four results were applied with the lens of an ‘on the job’ POCUS environment, results to inform standardization of training, especially for those in remote areas without access to mentorship and/or continuing competency education. As previously outlined, qualitative analysis of participant feedback concludes that study findings offer authentic and validated experiential learning (and teaching) data from which to present recommendations for future course design and ‘on the job’ best practice. These training recommendations, to be discussed in detail later in this chapter, are derived from study findings and data analyses, yielding a deeper understanding of learners' acquisition of cognitive, psychomotor, and affective operator-dependent skills of POCUS with a PUD in a DE format. Prior to the upcoming section on a recommended training plan, it is important to recognize the limitations of the study.

Study Limitations

Although study findings reflect overall success of the training intervention, it is important to place this success and study conclusions in the context of the study's five limitations as listed below:

1. One-time competency testing: Learners demonstrated success on one day within one hour of performance, demonstrating entry-level competency for an EFAST examination in three simulated settings. This one-time measure may not reflect ongoing competency beyond the day of testing. This is a common situation for all medical professionals who enter their respective professions following rigorous assessments such as OSCEs which simulate the real world however, this final testing usually follows some exposure to the clinical environment as a trainee under supervision, an element not experienced by learner study participants who only received three hours of hands-on scanning instruction and practice in the scanning lab. As continuing competency is mandated for several medical professions to ensure maintenance of skills and ethical practice, post-training activities are recommended for future POCUS training to ascertain competency maintenance to offset similar situations as described in this limitation.
2. Learning and testing conditions with simulation: This limitation is related to the simulated settings of the scanning labs and OSCEs which do not reflect the real-world of clinical practice. This is the inherent nature of training in ultrasound and the OSCE method of testing with human models and real bodies to interact with in an authentic simulation of clinical practice. It is the next best thing to clinical practice assessment with advantages of

safety and control/standardization of testing factors, versus reliance on random cases in the clinical milieu for examination.

3. Training in a single protocol: This limitation recognizes that learners demonstrated competency in one protocol of POCUS, the EFAST examination, which does not translate to competency in POCUS in general. However, the training intervention was designed for POCUS skills first, with EFAST content selected to learn imaging of most of the body. The researcher believes the acquired imaging skills in EFAST are transferable to other POCUS protocols with additional theory and practical learning in the parameters of the new protocol(s) where necessary.
4. Partial/insufficient representation of the allied health sector: The fourth limitation recognizes that learners in the study represented some allied health professions but not all; in some of the study professions there was only one representative. There are insufficient data to draw conclusions on any differences amongst or within the professions, or to speak to the transferability of the training intervention to other allied health professionals, however, there are certain data which highlighted potential transferability.
5. Small sample size (small scale research): The sample size of twenty participants limits generalization of study results to a wider population of healthcare professionals due to a large standard error and confidence interval in the data due to a small sample size (<30).

In brief summary of this section, where researcher conclusions and study limitations are presented, the remainder of the chapter will provide recommendations and guidance for future instructional design in POCUS and suggestions for future research, based on study results. Training recommendations are framed to capture best practices, from pre-training to the end including a post-training phase, and the analysis of learner and instructor feedback and their direct advice for future instructional DE design of POCUS.

Study Recommendations for Future Instructional Design in DE POCUS

The following recommendations for instructional design are presented in four training stages: 1) preparation, 2) delivery, 3) evaluation, and 4) post-training follow-ups, in the context of POCUS training delivered by distance.

Training Preparation

Pre-course Survey/Pre-requisites. Potential trainees may voluntarily request the training, be mandated, and/or be invited to a training course. A needs-assessment, e.g., pre-course survey, is recommended to assess learner needs and their background knowledge, skills, and attitudes. These results, in the spirit of prior learning assessment principles, can determine learner readiness for the quick and targeted nature of POCUS practice, including the application of required professional behaviors. Although most POCUS trainees will already practice professionalism due to their medical backgrounds, some professional behaviors for POCUS may be new, e.g. responses to the patient when applying pressure to a full urinary bladder in pelvic scanning. The strategy of a pre-course needs assessment optimizes learner reaction to the training (NWKM level one) with engagement and relevance, factors that contribute to learning satisfaction and conditions for learner success.

As a caveat, the researcher acknowledges training needs may be immediate and emergent with no time for pre-assessing individual learner needs, as is the environment in some POCUS settings, e.g. emergency medicine. In these cases, background knowledge/skills/attitudes of the learner(s) may be diverse and/or without course pre-requisites, depending on the reason for training and nature of the emergency. Regardless of the reason for training, ascertaining learner needs, e.g. a conversation or e-mail is advised and recommended for course success. If this is not possible due to the emergency nature of the situation, a de-brief session is advised between learner and mentor to reflect on what worked and did not work, thereby preparing the learner for the next training event.

There is one notable aspect with prospective POCUS learners who come from medical backgrounds that encompass high degrees of hand-eye coordination skills, such as surgeons. As hand-eye coordination is a key skill in POCUS competency (Bowra et al., 2015; Choo et al., 2017) the aptitude for POCUS learning may manifest in rapid success in a short time, as was the case in the study, where all participants already possessed some degree of hand-eye coordination. Equally important in the training preparation phase is understanding the potential transferability of a well-designed POCUS course to multiple learners, and pre-requisites and learner needs may be common to several POCUS beginners, no matter what their previous medical profession.

A next step in instructional design is the development of a content and delivery plan with a course description, outline, and syllabus, recommended to ensure alignment to learner interests (engagement), learner needs (relevance), and for promotion of learner satisfaction (level one NWKM).

Course Description/Outline/Syllabus. A key element in training preparation is the development of a course plan, to inform prospective learners and to manage learner expectations. A course description of two to three sentences informs the learner what they will achieve at the end of the training, e.g., “upon completion of this course the learner will…”. A companion outline and syllabus provide necessary details including course length, lesson plans, learning outcomes, course settings, and assessment methods/conditions. In POCUS training, the researcher recommends that elements be succinct and targeted to the desired training, training which may be hours in length such as the study’s six-hour time frame, or three months duration within a medical curriculum. Another factor in course success is learner confidence (I think I can do it) and commitment (I intend to do it) which can be attended to with accurate course descriptions for prospective learners. Where learners express doubt or skepticism, the researcher recommends citation of literature attestations where ultrasound naïve practitioners have successfully learned how to scan with a PUD remotely, in a very short time frame, such as the study by Mai et al. (2013). The results of this research study are also an attestation to success, with learner narratives expressing their surprise at the ability to attain PUD competency of EFAST after only three hours of scanning instruction from their ultrasound-naïve pre-study positions. In addition, study results provide instructor comments on the ease of delivering remote instruction of scanning skills.

Selection of Learning Management System & Learning Resources. In this section recommendations on selecting learning resources are presented, first for online theory, and second, for real-time interactive hands-on scanning instruction.

Online Theory. It is recommended that learning management systems selected for online POCUS courses have capacity for housing multimedia resources with asynchronous and synchronous delivery options, e.g., Moodle. As highly recommended by study participants, online theory content should include short narrated PowerPoints and step-by-step videos with multiple images of normal and abnormal ultrasound findings. Multimedia selections should include those that are focused and targeted to the learning outcomes of the course, such as YouTube videos, with assurance that online links are viable. Also recommended are formative quizzes for learners to self -check their learning progress and status, and for online facilitator(s) to monitor. Online forums for communication and learner support may be beneficial in providing the social networking that is possible for a community of practice during and after the training event. As evident by study results, data analysis and discussion, online discussion forums to enable/advance learning are not necessary provided the course is well-designed and monitored to ensure learner engagement and support.

Real-time Interactive Hands-on Scanning Instruction. Analysis of study data concludes that the most important recommendation for hands-on instruction by distance was reliable remote learning technology with capacity to maintain stable connectivity during instructor/learner real-time interactions. The researcher highly recommends pre-testing of the technology prior to training delivery with a back-up plan during delivery such as on-call IT support. In the selection of a remote training system and PUD, the following features are recommended: real-time interactive training with screen-sharing, onscreen pointer, video chat, options for multiple camera views, and high quality imaging capacity of ultrasound probe technology, e.g., similar to the system used in the study - the Philips Lumify, a PUD utilized and integrated with the REACTS® tele-assistance platform. As with the Lumify probe, PUDs can be connected to a smartphone or tablet, e.g., IPAD™, a common situation in POCUS environments where necessity for compact ultrasound equipment is the norm. Real-time screen-sharing features are essential for hands-on learning, enabling the instructor to guide learner manipulation of the ultrasound transducer, e.g., the PUD. With video chat capability and an onscreen pointer, the instructor can point to ultrasound anatomy, normal and abnormal findings, as well as artifacts inherent to ultrasound imaging. The identification of artifacts is essential in ultrasound imaging in order to discern real from non -real image phenomena. Live screen-sharing while the learner scans is essential for instructor and learner to simultaneously view the live images and discuss the effects on image quality when adjusting gain and depth - key instrumentation controls in ultrasound imaging. In addition to assessing the images produced by the learner, instructor assessment of ergonomics is highly recommended, especially to assess learner stance and hand-positions in holding the probe. This is key to mitigating repetitive strain injury, a long-standing and common occupational hazard in the medical sonography (ultrasound) profession (Kayman et al., 1999). In this last point, selecting a remote training system with multiple camera options is important, with options to place a second camera focused on the learner's hand, and another on the learner's body stance.

The major benefit of selecting the technology as recommended above is its capability to simulate, as much as possible, the f2f mode of teaching someone how to scan, where constant and subtle hand movements need guidance. Having the instructor confirm and validate hand/probe positions for progression of imaging skills is the main goal in teaching ultrasound imaging, whether f2f or remotely. For this study, the features of the REACTS® platform and Lumify PUD were effective in achieving this goal. To achieve this goal in future instructional success, it is highly recommended that the remote training scenario and its technology set-up be field-tested prior to delivery of the hands-on component of the training.

With the key elements above attended to, learner satisfaction and their expectations can be met, as exemplified in this study. Attending to these elements enables an overall favorable learner reaction to the training (level 1 NWKM) and promotes fertile ground for the transfer of learning (level 2 NWKM) in training delivery.

Training Delivery

The following recommendations for delivery encompass considerations for instructor recruitment, attention for stable connectivity for DE, awareness of learner ergonomic positions, planning for unexpected findings, instructor monitoring of learning progress and a mid-course ‘check-in’ to formatively assess progression of learning towards full transfer of learning.

Instructor Recruitment. As commented by multiple learners at mid-study, interactions with their instructors in the scanning labs reflected the important role that instructors played towards learner *feelings* of success in the learning and training satisfaction (Appendix M2, question #8). This finding aligns with Moore’s study (2014) where instructor presence correlates with student satisfaction and success. Learner feedback cited the value of instructor competence as well as their qualities of patience and helpfulness for hands-on learning. The researcher recommends that instructor recruitment for online teaching attends to instructor qualifications and experience as an ultrasound educator with online teaching skills, and proficiency with selected remote interactive technologies. A caveat in this parameter is in the reality of certain sectors of POCUS education where the ‘instructor’ may be a senior physician or practitioner teaching junior physicians/practitioners, a reality of on-the-job training especially in emergency medicine. In these cases, the instructor-physician would benefit from short remote training courses to learn *and* teach POCUS techniques. The research study utilized a two-person instructor model for team teaching which was cited by learners as beneficial in receiving different approaches for learning and application of theory. Although cited as an advantage for this study as a desirable recommendation, it is not essential.

Facilities, Equipment, and Models. The theory portion of the training can be delivered in any online learning management system, such as the Moodle platform used for the study, with choices open to the capacity and/or convenience of the learner. For the remote, interactive scanning lab instruction of a POCUS training environment, facilities will be diverse, from a patient's bedside, in a moving ambulance, or in a room dedicated for education, to name a few. Most important is the selection of an effective ultrasound and remote training equipment/system used, no matter the space or location of training. The research study utilized the Lumify curved array transducer from Philips Healthcare, attached to a six by eight-inch android tablet, however, PUDs such as the Lumify can also be connected to a trainee's smartphone (Philips, n.d.). Headphones for the learner are desirable for best sound quality in real-time instructor-learner interactive instruction, however, if headphones are not available, instruction can still be remotely delivered through the audio systems of the respective computers/phones used by the instructor and learner.

The ability to scan a live human model is advantageous, and a variety of models is recommended for diversity of body habitus as well as gender differences. Ultrasound phantoms and simulators currently used for ultrasound education are also recommended for POCUS training, however, the researcher notes their use is beneficial for early stages of training and not for advanced stages of learning, as advised by Grantcharov & Reznick (2008), cited by Bowra et al. (2015). In this article Bowra et al. assert that learning the psychomotor skills of competent ultrasound practice is the "greatest challenge for POCUS teaching programs delivered via e-Learning" (p. 24). Part of this challenge is that the task of scanning is new each time a new patient is scanned (Melniker et al., 2006), thus, practice with a variety of live models is a necessary element of POCUS training versus reliance on static manikins or ultrasound phantoms.

Stable DE Connectivity Plan. Despite pre-testing for optimal functionality of the remote DE set-up of the interactive instructional platform and related technology (PUD and tablet), connectivity issues will likely arise, as was the experience in the research study. Therefore, it is highly recommended that a back-up plan be pre-designed and available, such as immediate IT help and the ability for the instructor and learner to contact each other during these or any other type of disruption.

Learner Ergonomics. The study's learner feedback indicated their need for instructor visualization, assessment, and correction of any ergonomic issues with a learner's stance or hand position. Recommendation to attend to these elements include camera placement on the learner's hand with ability to move that camera, and/or an additional camera on body position. The ability to display multiple camera images on a screen-sharing set-up is a feature to seek when choosing the parameters of DE technology. The researcher repeats the caveat that if the training occurs in an urgent or confined setting, e.g. an ambulance, the advantage of extra cameras may not be an option, however, after the emergency has been dealt with, a debriefing session is advised with pre-training of ergonomics offered prior to subsequent emergency POCUS settings.

Unexpected Findings/Waivers. The recommendations in this section are presented in the context where learners are practicing on each other, and, not in a situation where a learner is learning/performing 'on the job' on a patient at the bedside. When peers are scanning each other, with the instructor viewing all acquired images, unexpected and/or atypical findings may be discovered, such as abnormal fluid collections in the abdomen, as was the case in the study. The researcher's recommendation is to anticipate these events with a prepared script to convey that these events are frequent in ultrasound education and the learner is advised to follow-up with their physician. Several ultrasound educational programs, e.g., NAIT, with students scanning each other, pre-advise the students that unexpected findings may happen and the student signs a waiver validating that they understand and consent to follow-up with their physician should this happen to them. In addition, they consent to confidentiality should unexpected findings occur on the model they are scanning after alerting the instructor of the finding(s).

Monitor Transfer of Learning Progress. In the short and focused nature of POCUS training, time is of the essence, thus it is recommended that the delivery phase of the training monitor how learning is progressing early in the training towards achievement of the learning outcomes. Debriefing principles are also recommended as part of the learning process where learners self-reflect on their performances with instructor guidance. Evaluation of learning progress is inherent to the role of the instructor and it is recommended that this skill be exercised for each lesson with strategies to stay on track of the course timeline or lesson. The researcher includes this recommendation for POCUS training to only teach/learn a part of an organ or body section, and not the whole. As previously described POCUS is targeted or focused and performed in ten or less minutes (Bobbia et al., 2015), unlike the longer comprehensive ultrasound examination of the whole body. Because so much of the body's anatomy is seen with an ultrasound probe, the temptation to learn and teach imaging skills beyond the intended target areas exists and can impede the transfer of learning in the context of learning outcomes, confirming the need for monitoring learner progress and to stay on track. Assessment of learning progress can also be served with a learner survey as an option. Best practice recommendations during training delivery include active instructor presence, to attend to learner needs (e-mail, questions/feedback).

Mid-course check-in, e.g., survey. The recommendation of a mid-course survey is primarily two-fold: to evaluate the learning for quality control and future improvement, and, to course-correct teaching strategies should survey data indicate negative progress or conditions that are impeding the learning. The researcher also recommends brevity in any survey due to the short and focused nature of POCUS education.

Training Evaluation

The study design utilized f2f OSCE evaluation methodology to assess attainment of learner outcomes as this is the current 'gold standard' in measuring entry-level competency. It is possible and recommended that POCUS training be evaluated by distance strategies which can be facilitated with the technology system and equipment already set up for training. The researcher recommends that evaluation of training success be designed to replicate or simulate what the learner will have to do 'on the job'. A key recommendation for assessment is utilization of SPs and not the model the learner was practicing on during the training. If models are not available, alternative measures can apply, such as learners submitting videos demonstrating their performance of the training in their geographical settings, perhaps on the patient they are assigned to or a model recruited for the purpose – a strategy reported successfully by Hay et al. (2013) where medical students created videos for assessment. The recommended number of assessments is a minimum of three, on three different models, as was the case in the study. The assessor can be a neutral third party or could be the instructor of the training, depending on the POCUS training situation. The discussion thus far describes short term evaluation. Evaluation of training outcomes in the long term are also recommended, especially progression within the affective learning domain, where time and elements such as 'valuing' will deepen and mature as learners use and apply skills ethically and responsibly.

Debriefing. A facilitator/instructor-guided reflection phase is highly recommended to encourage learners to provide feedback on their own performance, reflections that can deepen learning and position the learner for future success.

End-course Survey. The purpose of this element is evaluation of the course for future improvements, as well as the opportunity for learners and instructors to contribute to recommendations from their own experiences. As previously stated, all surveys in the short courses of POCUS education do best with brevity especially as they could be deployed within hours of each other or merged where necessary. To note is the feature of certain learning management systems, e.g., Moodle, with capacity for collecting mid and end course feedback and compiling the data for analysis, all in one day if necessary.

Post-Training Follow-up

In alignment with the fourth level of the NWKM (results) the researcher recommends a plan for post-training follow-up to assess if learning outcomes attained in the training are being applied and sustained when learners are back 'on the job'.

Trainee Performance 'on the job'. Recommendations for this element include communication of a post-training plan at the outset of the training in the course outline and syllabus. This course expectation will enable success for this stage of the training as learners will expect a connection with the instructor after they complete the training, perhaps with refresher options at this point. This strategy also emphasizes that learning outcomes are expected to be applied and sustained when learners are back in their professional POCUS settings no matter what the geographical setting. A tool for this goal could be an online community of practice for connection and qualitative assessment of the training. Post-training monitoring with learners may indicate ongoing shifts in learning domain taxonomies as POCUS 'graduates' continue to master their skills in all learning domains such as 'valuing' to 'organizing' in the affective domain, 'evaluating' to 'creatin g' in the cognitive domain, and mastery of psychomotor skills to a ‘complex overt response’ or ‘adaptation’ hierarchy.

Opportunity for Continuing POCUS Mentoring and/or Education. A planned post-training check-in also enables the instructor to evaluate where the POCUS ‘graduate’ is at in relation to competence and confidence. This awareness is an opportunity to provide further mentoring or continued professional POCUS learning in other areas and speaks strongly to the important fourth level of the NWKM which calls for sustainable training. The researcher advises the intentional design of a post-training mentoring phase within the training plan, of benefit to the ‘graduate’ and a method to evaluate the effectiveness of the training. No matter what format is used for check-in this post-training strategy could promote ‘on the job’ confidence and long-term affective learning, elements to promote standardization and sustainability of POCUS DE learning.

In summary of the discussion above, Table 18 below presents four major design components for DE POCUS instruction, their corresponding NWKM levels, and related hierarchical progressions through the learning domains, as identified in the study. Within this design, five *key* areas are identified as follows:

1. Preparation – ascertaining pre-requisites: Attention to this element informs optimal design of the targeted nature of POCUS training akin to ‘knowing the audience’. Understanding learner needs and expectations enables high degrees of learner reaction to the training, with positive engagement, relevance, and satisfaction (level 1 NWKM). As asserted by Kirkpatrick and Kirkpatrick (2010-2019) learner engagement directly impacts learning success. In addition, this design element ignites progression shifts in all learning domains.
2. Preparation - technology field test: As identified in the study, technical difficulties were experienced by learners and instructors resulting in disruptions of the active learning

process. Despite these difficulties, learners did succeed and were satisfied with their training overall, and instructors rated the technology as effective for teaching. The researcher recommends pre-testing of remote interactive instructional technologies to mitigate problems, in addition to expecting technical issues to emerge during the live instructional component. Proactive measures to attend to DE technical problems during instruction include the ability to call the instructor by phone and in securing back-up technical support, a feature that is often provided with the technology vendor of choice.

3. Delivery – instructor recruitment, remote interactive instruction, attention to learner ergonomics, diversity of ultrasound models, monitoring of progress, and back-up technical support:

    a. Instructor recruitment, remote interactive instruction, attention to learner ergonomics: As cited by learners in the study, instructors played an important role in their one-to-one interactive teaching, a critical instructor presence which positively impacted learner success and satisfaction. The researcher recommends strategic measures in recruiting instructors who are not only competent in POCUS instruction with remote interactive technology, they also demonstrate patience and understanding in the delivery of adult learning. In addition, due to the long-standing occupational hazards of repetitive strain injury in the ultrasound profession (sonography) instructors will need to include attention to a learner's posture and stance to promote safe ergonomic scanning practice (Kayman et al., 1999).

    b. Diversity of ultrasound models: Study participant data indicated a training weakness in the same gender/same person scanning partner expressed by some learners and both instructors. It is recommended that future POCUS learners acquire a minimum of three ultrasound models/SPs for the interactive scanning instruction with variety in body shape and from both genders. This training element is key to the nature of psychomotor skills required in ultrasound scanning - termed “open” as each time a new human model (patient) is scanned the psychomotor tasks will change (Melniker et al., 2006, as cited in Bowra et al., 2015). Scanning the same model for practice is not optimal and model variety will advance cognitive hierarchies from guided response (imitation) to mechanism (basic proficiency) and complex overt response (mastery) more rapidly and will also enable learner confidence and commitment. The above discussion aligns with the second level of the NWKM where active learning occurs.

c. Monitor transfer of learning: Instructor attention to learning progress during instruction is important and witnessed in synchronous delivery. Effective pedagogical monitoring and debriefing skills are related to instructor competence highlighting the importance of successful instructor recruitment and training support as discussed above.

d. Back-up technical support: As previously discussed in training preparation, effective back-up technical support is critical in the real-time live interactive nature of synchronous DE modes, for trainer and trainee, especially if training times are necessarily brief.

4. Evaluation - remediation plan: In the training evaluation phase learning outcomes are validated, and transfer of learning is assessed in behavior change (level 3 NWKM). Within this phase, a remediation plan is a key element to address learner deficiencies. As discussed earlier, learning progress is monitored and deficiencies addressed during

the training (formatively), however deficiencies in outcomes may also occur (summative). The researcher recommends that planned remediation strategies be implemented immediately if possible. If this is not possible due to the nature of POCUS learners who are training 'on the job', it is feasible to provide remediation in the post-training plan with continued mentoring.

5. Continued POCUS mentoring: After training is completed a tele-assisted model is recommended to continue and advance further learning progression. This phase is important in the context of the fourth level of the NWKM where training is considered successful if it is on track and sustained on the job. This phase is critical in the purpose and goals of this study to explore and recommend ways to achieve consistency and standardization in POCUS education. Continued POCUS monitoring/mentoring is a strategy and potential metric to realize these goals and to pivot training strategies if results are poor.

The instructional design components, with expanded discussion on key elements above, offer recommendations for future course design in DE POCUS education based on a delivery model of online theory (asynchronous or synchronous) and remote interactive hands-on ultrasound scanning instruction (synchronous only). The four training phases and respective NWKM levels are summarized in Table 18 below, highlighting their *five key* elements (horizontal arrows) and aspects of potential learner progression through the learning domain taxonomical hierarchies (vertical arrows), positive learning shifts which were reflected in study results.

Table 18

Summary of Training Phases and Key Elements for Recommended Instructional Design of DE for POCUS

Training Phases and Elements for instructional design of DE for POCUS & related NWKM level (key areas circled)	Learning Domains & potential hierarchy within taxonomy
1. **Preparation-** NWKM level 1 – engagement, relevance • Pre-course needs assessment, e.g. survey/pre-requisites • Course description/outline/syllabus; Course length • Selection of learning resources & learning management system • Technology Field Test	Affective - *Responding* Cognitive - *Understanding* Psychomotor - *Set*
2. **Delivery -** NWKM level 2 – transfer of learning • Instructor Recruitment • Remote, real-time interactive instruction • Variety of ultrasound models (minimum 3) • Learner ergonomics • Monitor learning progress, debriefing • Back-up for stable DE connectivity plan • Unexpected findings/Waivers • Mid-Course Survey	Affective - *Valuing* Cognitive - *Analyzing* Psychomotor – *Guided Response & Mechanism*
3. **Evaluation** (NWKM level 3- behaviors & level 1- degree of satisfaction) • Assessment of learning outcomes (short & long term) • Remediation plan (see delivery) • Debriefing • End-Course Survey	Affective - *Valuing* Cognitive - *Evaluating* Psychomotor - *Mechanism*
4. **Post-Training follow-up** (NWKM level 4 – Results for sustainable performance) • Trainee performance 'on the job' • Continuing POCUS monitoring, mentoring and/or education as required	Affective – *Valuing+* Cognitive – *Evaluating+* Psychomotor – *Complex Overt Response+*

In summary of the discussion above, the researcher presents recommendations derived from analysis of study findings, including learner and instructor advice and recommendations in the context of the experiential learning (and teaching) model of the study. Recommendations are outlined in a course sequence: 1) planning, 2) delivery, 3) evaluation, and 4) post-training activities, a framework aligned for potential learning domain progression, with utilization of the NWKM for training evaluation. The researcher asserts that the NWKM framework can optimize learner success and promote standardized POCUS training that is beneficial to the learner and the organization/community of practice that they serve, a primary purpose of the research study.

Summative Study Conclusions

In the next section study conclusions outlined at the beginning of this chapter are revisited in the context of their direct address to the study's research questions.

In response to the primary research question, the researcher concludes that yes, allied health practitioners *can* attain ultrasound imaging skills/competency with a PUD, via DE delivery; further, psychomotor skills are attainable via DE in simulated training conditions. This conclusion is primarily based on the quantitative OSCE data to assess EFAST competencies in simulated EFAST scenarios with standardized patients, where sixteen of twenty learner participants attained an OSCE average score of 70% or higher, the standard entry-level benchmark for accredited allied health programs in Canada.

Within the primary research question, the sub-question explored *how* the cognitive, psychomotor, and affective operator-dependent skills of POCUS with a PUD were taught and learned in a DE format. From qualitative and quantitative data analyses, the researcher concludes that learners acquired the operator-dependent skills of the EFAST protocol via DE due to three key training elements. First and foremost was the interactive remote instructional technology for the scanning labs. This key element enabled real-time interactions between learner and instructor, effectively allowing the instructor to view a learner's hand positions as they manipulated the transducer to create each diagnostic image, like the f2f instructional scanning labs that traditionally occur in sonography education. Similarly, instructors were able to remotely communicate and deliver training due to the live interactive sessions with each learner, scenarios closely resembling their f2f instructional experiences, an example of 'telepresence'. Second, the ease of use and simple design of the PUD contributed to learner success. Third, the efficient multimedia design of the online theory component of training effectively prepared learners for hands-on learning. Transfer of learning, as perceived by learners, observed by instructors, and measured via OSCEs, was progressive through each learning domain, with cognitive and psychomotor shifts advancing quickly with the application of theory to practical scanning, identifying the importance of theory preparation and hands-on learning with instructor presence and guidance.

Study conclusions to address the research questions are aligned with the goals of the researcher's educational institution and the study's case study methodology at the researcher's institution enabled a workplace question to be explored and answered: Can hands-on skills be taught with DE in the ultrasound profession? From study data analysis, the researcher further concludes the following: 1) DE is not only effective for POCUS education; it may be partially amenable to components of comprehensive ultrasound training, that is, a blended model of delivery, and, 2) DE for hands-on ultrasound training is effective for the continuing competency medical education needs of ultrasound practitioners and other healthcare professionals who require continual maintenance of ultrasound skills in their scopes of practice. Upon conclusion of the study the researcher reflects that the case study research method selected for the study met research goals in its ability to focus on a workplace need and arrive at a solution with cohesive engagement of workplace colleagues in collective action to effect change.

Future Research

Study results invite seven areas of further research as follows:

1. As manifested by this study, investigation into why online discussion forums are <u>not</u> necessary to attain learning outcomes and enable learner success.

2. Exploration on the necessity and purpose of online discussion forums for the element of 'social presence', given expectations of a new generation of learners and educators who question the traditional design of online forums. In this endeavor, investigation of new approaches that match learner and course needs is advised.

3. Inquiry if online discussion forums are necessary in the context of training interventions with high degrees of synchronous interactions in place (such as the design of this study).

4. Research on the correlation of learner beliefs to learning outcomes and learner confidence, e.g. mixed methods inquiry with quantitative data, e.g. grades, as well as qualitative data in how well learners *feel* they learned, the latter element related to learner confidence no matter how high the grades are.

5. Investigation on methods to measure progress in the affective learning domain, e.g. from short term 'valuing', to its continued manifestation and evolution in the long term.

6. Inquiry into the correlation of a favorable learner reaction to training and learning outcomes.

7. Further studies to investigate the transferability of POCUS education amongst different professions/professionals who are ultrasound-naive, given a robust sample size of adequate numbers per profession.

Summary

In summary of the final chapter, study conclusions are discussed within the framework of the study's research questions and organized by NWKM levels, followed by recommendations for future instructional DE design of POCUS. A detailed training plan is offered in four phases: preparation, instruction, delivery, evaluation, and post-training follow-up, with each phase aligned to the four levels of the NWKM and potential respective learning domain progressions. Conclusions and recommendations reflect the purpose, rationale, and significance of the study. In addition, areas for future research are also presented in consideration of certain study findings. Overall, the concluding chapter reflects the outcomes and product of the interpretative case study research framed in mixed methods inquiry, to explore the effectiveness of DE in POCUS.

Final Dissertation Summary

The research study responds to the call of the research questions thereby serving the purpose of the study and its significance to contribute to the standardization of POCUS education by distance in healthcare. To reiterate the salient points of the study, a high percentage of ultrasound-naïve participants from eight different allied health professions were successful in attaining competency with a PUD in the EFAST examination, after three hours of asynchronous online theory directly followed by three hours of synchronous remote interactive real-time scanning instruction in simulated EFAST settings. Ultrasound instructors experienced in f2f training models were able to teach hands-on ultrasound imaging skills by distance. Training conditions for learners encompassed a favorable reaction, strong learner perceptions of progression and transfer of learning, and a measured positive change in behaviors reflecting the effectiveness of the training intervention. Both learner and instructor participants contributed to recommendations for future DE in POCUS, recommendations from their authentic experiences in the study. The researcher anticipates that study recommendations will be utilized by the allied health and broader medical community, thereby contributing to standardized and sustainable POCUS DE POCUS with a PUD or with other equitable ultrasound devices appropriate to the space limitations of practice.

Final Dissertation Comments

From a research standpoint, the researcher's experience in this case study research at her workplace will realize benefits in workplace improvements towards the evolution of effective DE for hands-on skills and competency performance, for ultrasound as well as other disciplines in medical and veterinary curricula. The research design of the study brought faculty and staff together in a common project and purpose. The common goal to accelerate DE capacity for hands-on learning at NAIT enabled cohesion of activity towards this purpose.

It is notable that the experience of this interpretive case study research aligns with the researcher's ontological view and epistemological stance. In congruence with the researcher's anti-positivist view, learners and instructors constructed knowledge via the different perceptions and realities from their professional backgrounds, and respective learning and teaching styles, towards a common set of learning outcomes. From the researcher's epistemological position, participants learned 'by doing' in their discovery through experience, with roots of experiential learning now implanted in each learner to promote inner confidence and commitment, which can be applied to additional future learning experiences.

In closing, it has been an honor and a privilege to conduct this study to investigate how one aspect of healthcare can be served through academic research in contribution to the growing field of education by distance, and, in all learning domains. On a personal note, the final chapters of this dissertation were written in the peak time of the COVID-19 global pandemic (2020 in Alberta), and, as an educator, the importance of quality in education by distance became more important than ever.

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Appendix A: Course Design Template

Topic	Purpose	Resources (multimedia)
Preamble	Welcome	• Graphic: Sequence of Participant Activities • Document: Learning Outcomes for Research Study • Document: List of Nomenclature & Acronyms (Glossary) for Research Study • Forum: General News & Announcements
1. Introduction	Introduction to POCUS and Overview of Research Study. Forums for online social presence	• Narrated PowerPoint (15 mins) • YouTube: FAST scan from Ultrasoundpedia • Forum: Q & A for Topic 1
2. EFAST exam	The theory behind the EFAST exam Forums for online social presence	• Narrated PowerPoint (90 mins) • YouTube on FAST (10:09 mins) • YouTube EFAST (20-21 mins) • YouTube EFAST (8:36 mins) • YouTube EFAST with Fluid (11:06) • Forum: Q & A for Topic 2
3. Scanning Labs on EFAST exam	Performing the EFAST exam (applying the theory) with remote instruction Forums for online social presence	• Document: Guidelines to scanning in the POCUS study • PowerPoint: Preparing and Performing the Scan (25 mins) • PowerPoint: EFAST scan images to acquire • Document: OSCE Checklist • Forum: Q & A for Topic 3 • Moodle Schedule: OSCE Rotation Sign Up
	Scanning Labs	• Hands-on scanning instruction in the lab remotely connected to instructor: 3 labs per learner over one calendar week • One pair of learners per instructor • Learners are in pairs and switch roles halfway through the lab time • REACTS® system chosen for remote instruction
Selected Literature Review References to Inform DE Design		
Online social presence	Forums: Importance of Online Social Presence	Akcaoglu & Lee (2016); Brydges, Carnahan, Safir, et al. (2009 and 2015); Kane-Gill et al. (2013); Lee & Huang (2018); Leong et al. (2015); Sandars et al. (2012)
Theory	Importance of Multimedia – Narrated Instructional Video	Bloomfield & Jones (2013); Cooper & Higgins (2015); Grantcharov & Reznick (2008); Hay et al. (2013); Hayden (2013); Jang & Kim (2014); Lee & Shin (2012); McKenny (2011; White (2010

Practical: Instrumentation and Optimization of Imaging including Professional Behaviors	REACTS® system or equivalent with ultrasound equipment and supplies	Amini, Stolz, Javedani et al. (2016; Chenkin et al. (2008); Choo et al. (2017); Kim et al. (2017; Steinmetz et al. (2016); Woodworth et al. (2014)
Communication, Patient Interactions, and Professionalism before, during, after the ultrasound examination	REACTS®* roleplay with Ultrasound Equipment and Supplies. OSCE Rubrics	IFEM (2014) IFEM (2014); Matthews (2011); Sinclair et al. (2016); Steinmetz et al. (2016)
	Narrated Instructional Video of Sonographic Images	McFadden & Crim (2016); Steinmetz et al. (2016)
	Instructor Led	Mai et al. (2013); Montoya et al. (2016); Steinmetz et al. (2016)
Scanning Practice of E-FAST protocol and prep for OSCEs	REACTS®* or equivalent and Ultrasound Equipment and Supplies OSCE Rubrics	Amini, Stolz, Javedani et al. (2016); Mai et al. (2013); Montoya et al. (2016); Castro-Yuste et al. 2018); Steinmetz et al. (2016); Weil et al., 2015
	OSCES	
Objective Structured Clinical Evaluations (OSCEs)	OSCE Scenario on E-FAST Protocol to be performed three (3) separate times and assessed by a different evaluator each time*.	Amini, Stolz, Javedani et al. (2016); Berragan (2013); Burckett-St. Laurent, Cunningham, Abbas, (2016); Castro-Yuste et al. (2018); Chenkin et al. (2008); Kim et al. (2017); Mason Barber & Schuessler (2018); Walsh et al. (2010)

* REACTS® = Remote Education, Augmented Communication, and Training Supervision

Appendix B1: Pre-study Online Questionnaire

Participant Code Number:

1. Which professional group are you from? (select all that apply)
    - *a.* Respiratory Therapy
    - *b.* Primary Care Practitioner (paramedicine)
    - *c.* Advanced Care Practitioner (paramedicine)
    - *d.* Magnetic Resonance Imaging
    - *e.* Medical Radiological Technology
    - *f.* Combined Laboratory and X-Ray Technology
    - *g.* Medical Laboratory Technology
    - *h.* Medical Laboratory Assisting
    - *i.* Other (please specify)

2. Have you had any training or experience with ultrasound scanning? (Yes or No)
3. If yes, please describe the ultrasound scanning experience you had:
4. For each of the following statements please answer Yes or No:
   From the description of the study (Informed Consent Form) I expect to use the learning experience:
    - *a.* In my professional scope of practice (Yes/No)
    - *b.* For general interest (Yes/No)
    - *c.* To gain experience as a research participant (Yes/No)
    - *d.* To understand the effectiveness of hands-on training with Distance Education (Yes/No)
    - *e.* To experience the art and science of sonography (Yes/No)
5. From the description of the study (Informed Consent Form) my overall engagement with the study is (select all that apply):
    - *a.* Excited
    - *b.* Curious
    - *c.* Skeptical
    - *d.* Fearful (nervous)
    - *e.* Neutral
6. For each of the following statements please answer Yes or No:
   At this point of the study I am knowledgeable in the following:
    - *a.* Difference between *Comprehensive* and *Point of Care* ultrasound (Yes/No)
    - *b.* Purpose of *Point of Care* ultrasound (Yes/No)
    - *c.* Applications of *Point of Care* ultrasound (Yes/No)
    - *d.* Recognition of anatomy in cross-sectional format (Yes/No)
    - *e.* Operator-dependent nature of ultrasound scanning (Yes/No)
    - *f.* Ergonomic impacts of ultrasound scanning (Yes/No)
    - *g.* Definition of the *E-FAST** protocol (Yes/No)
    - *h.* What the ultrasound operator is looking for in a *E-FAST** exam (Yes/No)
    - *i.* The professional behaviors required in *Point of Care* ultrasound (Yes/No)
    - *j.* Why standardized patients are used in simulation (Yes/No)
    - *k.* What an *Objective Structured Competency Examination* is (Yes/No)
    - *l.* How Distance Education can work to learn hands-on skills (Yes/No)

   **Extended Focused Assessment with Sonography in Trauma*

7. Do you believe that hands-on training (psychomotor skills) can be taught entirely via Distance Education? (If No or Neutral please explain in final question/comment section)
    - Yes
    - No
    - Neutral
8. Do you believe that attitudes and professional behaviors (affective skills) can be taught entirely via Distance Education?
   (If No or Neutral please explain in final question/comment section)
    - Yes
    - No
    - Neutral
9. Do you have any concerns, questions, or comments?

Appendix B2: Mid-study Online Questionnaire

Participant Code Number:

1. Which allied health professional group are you from?

2. On a scale of 1 to 5 with **1= strongly disagree** and **5= strongly agree** how would you rate the following statements regarding your distance education learning experience?

a. The multimedia tools (PowerPoints and YouTube videos) on the Moodle course site enabled me to learn the theory of ultrasound principles.

b. I was able to learn ultrasound hands-on skills in the labs with remote instruction.

c. Any technical factors on Moodle did not cause a barrier to my learning.

d. Andy technical factors with the REACTS platform did not cause a barrier to my learning.

e. Interacting with my fellow participants on Moodle forums helped me to learn the course material.

f. Interacting with my instructors on Moodle forums helped me to learn the course material.

g. Participating on the Moodle forums made me feel a part of a class or cohort.

3. Did the theory part of the Moodle instruction prepare you for the hands-on scanning labs? If yes or no, please expand upon your answer:

4. Do you feel prepared for the upcoming OSCEs? If yes, why? If no, why not?

5. What stands out for you with online Moodle and remote-guidance training experience?

6. Would you recommend REACTS and distance education methods for learning pocket ultrasound devices? If yes, why? If not, why not?

7. What is your advice for future distance educational instructional design for remote skill acquisition?

8. Any Surprises?

9. Any other comments?

Appendix B3: End-study Online Questionnaire

Participant Code Number:

1. Which professional group are you from? (select all that apply)
    - *a.* Respiratory Therapy
    - *b.* Primary Care Practitioner (paramedicine)
    - *c.* Advanced Care Practitioner (paramedicine)
    - *d.* Magnetic Resonance Imaging
    - *e.* Medical Radiological Technology
    - *f.* Combined Laboratory and X-Ray Technology
    - *g.* Medical Laboratory Technology
    - *h.* Medical Laboratory Assisting
    - *i.* Other (please specify)

2. For each of the following statements please answer Yes or No:
   Now that you have completed the research study do you expect to use the learning experience:
    - *a.* In your professional scope of practice (Yes or No)
    - *b.* For general interest (Yes or No)
    - *c.* To continue volunteering as a research participant (Yes or No)
    - *d.* To recommend Distance Education to learn *E-FAST** protocol (Yes or No)
    - *e.* To recommend Distance Education to learn *Point of Care* ultrasound (Yes or No)
    - *f.* To recommend Distance Education to learn *Comprehensive* ultrasound (Yes or No)
    - *g.* To further your education in *Point of Care* ultrasound applications (Yes or No)
    - *h.* To further your education in an ultrasound career (Yes or No)

   **Extended Focused Assessment with Sonography in Trauma*

3. Now that you've completed the course (modules 1-4) how would you describe your overall satisfaction in the instructional phase of the study? Likert Scale 1 -5

4. Now that you've completed the Objective Structured Competency Examinations (OSCEs) of module 5 how would you describe your overall satisfaction in the OSCE phase of the study? (Likert Scale 1-5)

5. For each of the following statements please answer Yes or No:
   At this endpoint of the study I am knowledgeable in the following:
    - *a.* Difference between *Comprehensive* and *Point of Care* ultrasound (Yes or No)
    - *b.* Purpose of *Point of Care* ultrasound (Yes or No)
    - *c.* Applications of *Point of Care* ultrasound (Yes or No)
    - *d.* Recognition of anatomy in cross-sectional format (Yes or No)
    - *e.* Operator-dependent nature of ultrasound scanning (Yes or No)
    - *f.* Ergonomic impacts of ultrasound scanning (Yes or No)
    - *g.* Definition of the *FAST** protocol (Yes or No)
    - *h.* What the ultrasound operator is looking for in a *FAST** exam (Yes or No)
    - *i.* The professional behaviors required in *Point of Care* ultrasound (Yes or No)
    - *j.* Why standardized patients are used in simulation (Yes or No)
    - *k.* How to scan/perform a *FAST** exam (Yes or No)

l. How to recognize sonographic artifacts (Yes or No)
m. Demonstrating required professional behaviors in a *FAST** exam (Yes or No)
n. How Distance Education can work to learn ultrasound skills (Yes or No)

**Focused Assessment with Sonography in Trauma*

6. Do you believe that hands-on training (psychomotor skills) can be taught entirely via Distance Education? (If No or Neutral please explain in final question/comment section)
    - Yes
    - No
    - Neutral

7. Do you believe that attitudes and professional behaviors (affective skills) can be taught entirely via Distance Education? (If No or Neutral please explain in final question/comment section).
    a. Yes
    b. No
    c. Neutral
8. Overall, my expectations from this research study were: (please explain your choice in final question/comment section).
    a. Met
    b. Not met
    c. Partially met

9. Do you have any concerns, questions, or comments?

Appendix C: Instructor Field Notes - with Guidelines

Instructor Participant Code [ ]

Purpose of the Field Notes:

The purpose of these field notes is to record your instructor experiences in this study to teach ultrasound by distance education methods, and, to glean future recommendations for teaching ultrasound scanning by distance.

Instructions:

1. For each section record your impressions and insights as per the embedded guidelines.
2. You can quote or paraphrase participant questions or comments **anonymously.**
3. Regular check-ins with the PI are encouraged and important with urgent matters. Do not reveal the identity of any participants when speaking to the PI.
4. At the end of the study submit your completed electronic template to Ruvimbo who will witness your validation by her signature and will immediately store your file anonymously (as per participant code) on a password-protected and encrypted external device for later analysis by the PI.

Section I – Impressions and insights after Topic 1

1. Effectiveness of Moodle course activities and resources.
2. Technical factors with Moodle as a teaching tool.
3. Transfer of knowledge, skills, and professional behaviors in general.
4. Transfer of knowledge, skills, and professional behaviors for each professional group. Any differences and similarities amongst the different professions?
5. Interactions with participants via the Moodle Forums (via Forum posts).
6. Fostering a community of learning amongst the participants connected by Moodle.
7. Significant questions or comments (based on Forum posts).
8. Other?

Section II – Impressions and insights after Topic 2

9. Effectiveness of Moodle course activities and resources.
10. Technical factors with Moodle as a teaching tool.
11. Transfer of knowledge, skills, and professional behaviors in general.
12. Transfer of knowledge, skills, and professional behaviors for each professional group.
13. Any differences and similarities amongst the different professions?
14. Interactions with participants via the Moodle Forums (via Forum posts).
15. Fostering a community of learning amongst the participants connected by Moodle.
16. Significant questions or comments (based on Forum posts).
17. Other?

Section III – Impressions and insights after Topic 3

18. Effectiveness of REACTS platform for teaching ultrasound scanning.
19. Technical factors with REACTS as a teaching tool.
20. Transfer of knowledge, skills, and professional behaviors in general using REACTS to teach scanning.
21. Transfer of knowledge, skills, and professional behaviors with REACTS to teach scanning to each professional group. Any differences and similarities amongst the different professions?
22. Interactions with participants via REACTS.

23. Interactions with participants via Topic 3 Moodle Forum posts.
24. Significant questions or comments during Labs and/or Topic 3 Moodle Forum posts
25. Other?

Section IV - Overall Impressions

26. As a distance educator instructor, using online Moodle activities and REACTS methods, what worked for you and what did not work?

Section V - Recommendations

27. What recommendations do you have for further distance education instructional design of Point of Care Ultrasound using a pocket ultrasound?

Research Assistant Validation of Summative Field Notes Submission to PI:

I ______ (research instructor) verify that the following summary field notes are:

- Complete.
- Compiled by myself, and that
- Field Note Guidelines were followed.

(Signature) ______ (Date) ______

Appendix D: Data Collection and Analysis Framework

Research Questions

The primary research question reads:

Can allied health practitioners attain ultrasound imaging skills/competency with a Pocket Ultrasound Device (PUD) in a distance education (DE) learning environment?

One sub-question arises in relation to the primary question:

How can the cognitive, psychomotor, and affective operator-dependent skills of POCUS with a PUD be taught and learned in a DE format?

Data Analysis Framework

The following table represents the study's framework to evaluate the study's course (training) to address the research questions.

The evaluation framework utilizes the New World Kirkpatrick Model Levels; Level Four (Results) has been adapted for the study.

Narrative analyses were co-coded for data analysis – See Appendix L for co-coding guidelines.

References:

Anderson, L.W., Krathwohl, D.R. & Bloom, B.S. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives* (Complete ed.). Longman

Kirkpatrick, J., & Kirkpatrick, W. (2010-2019). An Introduction to the New World Kirkpatrick Model. Kirkpatrick Partners, LLC, Newman: GA

Kirkpatrick, J.D., & Kirkpatrick, W.K. (2016). *Kirkpatrick's Four Levels of Training Evaluation.* Association for Talent Development: Alexandria, VA

Simpson, E. J., & Illinois Univ., (1966). *The Classification of Educational Objectives in the Psychomotor Domain.* https://eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED010368

Wilson, L.Q. (2020). *The Three domains of learning: Cognitive, Affective, and Psychomotor/Kinesthetic.* The Second Principle. http://thesecondprinciple.com/instructional-design/threedomainsoflearning/

Data Analysis Methodology Evaluation Framework:

Data Collected to Analyze: Three Learner Questionnaires (pre-mid & end study), Learner OSCE Results, and Two Instructor Field Notes

New World Kirkpatrick Model (NWKM) Level	Relevance to Study	What is Researcher Measuring/Analyzing? and <u>Data Collection Tools</u>	Rationale	Related Research Question(s)	Data Analysis Approach (Appendix L)	Data Analysis Tool(s)	Data Sources: App = Appendix
1. REACTION	Learner reaction to the theory and practical components of the training (pre to end study)	Degree of Learner: Engagement, Relevance, and Satisfaction Was there any progression within the learning domains? <u>Data Collection Tools</u> Online Questionnaires	Learner expectations, whether training is meaningful or not, and degree of satisfaction will have impact on training effectiveness, behavior change, and results	<u>Sub-Question</u> Reaction will influence *how well* cognitive, psychomotor, and affective skills were attained, or if they were not	Comparison of data, pre to end study Narrative Analysis for coding of Learning Domains & hierarchies within	*Qualtrics* & *Excel* (record of individual responses; data entered by research assistant)	App: M1- M6 Figures 7 to 11 Tables 1-3
2. LEARNING	Transfer of learning: the degree to which participants acquired the intended EFAST learning outcomes, including their levels of confidence and commitment	Which knowledge areas were transferred (acquired)? Which learning outcomes were attained? Was theory applied to practical training in the scanning labs? Was there any progression within the learning domains? Was learner feedback on training aligned to instructor feedback? How did learner beliefs in DE for hands-on skills impact their learning? <u>Data Collection Tools</u> Online Questionnaires and Electronic Instructor Field Notes	Learner and Instructor data provide insights to which elements of training were effective and which created barriers to learning. Data include learners' evaluations of their training and instructor reflections of their teaching experiences. Above data to inform future instructional design of POCUS by DE (related to NWKM level 4)	<u>Sub-Question</u> Analysis of which areas of learning were transferred and which were not indicates *if and how* cognitive, psychomotor, and affective learning domains were active.	Comparison of data, pre to end study Narrative Analysis for coding of Learning Domains & hierarchies within Comparison of instructor feedback with learner feedback	*Qualtrics* & *Excel* (record of individual responses; data entered by research assistant)	App: M1-M6 O1– O3, Q, R, S, V1-13 Figures 12-17 Tables 1-5
3. BEHAVIOR	Learner's ability to apply training "on the job" – in the context of this study "on the job" is the OSCE	Was there a behavior change as a result of the training? Did the OSCE scores demonstrate that learners were able to perform an EFAST scan in simulated 'on the job' scenarios? <u>Data Collection Tools</u>	Learner OSCE performance validates whether the training was effective or not overall. OSCE data also provide insight where training elements are strong and weak to inform future instructional	<u>Primary Question</u> Were ultrasound-naïve allied health practitioners able to attain the required competencies to perform an	Review of the average score of 3 OSCEs per learner and a review of which competencies were attained or not over 3 separate OSCEs	*Excel* record of OSCE scores as entered by research assistant from submitted Assessor grading	App: N1 & N2, T1-T7, U1 & U2 Figures 18-24 Tables 6-9; 16 & 17

New World Kirkpatrick Model (NWKM) Level	Relevance to Study	What is Researcher Measuring/Analyzing? and Data Collection Tools	Rationale	Related Research Question(s)	Data Analysis Approach (Appendix L)	Data Analysis Tool(s)	Data Sources: App = Appendix
		OSCE scores (paper-based)	design	EFAST examination with a PUD after training in via 100% DE?		rubrics	
4. RESULTS	The degree to which targeted outcomes occur as a result of the training	What can be learned about the training from the experiences of the learners and instructors? What are the strengths and weaknesses of the training? What feedback and advice to learners and instructors have? Data Collection Tools Online Questionnaires and Electronic Instructor Field Notes OSCE score pass rates OSCE competency performance	How can data inform the future instructional design of POCUS by DE? What are the recommendations of the learners and instructors to support and reinforce 'targeted outcomes' i.e. instructional design for future workplace POCUS training?	All Questions For future researchers and future instructional designers: How study results answered the questions	Insights from learner and instructor experiences and their recommendations for future training Insights on which competencies were more easily attained than others	*Qualtrics* & *Excel* (record of individual responses; data entered by research assistant)	App: O1-O3; V2-13 Tables 10-15; 17 & 18 Figure 25

Appendix E: Pre-study Field Test Revisions to OSCE Grading Rubric for Assessment

Changes made pre-study field test

Learner Participant Code: [ ]

E-FAST EXAMINATION			
Competency area	Check if complete ✓	Competency performance	Points
Professional Behaviors (3)		Introduces self & explains role to patient	1
		Explains procedure to patient	1
		Obtains pertinent clinical history (if possible) REMOVED FOR STUDY – deemed not necessary; based on rationale that all ultrasound models would have a common history of trauma therefore requiring an E-FAST examination to be ordered.	1
		Prepares patient while protecting their modesty	1
Patient Interactions - throughout examination (1)		Responds to patient verbal and non-verbal questions/behaviors with respect	1
		Adapts to patient's medical needs with appropriate care REMOVED FOR STUDY – not feasible in controlled lab setting and group decision that competency of patient interactions could be tested with other question in this section where each ultrasound model would be scripted with a comment or question to pose to the learner.	1
Ergonomics (2)		Maintains ergonomic body posture for scanning tasks	1
		Holds transducer and scanning arm ergonomically	1
Exam Preparation (2)		Identifies correct pre-set for examination REMOVED as there is only one pre-set to consider with the transducer used in the study	1
RENAMED Instrumentation		Identifies appropriate transducer to be used REMOVED – see comment above	1
		Utilizes appropriate depth setting for optimal visualization REWORDED Uses DEPTH setting appropriately	1
		Applies appropriate amount of gel REMOVED – deemed not necessary in short time frame of	1

	protocol	
	Positions patient correctly for E-FAST protocol REMOVED – deemed not necessary in context of ultrasound models without pathology or trauma	1
	ADDED Uses GAIN correctly	1
E-FAST Protocol (21)		
7. Lungs	Obtains right and left parasternal views of lungs at mid-sternum REPLACED WITH sagittal apical views of lungs	1
	Freezes image (of right or left side) and points to area of “sliding” REPLACED WITH On live Image Point to areas of “sliding” (right and left)	1
	On frozen image – explain what would be seen with chest trauma to lungs REPLACED WITH On M-Mode image demonstrate areas of “sliding” (right AND/OR left)	1
	ADDED: On frozen or live image identify shadowing artifact on the image	
	ADDED: On frozen or live image identify reverberation artifact on the image	
	ADDED: On frozen or live image answer How would you identify a pneumothorax?	
6. Heart	Obtains sub-xiphoid 4-chamber view REPLACED WITH view of heart to see pericardial echo	1
	Freezes image and points to location where pericardial fluid would be REMOVED	1
	On frozen image - correctly points to pericardium REPLACED WITH Point to area where pericardial would be	1
1. Right Liver/Lung	Obtains parasagittal or coronal view	1
	Freezes image and points to location where pleural fluid would be REMOVED	1
	On frozen image – correctly points to diaphragm REPLACED WITH Point to location where pleural fluid would be	1
2. Right Liver/Kidney	Obtains parasagittal or coronal view	1
	Freezes image and points to location of Morrison’s pouch where fluid could be REMOVED	1
	On frozen image – Point to Morrison’s pouch where fluid would be	1
3. Left Spleen/Lung	Obtains parasagittal or coronal view	1
	Freezes image and points to location where pleural fluid would be REMOVED	1
	On frozen image – correctly points to diaphragm REPLACED WITH Point where pleural fluid would be	1

4. Left Spleen/Kidney	Obtains parasagittal or coronal view	1
	Freezes image and points to location where intraperitoneal fluid may be REMOVED	1
	On frozen image – correctly points to spleen/kidney interface REPLACED WITH Point to splenic/kidney space where intraperitoneal fluid would be	1
5. Pelvis	Obtains midline sagittal view	1
	Freezes image and points to location where intraperitoneal fluid would be REMOVED	1
	On frozen image – correctly points to urinary bladder and pouch of Douglas REPLACED WITH Point to space where intraperitoneal fluid would be	1
Exam Closure (2)	Wipes gel off patient with care	1
	Cleans and secures transducer REMOVED – deemed not necessary in this study	1
	Dismisses patient with instructions on next steps (if applicable) REMOVED – deemed not necessary as ultrasound models acting as “patients” not being discharged in this study protocol	1
Imaging Techniques (0) REMOVED - with elements integrated in previous sections	Selects appropriate scanning depth for body part – MOVED TO Instrumentation	1
	Identifies reverberation artifact on one image – MOVED to Lungs section	1
	Identifies shadowing on one image – MOVED to Lungs section	1
TOTAL POINTS		/34

Assessor Participant Code: [ ]
Date: [ ]

Appendix F1: OSCE Evaluation Grading Rubric for EFAST (revised post-field test)

Learner Participant Code: ______ (participant to write code here BEFORE OSCE starts)

Maximum of 15 minutes with a 3-minute alert before time is up

Competency area	Competency performance	Check if Completed ✓
Professional Behaviors	Introduces self & explains role to patient RECORD ANSWER	
	Explains procedure to patient RECORD ANSWER	
	Prepares patient while protecting their modesty	
	Applies appropriate amount of gel	
Patient Interactions - throughout examination	Responds to patient verbal and non-verbal questions/behaviors with respect RECORD ANSWER	
Ergonomics	Maintains ergonomic body posture for scanning tasks	
	Holds transducer and scanning arm ergonomically	
Instrumentation	Uses DEPTH setting correctly	
	Uses GAIN correctly	
E-FAST Protocol		
Right Liver/Lung	Obtains parasagittal or coronal view	
	Freezes image	
	ON FROZEN IMAGE ASK PARTICIPANT: Point to location where pleural fluid would be RECORD ANSWER: SAY “THANK YOU, PLEASE MOVE ON”	

Right Liver/Kidney	Obtains parasagittal or coronal view Freezes image ON FROZEN IMAGE ASK PARTICIPANT Point to Morrison's pouch where fluid would be RECORD ANSWER: SAY "THANK YOU, PLEASE MOVE ON"
Left Spleen/Lung	Obtains parasagittal or coronal view Freezes image ON FROZEN IMAGE ASK PARTICIPANT Point where pleural fluid would be RECORD ANSWER; SAY "THANK YOU, PLEASE MOVE ON"
Left Spleen/Kidney	Obtains parasagittal or coronal view Freezes image ON FROZEN IMAGE: ASK PARTICIPANT Point to splenic/kidney space where fluid would be RECORD ANSWER: SAY "THANK YOU, PLEASE MOVE ON"
Pelvis	Obtains midline sagittal view Freezes image ON FROZEN IMAGE: ASK PARTICIPANT Point to space where intraperitoneal fluid would be RECORD ANSWER: SAY "THANK YOU, MOVE ON PLEASE"
Heart	Obtains sub-xiphoid view of heart to see pericardial echo Freezes image
Heart continued	ON FROZEN IMAGE ASK PARTICIPANT Point to area where pericardial fluid would be RECORD ANSWER; SAY "THANK YOU,

	MOVE ON PLEASE”
Lungs	Obtains right and left sagittal apical views of lungs ON LIVE IMAGE ASK PARTICIPANT Point to areas of “sliding” (right and left) RECORD ANSWER; SAY “THANK YOU, MOVE ON PLEASE” ON M-MODE IMAGE ASK PARTICIPANT to demonstrate areas of “sliding” (right AND/OR left) RECORD ANSWER: SAY “THANK YOU, MOVE ON PLEASE” ON FROZEN OR LIVE IMAGE ASK PARTICIPANT to identify shadowing artifact on the image RECORD ANSW; SAY “THANK YOU, MOVE ON PLEASE”ER ON FROZEN OR LIVE IMAGE ASK PARTICIPANT to identify reverberation artifact on the image RECORD ANSWER: SAY “THANK YOU, MOVE ON PLEASE” ON FROZEN OR LIVE IMAGE ASK PARTICIPANT How would you identify a pneumothorax? RECORD ANSWER: SAY “THANK YOU, MOVE ON PLEASE”
Exam Closure	Wipes gel off patient with care Cleans transducer

Assessor Participant Code:

Date: June 2019

Appendix F2: Learning Outcomes for EFAST and Checklist

Title of Project: Point of Care Ultrasound: Distance Education for the use of Pocket Ultrasound Devices

Principal Investigator (Researcher): Denise MacIver
Supervisor: Dr. Susan Bainbridge

Learning Outcomes: At the end of the course (prior to the OSCEs) the participant will be able to:

1. Operate the basic instrumentation controls of a Pocket Ultrasound Device.
2. Acquire the images (views) as per the E-FAST Protocol with diagnostic quality.
3. Identify and explain the sonographic anatomy and landmarks for each view.
4. Identify and explain where free fluid (signs of trauma) would be found on each image/view.
5. Identify sonographic artifacts for each view, if applicable.
6. Demonstrate professional behaviors and respectful patient interactions throughout the exam.
7. Demonstrate proper ergonomics while scanning.

Standard Ultrasound Routine for E-FAST Protocol	✓
Professional Behaviors	
Introduces self and explains role to patient	
Explains procedure to patient	
Obtains pertinent clinical history (if possible)	
Prepares patient while respecting their modesty	
Patient Interactions	
Responds to patient verbal and non-verbal questions/behaviors with respect	
Adapts to patient's medical needs with appropriate care	
Ergonomics	
Maintains ergonomic body posture for scanning tasks	
Holds transducer and scanning arm ergonomically	
Exam Preparation	
Identifies correct pre-set	
Selects/Identifies appropriate transducer	
Uses appropriate depth setting(s)	
Applies appropriate amount of gel	
Positions patient correctly for E-FAST protocol	
Scanning Skills & Image Acquisition for E-FAST Protocol	
Lungs – parasternal – right and left mid-sternum	
Heart – Standard sub-xiphoid coronal view of 4-chamber heart and pericardium	
Thorax & Right Upper Quadrant Abdomen– Standard sagittal liver/lung	
Right Upper Quadrant Abdomen - Standard sagittal liver/right kidney	
Thorax & Left Upper Quadrant Abdomen – Standard sagittal spleen/lung interface	
Left Upper Quadrant Abdomen – Standard sagittal spleen/left kidney interface	
Pelvis – Standard sagittal view of midline pelvis	

Appendix G1: Recruitment E-mail for Learner Participants

Invitation to participate for learners
The following e-mail will be sent to staff and faculty of the NAIT School of Health and Life Sciences (SHLS)

Subject title: Invitation to participate in school-based research project
Sent by Ruvimbo Sakutukwa on behalf of Denise MacIver

Dear SHLS Staff:

As part of my doctoral dissertation with Athabasca University (Doctorate in Distance Education) I have received NAIT and AU Research Ethics Board approvals to proceed with my research project. The kind of research is *Action Research [Case Study]* to be conducted at my place of employment.

You are invited to participate in this research study to explore if and how ultrasound imaging competency can be learned remotely and attained with distance education, using a pocket ultrasound device. The project title is: *Point of Care Ultrasound (PoCUS): Distance Education for the use of Pocket Ultrasound Devices*

The primary purpose of the study is to potentially contribute to the standardization and consistency of training in point of care ultrasound using remote training methods, e.g. distance education, to:

1. meet a global need in general, and,
2. meet a current gap of training for the allied health sector,
3. meet a current gap for distance education methods for training
4. gain insights into the training needs of the different allied health professions, and
5. provide recommendations towards effective distance education techniques in PoCUS.

There are 3 criteria for eligibility in the study:

6. possess knowledge of human anatomy of the chest, heart, abdomen and pelvis,
7. have current or past experiences with patient interactions in a healthcare setting, and
8. have had NO prior training in hands-on ultrasound scanning (need to be “ultrasound naïve”).

Participants will receive ultrasound training in point-of-care ultrasound (PoCUS) and will focus on targeted views of the human body using a pocket ultrasound device (PUD). The PoCUS protocol selected is the Extended Focused Assessment with Sonography in Trauma (E-FAST) examination which scans the thorax, heart, abdomen, and pelvis for signs of trauma.

The estimated time of commitment to be a participant in the study is 8-9 hours, spread over 4-5 calendar weeks with an estimate start time in mid-May of 2019. All data will be anonymized with each participant receiving a study code.

Should you be interested it is very important for you to know that I do not need to know who the participants are unless you wish to disclose this. One of the research assistants, Ruvimbo Sakutukwa, will handle all correspondence and interactions with the participants and I will be completely “hands-off” from the beginning of participant recruitment (this e-mail) to the end of the study.

The attached *Letter of Information/Informed Consent Form* provides many details of the study, sequence of steps, how privacy and confidentiality will be maintained, the risks and benefits, etc.

If you are interested in participating, please follow the instructions on the Informed Consent form on the last page of the attached. Please know that you can ask myself or Ruvimbo as many questions as you need to so you can make a fully informed and voluntary consent. The deadline to apply for consideration and send your Consent Form for the study is____ ______________, 2019.

Sincerely,
Denise MacIver
Doctoral Candidate
Athabasca University

Appendix G2: Recruitment E-mail for Instructor Participants

Invitation to participate for instructors
The following e-mail will be sent to the faculty of the NAIT Diagnostic Medical Sonography (DMS) Program

Subject title: Invitation to participate in school-based research project
Sent by Ruvimbo Sakutukwa on behalf of Denise MacIver

Dear DMS Faculty Members:

As part of my doctoral dissertation with Athabasca University (Doctorate in Distance Education) I have received NAIT and AU Research Ethics Board approvals to proceed with my research project. The kind of research is *Action Research [Case Study]* to be conducted at my place of employment.

You are invited to participate in this research study to explore if and how ultrasound imaging competency can be learned remotely and attained with distance education, using a pocket ultrasound device. The project title is: *Point of Care Ultrasound (PoCUS): Distance Education for the use of Pocket Ultrasound Devices*

The primary purpose of the study is to potentially contribute to the standardization and consistency of training in point of care ultrasound using remote training methods, e.g. distance education, to:

1. meet a global need in general, and,
2. meet a current gap of training for the allied health sector,
3. meet a current gap for distance education methods for training
4. gain insights into the training needs of the different allied health professions, and
5. provide recommendations towards effective distance education techniques in PoCUS.

There are selected criteria for eligibility as an instructor in the study:

1. possess instructional knowledge in teaching point of care ultrasound and the Extended Focused Assessment with Sonography in Trauma (EFAST) protocol - theory and practical labs,
2. credentialed in generalist and cardiac sonography,
3. experienced in delivering instruction on Moodle, and
4. willing to learn remote live interactive technology to deliver hands-on scanning labs to learners.

During your teaching time you will be asked to maintain "field notes" on your teaching experiences in teaching ultrasound with distance education methods and technology. Your participant data will be anonymized with each instructor participant receiving a study code.

The learner participants will receive ultrasound training in point-of-care ultrasound (PoCUS) and will focus on targeted views of the human body using a pocket ultrasound device (PUD). The PoCUS protocol selected is the Extended Focused Assessment with Sonography in Trauma (E-FAST) examination which scans the thorax, heart, abdomen, and pelvis for signs of trauma. After their theory and hands-on lab instruction with you, assessors will evaluate their training in three consecutive face-to-face evaluations using the objective structured competency evaluation (OSCE) method.

The estimated time of commitment to be an instructor in the study is 10-16 hours, spread over 4-5 calendar weeks with an anticipated start time in mid-May of 2019.

The attached *Letter of Information/Informed Consent Form for Instructors* provides many details of the study, sequence of steps, how privacy and confidentiality will be maintained, the risks and benefits, etc.

If you are interested in participating, please follow the instructions on the Informed Consent form on the last page of the attached. Please know that you can ask myself or Ruvimbo as many questions as you need to so you can make a fully informed and voluntary consent. The deadline to apply for consideration and send your Consent Form for the study is____ ______________, 2019.

Sincerely,
Denise MacIver
Doctoral Candidate
Athabasca University

Appendix G3: Recruitment E-mail for Assessor Participants

Invitation to participate for assessors
The following e-mail will be sent to faculty of the NAIT Diagnostic Medical Sonography (DMS) Program

Subject Title: Invitation to participate in school-based research project
Sent by Ruvimbo Sakutukwa on behalf of Denise MacIver

Dear Diagnostic Medical Sonography Faculty Members:

As part of my doctoral dissertation with Athabasca University (Doctorate in Distance Education) I have received NAIT and AU Research Ethics Board approvals to proceed with my research project. The kind of research is *Action Research [Case Study]* to be conducted at my place of employment.

You are invited to participate in this research study to explore if and how ultrasound imaging competency can be learned remotely and attained with distance education, using a pocket ultrasound device. The project title is: *Point of Care Ultrasound (PoCUS): Distance Education for the use of Pocket Ultrasound Devices*

The primary purpose of the study is to potentially contribute to the standardization and consistency of training in point of care ultrasound using remote training methods, e.g. distance education, to:

1. meet a global need in general, and,
2. meet a current gap of training for the allied health sector,
3. meet a current gap for distance education methods for training
4. gain insights into the training needs of the different allied health professions, and
5. provide recommendations towards effective distance education techniques in PoCUS.

There are selected criteria for eligibility as an assessor in the study:

6. credentialed in generalist and cardiac sonography, and
7. experienced in evaluating a learner's ultrasound scanning skills in a simulated ultrasound examination with live models.

During the assessment period of the study you will be asked to grade the performance of each learner participant using a hard-copy checklist grading tool. Live models will be recruited for the evaluations and each model will have learned a short script for their scenario. No names will appear on the hardcopy checklist grading tool.

For your information: The learner participants will receive ultrasound training from two ultrasound instructors. The learning content will consist of point-of-care ultrasound (PoCUS) and will focus on targeted views of the human body using a pocket ultrasound device (PUD). The PoCUS protocol selected is the Extended Focused Assessment with Sonography in Trauma (E-FAST) examination which scans the thorax, heart, abdomen, and pelvis for signs of trauma. After their theory and hands-on lab instruction, you will assess their training in three consecutive face-to-face evaluations using the objective structured competency evaluation (OSCE) method. You will be assigned one OSCE station and the learner participants will rotate through your station in 15-minute intervals.

The estimated time of commitment to be an instructor in the study is 8-12 hours of your time overall, the majority anticipated over 2-3 calendar days in June 2019.

The attached *Letter of Information/Informed Consent Form for Assessors* provides many details of the study, sequence of steps, how privacy and confidentiality will be maintained, the risks and benefits, etc.

If you are interested in participating, please follow the instructions on the Informed Consent form on the last page of the attached. Please know that you can ask myself or Ruvimbo as many questions as you need to so you can make a fully informed and voluntary consent. The deadline to apply for consideration and send your Consent Form for the study is____ ______________, 2019.

Sincerely,
Denise MacIver
Doctoral Candidate
Athabasca University

Appendix G4: Recruitment E-mail for Ultrasound Models

Invitation to participate for ultrasound models
The following e-mail will be sent to the pool of ultrasound models

Subject title: invitation to participate in school-based research project
Sent by Ruvimbo Sakutukwa on behalf of Denise MacIver

Dear All:

As part of my doctoral dissertation with Athabasca University (Doctorate in Distance Education) I have received NAIT and AU Research Ethics Board approvals to proceed with my research project. The kind of research is *Action Research [Case Study]* to be conducted at my place of employment.

You are invited to participate in this research study to explore if and how ultrasound imaging competency can be learned remotely and attained with distance education, using a pocket ultrasound device. The project title is: *Point of Care Ultrasound (PoCUS): Distance Education for the use of Pocket Ultrasound Devices.*

Purpose of the Study:
The primary purpose of the study is to potentially contribute to the standardization and consistency of training in point of care ultrasound using remote training methods, e.g. distance education, to:

1. meet a global need in general, and,
2. meet a current gap of training for the allied health sector,
3. meet a current gap for distance education methods for training
4. gain insights into the training needs of the different allied health professions, and
5. provide recommendations towards effective distance education techniques in PoCUS.
6. You are invited to participate as an ultrasound model to simulate an ultrasound examination.

The role of the ultrasound model in the study:

Background information: The learner participants will receive ultrasound training from ultrasound instructors. The learning content will consist of point-of-care ultrasound (PoCUS) and will focus on targeted views of the human body using a pocket ultrasound device (PUD). The PoCUS protocol selected is the Extended Focused Assessment with Sonography in Trauma (E-FAST) examination which scans the thorax, heart, abdomen, and pelvis for signs of trauma. After their theory and hands-on lab instruction, assessors will evaluate each learner in three consecutive face-to-face scenarios using the objective structured competency evaluation (OSCE) method with the learners scanning an ultrasound model for each scenario. Learners will rotate through each OSCE station while the assessor is in the room evaluating their performance; the learner participants will rotate through each scenario in 15-minute intervals.

The estimated time of commitment to be an ultrasound model in the study is 8-12 hours of your time anticipated over 2-3 calendar days in June 2019.

The attached *Letter of Information/Informed Consent Form for Ultrasound Models* provides many details of the study, sequence of steps, how privacy and confidentiality will be maintained, the risks and benefits, etc.

If you are interested in participating, please follow the instructions on the Informed Consent form on the last page of the attached. Please know that you can ask myself or Ruvimbo as many questions as you need to so you can make a fully informed and voluntary consent. The deadline to apply for consideration and send your Consent Form for the study is____ ______________, 2019.

Sincerely,
Denise MacIver
Doctoral Candidate
Athabasca University

Appendix G5: Letter of Information/Informed Consent for Learners

Date:

Principal Investigator (Researcher): Denise MacIver **Supervisor:** Dr. Susan Bainbridge

You are invited to take part in a research project entitled *Point of Care Ultrasound: Distance Education for the use of Pocket Ultrasound Devices.*

This form is part of the process of informed consent. The information presented should give you the basic idea of what this research is about and what your participation will involve, should you choose to participate. It also describes your right to withdraw from the project. In order to decide whether you wish to participate in this research project, you should understand enough about its risks, benefits and what is required of you to be able to make an informed decision. This is the informed consent process. Take time to read this carefully as it is important that you understand the information given to you. Please contact the principal investigator, *Denise MacIver,* if you have any questions about the project or would like more information before you consent to participate.

It is entirely up to you whether or not you take part in this research. If you choose not to take part, or if you decide to withdraw from the research once it has started, there will be no negative consequences for you now, or in the future.

Introduction
My name is Denise MacIver and I am a doctoral student at Athabasca University. As a requirement to complete my degree, I am conducting a research project about the effectiveness of teaching ultrasound scanning skills to allied health professionals entirely by using distance education methods and technology. I am conducting this project under the supervision of Dr. Susan Bainbridge.

Why are you being asked to take part in this research project?
You are being invited to participate in this project because you may meet the learner participant criteria as a member of an allied health profession with knowledge of anatomy and physiology, with experience with patient interactions in the healthcare field, and, someone who has not yet been trained in ultrasound scanning.

What is the purpose of this research project?
Point of care ultrasound (PoCUS), aka ‘bedside ultrasound’ is growing in user numbers in health and allied health, and it is being performed in a variety of locations – urban, rural, and in geographically isolated remote regions (Dietrich, et al., 2017). This rapid growth has raised concerns on the quality, consistency, and standardization of PoCUS. There is a global call for action to standardize PoCUS training. Furthermore, there is a call to provide training by distance education so that all users can access the training, especially those users in remote regions who do not have an option for traditional face-to-face training or guidance (Bowra et al., 2015). A literature review has revealed pockets of training (traditional and distance) for physicians and nurses, however, there is scant evidence of standardized training for the allied health sector, e.g. paramedicine, respiratory therapy, medical radiation sciences, etc.

The primary purpose of the study is to potentially contribute to the standardization and consistency of training in point of care ultrasound using remote training methods, e.g. distance education, to:

1. meet a global need in general,
2. meet a current gap for distance education methods for training,
3. meet a current gap of training for the allied health sector,
4. gain insights into the training needs of the different allied health professions, and
5. provide recommendations towards effective distance education techniques in PoCUS.

Participants will receive hands-on ultrasound training in point-of-care ultrasound on targeted views of the human body using a pocket ultrasound device (PUD). The PoCUS protocol selected is the Extended Focused Assessment with Sonography in Trauma (E-FAST) examination which scans the lungs, heart, abdomen, and pelvis areas for signs of trauma (potential spaces for free fluid or blood). Once trained, the E-FAST protocol takes 5-10 minutes to perform in the medical setting.

What will you be asked to do?
Once all participant consent forms have been signed and once you have been assigned a participant code (for anonymity of data) your time commitment for the study will be:

- 8-9 hours over 4-5 weeks
- potentially scheduled for mid-May to mid-June 2019.

Your responsibilities will include the following sequence of steps: 1.
Online Questionnaire

You will complete a Pre-Study online questionnaire **on your own time - estimate 20 minutes.**

2. Facilitated online learning to be completed on your own.
After completing the pre-study questionnaire, you will be registered in the course Moodle site to access the instructional resources to learn the theory portion of the training and to engage in asynchronous discussion forums with 1-2 NAIT ultrasound instructors **- estimate total of 3 hours on your own time**, over this 7-day window.

3. Practical hands-on training (1-hour scanning labs in one week)
After completing the theory portion of the course, you will be scheduled to complete three one-hour labs. During the lab sessions you will receive the hands-on or practical portion of the training from a NAIT instructor from the Ultrasound faculty. You will be interacting with the instructors for the practical ultrasound training delivered by remote instruction in the NAIT Diagnostic Medical Sonography (DMS) Labs. Remote instruction me and that you will be in the DMS Lab for the scanning instruction while interacting in real-time with your instructor located in another location, likely another lab within walking distance. The remote instruction "set-up" is like a Skype session with a video camera where you and your instructor can see each other and talk to each other. For the labs you will be scanning a fellow participant. After 25-30 minutes of instruction you will switch with your partner who will then scan you for 25-30 minutes. To note: a non-ultrasound staff member will be present in the labs as a monitor, that is, to let you in and make sure the equipment and supplies are there for you. Total time for three labs is **3 hours.**

4. Online Questionnaire

You will complete a Mid-Study online questionnaire on your own, **estimate 30 minutes.**

5. Objective Structured Competency Evaluations (OSCEs)
   After you complete your mid-study questionnaire you will be scheduled to complete three consecutive and separate OSCEs on three separate ultrasound models (simulated patients) in a face-to-face setting in the NAIT DMS Lab according to a set OSCE rotation. You will arrive for you first OSCE 15 minutes ahead of time and then proceed to do three OSCEs one after the other. The estimate time per OSCE is 15 minutes for a total of 45-minutes for all three OSCEs. Each OSCE assessment will be conducted by a different assessor, assigned from the NAIT Ultrasound faculty. OSCE assessors will not be your instructor from the theory/practical portions of the course. Each assessor will not know how you did on the other two OSCEs. You will be assessed on completing the E-FAST protocol while interacting with the 'patient'. The assessors will follow a pre-set checklist for grading/assessment (one grading sheet per OSCE). You will become familiar with the checklist and criteria for success during your training so that you know what is expected of you in the OSCEs.

   Each assessor will submit the OSCE grading sheets to a research administrative assistant who will determine the average of three OSCEs scores per learner. You will receive your summary OSCE score (average of 3 scores) by e-mail from the same administrative assistant prior to your completion of the end-study online questionnaire. The total time for your OSCE phase is **one hour.**

6. Online Questionnaire
   When your OSCEs are complete you will complete an End-Study online questionnaire on your own, **estimate 40 minutes.**

To note: The Principal Investigator (PI) (Denise MacIver) will be blinded to your OSCE results and these will remain confidential; only you can reveal/share your OSCE results. The PI will receive the OSCE results by participant code only.

All data collected throughout the study is anonymized and will be analyzed by the PI and a co-coder followed by a written description of the study results, discussion, and recommendations in the PIs doctoral dissertation format.

What are the risks and benefits?
Risks
Part of obtaining consent for this research study involves explaining any real or perceived risks for you as a participant.

- It is important that you know you will be expected to scan a fellow participant for the hands-on training, and vice versa, a fellow participant will be scanning you. This is contact scanning (nothing that is invasive) with the transducer (ultrasound probe) sliding over the skin of the body area with a small amount of non-toxic gel between the skin and the probe. These ultrasound-performing activities do not have any biological risks as ultrasound energy is non-ionizing with no adverse biological effects reported to date. Students/learners scanning each other is a standard practice in medical ultrasound training programs across Canada and other countries, for physicians and technologists. This is the standard practice for NAIT's Diagnostic Medical Sonography (DMS) program.

Although the scanning practice is not done for diagnostic reasons students sometimes find unexpected findings, e.g. possible gallstone. The ultrasound instructors are trained to deal with this matter, and they will relate the unexpected finding to the person and advise checking it out with the person's physician. The body areas to be scanned for this study are: the chest wall on each side of the breastbone, the lower abdomen in the middle of the pelvis, the right side near the liver, the left side near the spleen and in the midline where the abdomen meets the rib cage (bottom of the breastbone) to image the heart. Participants' modesty and privacy will be maintained at all times as the NAIT DMS Lab is designed like an emergency room or clinic where each scanning station has curtains which can be drawn for the scanning practice sessions. In the event of any findings discovered during these scans which raise health concerns regarding the participant or model, the participant or model will be advised of the findings and will also be advised to consult their physician. "By consenting, participants have not waived any rights to legal recourse in the event of research-related harm" (TriCouncil Research Policy, 2014).

- Another best practice related to students scanning each other in DMS programs is that what the student sees on anyone's scan remains confidential; this is part of the medical profession's code of conduct and this is applied in ultrasound training as well, even though the persons being scanned are not real patients. This means that all students sign a confidentiality agreement, as do the instructors and assessors. This study will adhere to the NAIT DMS norm and best practice as described. As a participant you will be asked to agree to adhere to confidentiality as part of the Informed Consent process.

- The OSCE assessments may induce anxiety, however, this is no different than any other testing situation. In addition, your scanning score sheets in the OSCE phase are identified by your participant number only and not by name. Please refer to the Limitations and Delimitations section below to ensure you are familiar with what the study can and cannot do.

Benefits

If you participate in this research study, you will have the following perceived benefits:

- You will experience ultrasound practice using a pocket ultrasound device (PUD) while scanning selected areas of the body as described above,

- You will receive PUD training of benefit to you if ultrasound is part of your scope of practice (or part of your future scope of practice),
- You will be part of a study that potentially identifies PoCUS needs of different allied health professionals,
- You will be part of a study that potentially contributes to future instructional design for distance education in PoCUS and PUD experience in the E-FAST protocol,
- You will contribute to the potential standardization of PoCUS education for the global ultrasound community, including DE methods, which in turn will benefit patients and the health care industry,
- There are no monetary incentives for participation in this study, however, participants will receive a certificate of participation should this be eligible as evidence of continuing medical education/continuing professional development credits/hours for the participant's association and/or regulatory/licensing organization.

Limitations of the Study

Limitations include the following:

1. The scanning of pre-selected live subjects (ultrasound models) will occur for the OSCEs, as well as participants scanning each other. This 'pre-selected 'element does not represent the real world of clinical ultrasound as the ultrasound models will be vetted and selected for the suitability of their body-habitus to standardize the subject matter for all research participants. This element will avoid the myriad of variables that present themselves with non-vetted random human subjects and the variations of body habitus and unexpected conditions. Participants cannot expect their scanning experience to fully represent the clinical field where patient conditions vary.
2. Unexpected and/or emerging technical delays with the DE instructional methods. These potential difficulties hope to be prevented by pre-study field test to test the DE instructional resources and tools and by engaging dedicated technical help during the instructional phase of the study.
3. Convenience sampling: restricting a sample from the allied health sector may limit the generalizability of study results. The sample does not rep resent the full practitioner demographic of PoCUS environments; however, the sample does represent itself. This limitation is somewhat offset by the diversity of multiple professions in the sample.
4. Potential lack of a viable sample from the recruitment process or drop-outs after the start of the study could affect robust data outcomes, however, even a small sample would be worthy to answer the primary research question. Low participation from a particular allied health professional group would affect the second research sub-question, however, the net is being 'cast wide' in this element with the hopes of a minimum of 3 professions participating from a potential of 8 professional groups on the NAIT campus. The potential of not enough volunteers and/or lack of balance in professions can be off set with a well-planned recruitment strategy.
5. Targeted Ultrasound: The study's PUD scanning experience encompass certain body areas only which does not represent the full scope of PUD and PoCUS practice. Participants will not be proficient in scanning other body organs that could be investigated with PUDs. This factor is both a limitation and delimitation.

Delimitations of the Study

The study encompasses the following delimitations:

1. Participant instruction with a PUD will be restricted. The goal of the study is for participants to attain competency in limited views of the lungs, heart, abdomen, and pelvis. Learning how to perform a complete (comprehensive) lung, heart, abdominal, or pelvic ultrasound will not be possible for the learners. This delimitation is in alignment with the actual practice of PoCUS which is quick and focused with the intention of producing a limited ultrasound study for diagnosis and treatment plan. In addition, learning ultrasound scanning in the study does not represent the full practice of ultrasound in general, a delimitation related to limitation #5 above.

2. The study will not investigate the attainment of PUD competency with DE instruction for physicians (non-allied health) and diagnostic medical sonographers (non-ultrasound-naïve). Despite the restriction to allied health professions the researcher believes that the study's findings will be transferable to other health professions with a PoCUS scope of practice.

Do you have to take part in this project?
As stated earlier in this letter, involvement in this project is entirely voluntary. You are under no obligation to participate; your participation in this research study is entirely voluntary. It is your choice whether to participate or not. Whether you participate or not will have no impact on your employment status. You may change your mind at any time and withdraw from the study even if you agreed earlier. Withdrawal at any time can be without explanation and without prejudice. As the study progresses you will be given any information that may be relevant to your decision to withdraw, such as an unexpected delay in the timeline (as outlined in limitation #2 above).

If you wish to participate, you'll be asked to sign the consent form (at the end of this document). Informed consent is an ongoing process, which means that at any time you may revoke your consent and withdraw from the study, without consequence. If you wish to withdraw from the study, your information will be removed from the results upon your request and if it is not yet aggregated into its anonymized form.

After the data collection phase of the study is completed anonymized data will be in an aggregate form for analysis and at this time it will not be possible to remove individual participant code data from its aggregate form.

How will your privacy and confidentiality be protected?
The ethical duty of confidentiality includes safeguarding participants' identities, personal information, and data from unauthorized access, use or disclosure.

Part of this research involves data collected from 3 questionnaires (for participant learning experiences), instructor field notes (for instructor experiences), and participant OSCE results, as described earlier. As a learner participant the data you provide will include anonymized questionnaire and OSCE results data. Data will be anonymized as follows: your name will not appear on any of the data collected; instead a participant code will be used on all collected data. Only one research administrative assistant will know your participant code, and your name and assigned code will be recorded on a paper document to be locked and only accessible to said research assistant. Upon completion of the study the paper document will be shredded by the research assistant. Another research assistant will enroll you in the Moodle course site and this person will know your e-mail identity for enrollment but not your participant code. The two ultrasound instructors will interact with you on the Moodle course site by your code (or your chosen pseudonym). The OSCE assessors will likely recognize you for the OSCEs however your name does not appear on any of your grading sheets as only your participant code will be recorded on these hard copy grading sheets. **All research assistants must sign a non-disclosure confidentiality agreement which is valid before, during, and after the study**.

All questionnaire data are anonymized, and compiled data will be viewed and analyzed by the PI and a non-NAIT co-coder. The ultrasound instructors who are assisting in the study may know you by voice during the practical scanning sessions. Any identify provided in the Moodle discussion data is by your code only (or your chosen pseudonym) and all Moodle content will be deleted after the study is completed. Moodle content will not be analyzed.

After the Moodle and practical scanning labs are complete, and after your mid-study online questionnaire is complete, you will perform the OSCE rotation. Each of your personal OSCE results will only be known by the assessor who evaluated you per OSCE. The other two assessors will not know your OSCE scores; they will only know the OSCE they themselves graded. As stated before, instructors, assessors, and all research assistants will sign a non-disclosure confidentiality agreement. To note: OSCE assessors will not be involved with the instructional activities of the study and Instructors will not be involved with your OSCEs. Assessors will only be recruited for the OSCEs. Instructor field notes will be viewed by the principal investigator however these are not data on participants – these notes are the teaching experiences of the instructors, e.g. technical difficulties, comments on time for training, instructional resource quality, etc. OSCE results will be viewed by the PI, however, will be coded by your participant number.

The PI will only have access to anonymized data. All anonymized data (hardcopy) will be stored in a locked cabinet in room 508D at NAIT. Your name and assigned code will be recorded on paper only and will not be accessible to the PI. All electronic data will be anonymized and stored on a password-protected and encrypted external hard drive. Data will be kept for five (5) years, after which they will be shredded (paper) and expunged (electronic).

Confidential information will not be shared. The results that are published are anonymized aggregate results from the entire study. The results are being published in order that other interested people may learn from this research and to meet the PIs requirements for a doctoral dissertation.

Who will know you are a participant?
The research assistant team (administrative assistants, ultrasound instructors, ultrasound assessors) who are your peers will likely know you. As stated before, each member of the research assistant team will sign confidentiality agreements which include the non-disclosure of who is participating and who is not or who has withdrawn if that occurs. All participants will also agree to not disclose who is participating or not via the informed consent process. These measures are put in place to protect the privacy and confidentiality of each participant and to protect the privacy and confidentiality of those who did not choose to participate. Equally important are measures so that the PI (Denise MacIver) does not know who is participating and who is not, including any withdrawals from the study. The PI will be not be present in the labs or for the OSCEs, that is, the PI will be "hands-off" from the study from the onset of participant recruitment to the completion of the final participant step.

How will my anonymity be protected?
Anonymity refers to protecting participants' identifying characteristics, such as name or description of physical appearance.

When you identify yourself to the research administrative assistant for recruitment you will be given your own participant code. You will also be asked which allied health profession you represent. As explained in the previous section, your participation is not anonymous for recruitment, practical labs and OSCEs, however, all data collected from you is anonymous (questionnaires and OSCE scores/results).

<u>Every reasonable effort</u> will be made to ensure your anonymity; you will not be identified in publications without your explicit permission.

Should you wish to be identified as participating in the study for future presentations and/or publications please contact the PI directly, or the same research assistant who recruited you and this information will be relayed to the PI. Also, as mentioned previously, upon request, a certificate of participation can be issued to you via the same research administrative assistant, and you would insert your name on the certificate of participation.

How will the data collected be stored?
There will be two types of data stored on paper (hard copy data): 1) participant recruitment information (assigned code, all signed consent forms per participant, and participant coded OSCE scores), and 2) electronic data (compiled online questionnaire data and instructor participant field notes).

Paper data will be stored in a locked filing cabinet in Room 508D (office of the research administrative assistant). Electronic data will be stored on a password-protected and encrypted external hard drive. At the end of the study's data retention period (5 years), paper data will be shredded, and electronic data expunged.

The only data the PI will have access to is the anonymized questionnaire data, the anonymized instructor field notes data, and the anonymized OSCE results data. These anonymized data will be used for the PIs doctoral dissertation, presentations to the healthcare community, and publications in peer-reviewed journals. There is no anticipated/future secondary use of the data and if there was, further REB approval would be sought for another project.

Although the questionnaires will not identify you by name (only participant code) it is prudent to communicate to you that the study will use an online survey company to collect data from the study's three questionnaires. The on-line survey company *Qualtrics* is an online survey research platform that can be used by NAIT staff to fulfill most of their data collection needs. The security and privacy policy for the web survey company can be found at the following link: https://staff.nait.ca/departments-schools/institutional-research/surveys/qualtrics

Who will receive the results of the research project?

- The existence of the research will be listed in an abstract posted online at the Athabasca University Library's Digital Thesis and Project Room and the final research paper will be publicly available.

- After the project and the PIs doctoral dissertation is completed interested participants will have access to reports and/or presentations on the project available on the NAIT School website. School presentations on the study's results will also provide participants the opportunity to learn of the results as well as the broader healthcare community.

- Application to publish the study results in a professional peer-reviewed journal, e.g. Journal of Allied Health, will also be a form of dissemination.

Who can you contact for more information or to indicate your interest in participating in the research project?
IF YOU DO NOT UNDERSTAND SOME OF THE INFORMATION OR CONCEPTS YOU MAY CONTACT THE PRINCIPAL INVESTIGATOR, DENISE MACIVER, (denisem@nait.ca or 780-471-8422) to discuss the research study prior to signing the certificate of consent.

If you are ready to participate in this project, please complete and sign the attached Consent Form and return in person to Ruvimbo Sakutukwa at NAIT, room 508D, or scan and e-mail to Ruvimbo Sakutukwa at ruvimbos@nait.ca.

Thank you for considering this invitation.

Denise MacIver

This project has been reviewed by the Athabasca University Research Ethics Board. Should you have any comments or concerns regarding your treatment as a participant in this project, please contact the Research Ethics Office by e-mail at rebsec@athabascau.ca **or by telephone at 1-800-788-9041, ext. 6718.**

Informed Consent:
Your signature on this form means that:

- You have read the information about the research project.
- You have been able to ask questions about this project.
- You are satisfied with the answers to any questions you may have had.
- You understand what the research project is about and what you will be asked to do.
- You understand that you are free to withdraw your participation in the research project without having to give a reason, and that doing so will not affect you now, or in the future.
- You understand that if you choose to end your participation during data collection, any data collected from you up to that point will be retained by the researcher, unless you indicate otherwise.
- You understand that your data is being collected anonymously, and therefore cannot be removed once the data collection has ended.
- You agree to not disclose the names of your fellow participants
- You agree to not disclose any ultrasound information from your fellow participants

Your signature confirms:

- You have read what this research project is about and understood the risks and benefits. You have had time to think about participating in the project and had the opportunity to ask questions and have those questions answered to your satisfaction.
- You understand that participating in the project is entirely voluntary and that you may end your participation at any time without any penalty or negative consequences.
- You have been given a copy of this Informed Consent form for your records; and
- UNDERSTAND THE CONCEPTS OF RESEARCH CONFIDENTIALITY AND CONFLICT OF INTEREST AS PRESENTED IN A REVIEW OF Chapter Seven of the Tri-Council Policy Statement, 2nd version (TCP2) AND RELEVANT DOCUMENTS FROM THE ATHABASCA UNIVERSITY AND NAIT.
- You agree to participate in this research project.

______________________________ ____________________________

Signature of Participant Date

Research Administrative Assistant's Signature AS WITNESS:

Signature of Research Administrative Assistant Date

Appendix G6: Letter of Information/Informed Consent for Instructors

Date:

You are invited to take part in a research project entitled *Point of Care Ultrasound: Distance Education for the use of Pocket Ultrasound Devices.*

This form is part of the process of informed consent. The information presented should give you the basic idea of what this research is about and what your participation will involve, should you choose to participate. It also describes your right to withdraw from the project. In order to decide whether you wish to participate in this research project, you should understand enough about its risks, benefits and what is required of you to be able to make an informed decision. This is the informed consent process. Take time to read this carefully as it is important that you understand the information given to you. Please contact the principal investigator, *Denise MacIver,* if you have any questions about the project or would like more information before you consent to participate.

It is entirely up to you whether or not you take part in this research. If you choose not to take part, or if you decide to withdraw from the research once it has started, there will be no negative consequences for you now, or in the future.

Introduction
My name is Denise MacIver and I am a doctoral student at Athabasca University. As a requirement to complete my degree, I am conducting a research project about the effectiveness of teaching ultrasound scanning skills to allied health professionals entirely by using distance education methods and technology. I am conducting this project under the supervision of Dr. Susan Bainbridge.

Why are you being asked to take part in this research project?
You are being invited to participate in this project because you may meet the instructor participant criteria as a credentialed ultrasound instructor at NAIT.

What is the purpose of this research project?
Point of care ultrasound (PoCUS), aka ‘bedside ultrasound’ is growing in user numbers in health and allied health, and it is being performed in a variety of locations – urban, rural, and in geographically isolated remote regions (Dietrich, et al., 2017). This rapid growth has raised concerns on the quality, consistency, and standardization of PoCUS. There is a global call for action to standardize PoCUS training. Furthermore, there is a call to provide training by distance education so that all users can access the training, especially those users in remote regions who do not have an option for traditional face-to-face training or guidance (Bowra et al., 2015). A literature review has revealed pockets of training (traditional and distance) for physicians and nurses, however, there is scant evidence of standardized training for the allied health sector, e.g. paramedicine, respiratory therapy, medical radiation technologists, etc.

The primary purpose of the study is to potentially contribute to the standardization and consistency of training in point of care ultrasound using remote training methods, e.g. distance education, to:

1. meet a global need in general,
2. meet a current gap for distance education methods for training
3. meet a current gap of training for the allied health sector,

4. gain insights into the training needs of the different allied health professions, and
5. provide recommendations towards effective distance education techniques in PoCUS.

For your information: Learner participants will receive hands-on ultrasound training in point-of-care ultrasound on targeted views of the human body using a pocket ultrasound device (PUD). The PoCUS protocol selected is the Extended Focused Assessment with Sonography in Trauma (E-FAST) examination which scans the lungs, heart, abdomen, and pelvis areas for signs of trauma (potential spaces for free fluid or blood). Once trained, the E-FAST protocol takes 5-10 minutes to perform in the medical setting.

Instructor participants (two) will facilitate the theory training (Moodle course) for the learners. In addition, instructor participants will deliver remote scanning instruction for the learner participants with the learners in NAIT's ultrasound lab and the instructors situated in another location and interacting in real time with the learners using a software called Remote Education, Augmented Communication Training System (REACTS). For the scanning labs the learners will be scanning each other in pairs in sections of six learners per section (3 pairs per section). The anticipated number of learner participants is 18-36.

When the instruction is complete, assessor participants (three) will assess the learners in face-to-face objective structured competency evaluations (OSCEs) in NAIT's ultrasound lab using a standard checklist for assessment to evaluate the learners. For the OSCEs the learners will be scanning ultrasound models (simulated patients).

What will you be asked to do?
Once all participant consent forms have been signed and once you have been assigned a participant code (for anonymity of data) your time commitment for the study will be 10 -16 hours over 4-5 calendar weeks (exact number is dependent on number of learners)

Responsibilities will include the following sequence of steps:

1. Participating in the pre-study field test to check instructional resources and distance delivery technology and methods,

2. Facilitating online learning (Moodle) for the learner participants for the theory portion of the course - **estimate 3 hours** over a 7-day window,

3. Delivering practical hands-on training (scanning labs):
   Over a 10-day window, learners (in pairs) will attend three separate one-hour labs (6 students to a lab section, that is 3 pairs per section). During the lab sessions you will deliver hands-on practical training using REACTS software and interacting with each pair of learners to provide remote instruction. The learners will be in the NAIT Diagnostic Medical Sonography IDMS) Labs and you will be located in a different location, likely another lab within walking distance. The remote instruction "set-up" is like a Skype session with a video camera where the learners and the instructor can see each other and talk to each other. Learners will be scanning each other. After 25-30 minutes of instruction learners will switch roles for the remaining 25-30 minutes. To note: a non-ultrasound staff member will be present in the labs as a monitor for the learners, that is, to admit the learners into the lab and

make sure the equipment and supplies are there for them. Total time for three labs is **3 hours of instruction** per section of 2-6 learners.

During the instructional phase (theory and practical) you will be asked to keep "field notes" according to pre-set guidelines and submit these notes in their summative form at the end of the instructional phase of the study. These data will be anonymized, that is, the data you submit will be identified by your participant code and not your name.

All data collected throughout the study is anonymized and will be analyzed by the PI and a co-coder followed by a written description of the study results, discussion, and recommendations in the PIs doctoral dissertation format.

What are the risks and benefits?
There are no known risks for you as an instructor as the tasks performed are no different than your current role at NAIT as an ultrasound instructor. However, it is important that you read the following risks outlined for the learners.

Risks for the learners
Part of obtaining consent for this research study involves explaining any real or perceived risks for you as a participant.

- It is important that you know you will be expected to scan a fellow participant for the hands-on training, and vice versa, a fellow participant will be scanning you. This is contact scanning (nothing that is invasive) with the transducer (ultrasound probe) sliding over the skin of the body area with a small amount of non-toxic gel between the skin and the probe. These ultrasound-performing activities do not have any biological risks as ultrasound energy is non-ionizing with no adverse biological effects reported to date. Students/learners scanning each other is a standard practice in medical ultrasound training programs across Canada and other countries, for physicians and technologists. This is the standard practice for NAIT's Diagnostic Medical Sonography (DMS) program.

- Although scanning practice is not done for diagnostic reasons students sometimes find unexpected findings, e.g. possible gallstone. The ultrasound instructors are trained to deal with this matter, and they will relate the unexpected finding to the person and advise checking it out with the person's physician. The body areas to be scanned for this study are: the chest wall on each side of the breastbone, the lower abdomen in the middle of the pelvis, the right side near the liver, the left side near the spleen and in the midline where the abdomen meets the rib cage (bottom of the breastbone) to examine the heart. Participants modesty and privacy will be maintained at all times as the NAIT DMS Lab is designed like an emergency room or clinic where each scanning station has curtains which can be drawn for the scanning practice sessions. This study will adhere to the NAIT DMS norm and best practice as described. In the event of any findings discovered during these scans which raise health concerns regarding the participant or model, the participant or model will be advised of the findings and will also be advised to consult their physician. "By consenting, participants have not waived any rights to legal recourse in the event of research-related harm" (TriCouncil Research Policy, 2014).

- Another best practice related to students scanning each other in DMS programs is that what the student sees on anyone's scan remains confidential; this is part of the medical profession's code of conduct and this is applied in ultrasound training as well, even though the persons being scanned are not real patients. This means that all students sign a confidentiality agreement, as do the instructors and assessors. This study will adhere to the NAIT DMS norm and best practice as described. As a participant you will be asked to agree to confidentiality as part of the informed consent process.

- The OSCE assessments may induce anxiety, however, this is no different than any other testing situation. In addition, your scanning score sheets in the OSCE phase are identified by your participant number only and not by name. Please refer to the Limitations and Delimitations section below to ensure you are familiar with what the study can and cannot do.

Benefits for Instructors

If you participate in this research study, you will have the following perceived benefits:

- As an instructor you will learn how to teach the EFAST protocol with a PUD and how to teach remotely, using the REACTS technology for remote guidance.
- You will be part of a study that potentially identifies PoCUS needs of different allied health professionals,
- You will be part of a study that potentially contributes to future instructional design for distance education in PoCUS and PUD experience in the E-FAST protocol, and
- You will contribute to the potential standardization of PoCUS education for the global ultrasound community, including DE methods, which in turn will benefit patients and the health care industry.
- There are no monetary incentives for participation in this study, however, study participants will receive a certificate of participation (sample attached) should this be eligible as evidence of continuing medical education/continuing professional development credits/hours for the participant's association and/or regulatory/licensing organization.

Limitations of the Study

Limitations include the following:

1. The scanning of pre-selected live subjects (ultrasound models) will occur for the OSCEs, as well as participants scanning each other. This 'pre-selected 'element does not represent the real world of clinical ultrasound as the ultrasound models will be vetted and selected for the suitability of their body-habitus to standardize the subject matter for all research participants. This element will avoid the myriad of variables that present themselves with non-vetted random human subjects and the variations of body habitus and unexpected conditions. Participants cannot expect their scanning experience to fully represent the clinical field where patient conditions vary.
2. Unexpected and/or emerging technical delays with the DE instructional methods. These potential difficulties hope to be prevented by pre-study pilot to test the DE instructional resources and tools and by engaging dedicated technical help during the instructional phase of the study.
3. Convenience sampling: restricting a sample from the allied health sector may limit the generalizability of study results. The sample does not represent the full practitioner demographic of PoCUS environments however, the sample does represent itself. This limitation is somewhat offset by the diversity of multiple professions in the sample.
4. Potential lack of a viable sample from the recruitment process or drop-outs after the start of the study could affect robust data outcomes, however, even a small sample would be worthy

to answer the primary research question. Low participation from a particular allied health professional group would affect the second research sub-question, however, the net is being 'cast wide' in this element with the hopes of a minimum of 3 professions participating from a potential of 8 professional groups on the NAIT campus. The potential of not enough volunteers and/or lack of balance in professions can be offset with a well-planned recruitment strategy.

5. Targeted Ultrasound: The study's PUD scanning experience encompass certain body areas only which does not represent the full scope of PUD and PoCUS practice. Participants will not be proficient in scanning other body organs that could be investigated with PUDs. This factor is both a limitation and delimitation.

Delimitations of the Study

The study encompasses the following delimitations:

6. Participant instruction with a PUD will be restricted. The goal of the study is for participants to attain competency in limited views of the lungs, heart, abdomen, and pelvis. Learning how to perform a complete (comprehensive) lung, heart, abdominal, or pelvic ultrasound will not be possible for the learners. This delimitation is in alignment with the actual practice of PoCUS which is quick and focused with the intention of producing a limited ultrasound study for diagnosis and treatment plan. In addition, learning ultrasound scanning in the study does not represent the full practice of ultrasound in general, a delimitation related to limitation #5 above.
7. The study will not investigate the attainment of PUD competency with DE instruction for physicians (non-allied health) and diagnostic medical sonographers (non-ultrasound-naïve). Despite the restriction to allied health professions the researcher believes that the study's findings will be transferable to other health professions with a PoCUS scope of practice.

Do you have to take part in this project?

As stated earlier in this letter, involvement in this project is entirely voluntary. You are under no obligation to participate; your participation in this research study is entirely voluntary. It is your choice whether to participate or not. Whether you participate or not will have no impact on your employment status. You may change your mind at any time and withdraw from the study even if you agreed earlier. Withdrawal at any time can be without explanation and without prejudice.

If you wish to participate, you'll be asked to sign the consent form (at the end of this document). Informed consent is an ongoing process, which means that at any time you may revoke your consent and withdraw from the study, without consequence. If you wish to withdraw from the study, your information will be removed from the results upon your request if possible.

After the data collection phase of the study is completed anonymized data will be in an aggregate form for analysis and at this time it will not be possible to remove individual participant code data from its aggregate form.

You may contact anyone you feel comfortable with to discuss the research study prior to signing the certificate of consent. If you do not understand some of the information or concepts you may contact the Principal Investigator, Denise MacIver, or the designated Research Administrative Assistant, Ruvimbo Sakutukwa, at any time for clarification.

How will your privacy and confidentiality be protected?
The ethical duty of confidentiality includes safeguarding participants' identities, personal information, and data from unauthorized access, use or disclosure.

For instructors the data collected are field notes of your instructional experiences, not data on the learners, rather, what you experienced in teaching by distance and your evaluation of the course length and resources, etc. The data you provide will be anonymized, that is, your name will not appear on the data collected; instead a participant code will be used on all collected data. Only one research administrative assistant will know your participant code, and your name and assigned code will be recorded on a paper document to be locked and only accessible to said research assistant. Upon completion of the study the paper document will be shredded by the research assistant. Another research assistant will enroll you in the Moodle course site and this person will know your e-mail identity but not your participant code.

The learners will likely recognize you (and/or your voice) as they will be your peers, however your name does not appear on any of the learning tools.

The PI will only have access to anonymized data. All anonymized data (paper) will be stored in a locked cabinet in room 508D at NAIT. All anonymized electronic data will be stored on a password-protected and encrypted external hard drive. Data will be kept for five (5) years, after which they will be shredded (paper) and expunged (electronic).

Confidential information will not be shared. The results that are published are anonymized aggregate results from the entire study. The results are being published in order that other interested people may learn from this research and to meet the PIs requirements for a doctoral dissertation.

Who will know you are a participant?
The Principal Investigator and the research assistant team (administrative assistants, ultrasound assessors, IT assistants) will likely know you. Despite any pre-existing relationship, each member of the research assistant team and the learner participants will sign confidentiality agreements which include the non-disclosure of who is participating and who is not or who has withdrawn if that occurs. There is no hierarchical relationship in the study.
How will my anonymity be protected?
Anonymity refers to protecting participants' identifying characteristics, such as name or description of physical appearance.

When you identify yourself to the research administrative assistant for recruitment you will be given your own participant code. As explained in the previous section, your participation is not anonymous for recruitment, however, all data collected from you are anonymous (field notes).

<u>Every reasonable effort</u> will be made to ensure your anonymity; you will not be identified in publications without your explicit permission.

Should you wish to be identified as participating in the study for future presentations and/or publications please contact the PI directly or the same research assistant who recruited you and this information will be relayed to the PI. Also, as mentioned previously, upon request, a certificate of participation can be issued to you via the same research administrative assistant, and you would insert your name on the certificate of participation.

How will the data collected be stored?
There will be two types of data stored on paper (hard copy data): 1) participant recruitment information (assigned code, all signed consent forms per participant, and learner participant coded OSCE scores), and 2) electronic data (compiled online questionnaire data and instructor participant field notes).

Paper data will be stored in a locked filing cabinet in Room 508D (office of the research administrative assistant). Electronic data will be password-protected and stored on an encrypted and external hard drive. At the end of the study's data retention period (5 years) paper data will be shredded, and electronic data expunged.

The only data the PI will have access to is the anonymized questionnaire data, the anonymized instructor field notes data, and the anonymized OSCE results data. These anonymized data will be used for the PIs doctoral dissertation, presentations to the healthcare community and publications in peer-reviewed journals. There is no anticipated/future secondary use of the data and if there was further REB approval would be sought for another project.

Who will receive the results of the research project?

- The existence of the research will be listed in an abstract posted online at the Athabasca University Library's Digital Thesis and Project Room and the final research paper will be publicly available.

- After the project and the PIs doctoral dissertation is completed interested participants will have access to reports and/or presentations on the project available on the NAIT School website. School presentations on the study's results will also provide participants the opportunity to learn of the results as well as the broader healthcare community.

- Application to publish the study results in a professional peer-reviewed journal, e.g. Journal of Allied Health, will also be a form of dissemination.

Who can you contact for more information or to indicate your interest in participating in the research project?
IF YOU DO NOT UNDERSTAND SOME OF THE INFORMATION OR CONCEPTS YOU MAY CONTACT THE PRINCIPAL INVESTIGATOR, DENISE MACIVER, (denisem@nait.ca or 780-471-8422) to discuss the research study prior to signing the certificate of consent.

If you are ready to participate in this project, please complete and sign the attached Consent Form and DMS Waiver Form and return both forms in person to Ruvimbo Sakutukwa at NAIT, room 508D, or scan and e-mail to Ruvimbo Sakutukwa at ruvimbos@nait.ca.

Thank you for considering this invitation.

Denise MacIver

This project has been reviewed by the Athabasca University Research Ethics Board. Should you have any comments or concerns regarding your treatment as a participant in this project, please contact the Research Ethics Office by e-mail at rebsec@athabascau.ca or by telephone at 1-800-788-9041, ext. 6718.

Informed Consent:

Your signature on this form means that:

- You have read the information about the research project.
- You have been able to ask questions about this project.
- You are satisfied with the answers to any questions you may have had.
- You understand what the research project is about and what you will be asked to do.
- You understand that you are free to withdraw your participation in the research project without having to give a reason, and that doing so will not affect you now, or in the future.
- You understand that if you choose to end your participation during data collection, any data collected from you up to that point will be retained by the researcher, unless you indicate otherwise.
- You understand that your data is being collected anonymously, and therefore cannot be removed once the data collection phase has ended.
- You agree to not disclose the names of your fellow participants
- You agree to not disclose any ultrasound findings or course standings about the learner participants.

Your signature confirms:

- You have read what this research project is about and understood the risks and benefits. You have had time to think about participating in the project and had the opportunity to ask questions and have those questions answered to your satisfaction.
- You understand that participating in the project is entirely voluntary and that you may end your participation at any time without any penalty or negative consequences.
- You have read Chapter 7 of the Tri-Council Policy Statement – 2nd version (TCPS2).
- You have read Athabasca University's Conflict of Interest information.
- You have been given a copy of this Informed Consent form for your records; and
- UNDERSTAND THE CONCEPTS OF RESEARCH CONFIDENTIALITY AND CONFLICT OF INTEREST AS PRESENTED IN A REVIEW OF Chapter Seven of the Tri-Council Policy Statement, 2nd version (TCP2) AND RELEVANT DOCUMENTS FROM THE ATHABASCA UNIVERSITY AND NAIT.
- You agree to participate in this research project.

______________________________ ______________________________

Signature of Participant Date

Principal Investigator's Signature:

I have explained this project to the best of my ability. I invited questions and responded to any that were asked. I believe that the participant fully understands what is involved in participating in the research project, any potential risks and that he or she has freely chosen to participate.

______________________________ ______________________________

Signature of Principal Investigator Date

Appendix G7: Letter of Information/Informed Consent for Assessors

Date:

You are invited to take part in a research project entitled *Point of Care Ultrasound: Distance Education for the use of Pocket Ultrasound Devices.*

This form is part of the process of informed consent. The information presented should give you the basic idea of what this research is about and what your participation will involve, should you choose to participate. It also describes your right to withdraw from the project. In order to decide whether you wish to participate in this research project, you should understand enough about its risks, benefits and what is required of you to be able to make an informed decision. This is the informed consent process. Take time to read this carefully as it is important that you understand the information given to you. Please contact the principal investigator, *Denise MacIver,* if you have any questions about the project or would like more information before you consent to participate.

It is entirely up to you whether or not you take part in this research. If you choose not to take part, or if you decide to withdraw from the research once it has started, there will be no negative consequences for you now, or in the future.

Introduction
My name is Denise MacIver and I am a doctoral student at Athabasca University. As a requirement to complete my degree, I am conducting a research project about the effectiveness of teaching ultrasound scanning skills to allied health professionals entirely by using distance education methods and technology. I am conducting this project under the supervision of Dr. Susan Bainbridge.

Why are you being asked to take part in this research project?
You are being invited to participate in this project because you may meet the assessor participant criteria as a credentialed ultrasound instructor at NAIT.

What is the purpose of this research project?
Point of care ultrasound (PoCUS), aka 'bedside ultrasound' is growing in user numbers in health and allied health, and it is being performed in a variety of locations – urban, rural, and in geographically isolated remote regions (Dietrich, et al., 2017). This rapid growth has raised concerns on the quality, consistency, and standardization of PoCUS. There is a global call for action to standardize PoCUS training. Furthermore, there is a call to provide training by distance education so that all users can access the training, especially those users in remote regions who do not have an option for traditional face-to-face training or guidance (Bowra et al., 2015). A literature review has revealed pockets of training (traditional and distance) for physicians and nurses, however, there is scant evidence of standardized training for the allied health sector, e.g. paramedicine, respiratory therapy, medical radiation technologists, etc.

The primary purpose of the study is to potentially contribute to the standardization and consistency of training in point of care ultrasound using remote training methods, e.g. distance education, to:

1. meet a global need in general,
2. meet a current gap for distance education methods for training
3. meet a current gap of training for the allied health sector,

4. gain insights into the training needs of the different allied health professions, and
5. provide recommendations towards effective distance education techniques in PoCUS.

For your information: Learner participants will receive hands-on ultrasound training in point-of-care ultrasound on targeted views of the human body using a pocket ultrasound device (PUD). The PoCUS protocol selected is the Extended Focused Assessment with Sonography in Trauma (E-FAST) examination which scans the lungs, heart, abdomen, and pelvis areas for signs of trauma (potential spaces for free fluid or blood). Once trained, the E-FAST protocol takes 5-10 minutes to perform in the medical setting.

Instructor participants (two) will facilitate the theory training (Moodle course) for the learners. In addition, instructor participants will deliver remote scanning instruction for the learner participants with the learners in NAIT's ultrasound lab and the instructors situated in another location and interacting in real time with the learners using a software called Remote Education, Augmented Communication Training System (REACTS). For the scanning labs the learners will be scanning each other in pairs in sections of 2-6 learners per section (1-3 pairs per section). The anticipated number of learner participants is 18-36.

When the instruction is complete, assessor participants (three) will assess the learners in face-to-face objective structured competency evaluations (OSCEs) in NAIT's ultrasound lab using a standard checklist for assessment to evaluate the learners. For the OSCEs the learners will be scanning ultrasound models (simulated patients).

What will you be asked to do?
Once all participant consent forms have been signed and once you have been assigned a participant code (for anonymity) the time commitment for the study will be 8-12 hours, the majority of these hours spread over 2-3 days near the end of the study, estimated to sometime from early to mid-June 2019.

Responsibilities will include the following sequence of steps:

1. Participating in the pre-study pilot to familiarize yourself with the learning outcomes and assessment tools.

2. Objective Structured Competency Evaluations (OSCEs)
During a 2-3-day window, learners will be assigned to three consecutive and separate OSCEs on three separate simulated patients (ultrasound models) in a face-to-face setting in the NAIT DMS Lab according to a set OSCE rotation. The estimate time per OSCE is 15 minutes each for a total estimate time of 45 minutes for all three OSCEs. You will remain in one assessment station with the learners rotating through the OSCE stations. You will not know how the learners performed on the other two OSCEs. You will assess each learner participant on how they performed the E-FAST protocol. You will check-off whether they completed a task or not, according to a pre-set OSCE checklist for assessment. You will become familiar with the checklist during the pre-study pilot so that you know what is expected of you in the OSCEs. You will submit the OSCE results to a research administrative assistant who will store them until it is time for the results to be revealed to each learner.

To note: For each OSCE your name will not appear on the grading sheets, only the participant code that you are assigned at the beginning of the study. Learners will not know how they were marked on any one OSCE as the grades they receive will be one summative average of their 3 OSCEs.

To note: The Principal Investigator (PI) (Denise MacIver) will be blinded to all OSCE results and these will remain confidential; only the student can reveal/share their summative OSCE results should they choose to do so. The PI will receive the OSCE results by participant code only and all instructors, assessors, and research administrative assistants will sign confidentiality agreements.

All data collected throughout the study is anonymized and will be analyzed by the PI and a co -coder followed by a written description of the study results, discussion, and recommendations in the PIs doctoral dissertation format.

What are the risks and benefits?
There are no known risks for you as an assessor as the tasks performed are no different than your current role at NAIT as an ultrasound instructor. However, it is important that you read the following risks outlined for the learners.

Risks for the learners
Part of obtaining consent for this research study involves explaining any real or perceived risks for you as a participant.

- It is important that you know you will be expected to scan a fellow participant for the hands-on training, and vice versa, a fellow participant will be scanning you. This is contact scanning (nothing that is invasive) with the transducer (ultrasound probe) sliding over the skin of the body area with a small amount of non-toxic gel between the skin and the probe. These ultrasound-performing activities do not have any biological risks as ultrasound energy is non-ionizing with no adverse biological effects reported to date. Students/learners scanning each other is a standard practice in medical ultrasound training programs across Canada and other countries, for physicians and technologists. This is the standard practice for NAIT's Diagnostic Medical Sonography (DMS) program.

- Although the scanning practice is not done for diagnostic reasons students sometimes find unexpected findings, e.g. possible gallstone. The ultrasound instructors are trained to deal with this matter, and they will relate the unexpected finding to the person and advise checking it out with the person's physician. The body areas to be scanned for this study are: the chest wall on each side of the breastbone, the lower abdomen in the middle of the pelvis, the right side near the liver, the left side near the spleen and in the midline where the abdomen meets the rib cage (bottom of the breastbone) to image the heart. Participants' modesty and privacy will be maintained at all times as the NAIT DMS Lab is designed like an emergency room or clinic where each scanning station has curtains which can be drawn for the scanning practice sessions. This study will adhere to the NAIT DMS norm and best practice as described. In the event of any findings discovered during these scans which raise health concerns regarding the participant or model, the participant or model will be advised of the findings and will also be advised to consult their physician. "By consenting, participants have not waived any rights to legal recourse in the event of research -related harm" (TriCouncil Research Policy, 2014).

- Another best practice related to students scanning each other in DMS programs is that what the student sees on anyone's scan remains confidential; this is part of the medical profession's code of conduct and this is applied in ultrasound training as well, even though the persons being scanned are not real patients. This means that all students sign a confidentiality agreement, as do the instructors and assessors. This study will adhere to the NAIT DMS norm and best practice as described. As a participant you will be asked to sign the standard DMS Confidentiality Agreement.

- The OSCE assessments may induce anxiety, however, this is no different than any other testing situation. In addition, your scanning score sheets in the OSCE phase are identified by your participant number only and not by name. Please refer to the Limitations and Delimitations section below to ensure you are familiar with what the study can and cannot do.

Benefits for Assessors

If you participate in this research study, you will have the following perceived benefits:

- As an assessor you will learn how to evaluate PUD scanning of the EFAST protocol in an OSCE setting.
- You will be part of a study that potentially identifies PoCUS needs of different allied health professionals,
- You will be part of a study that potentially contributes to future instructional design for distance education in PoCUS and PUD experience in the E-FAST protocol, and
- You will contribute to the potential standardization of PoCUS education for the global ultrasound community, including DE methods, which in turn will benefit patients and the health care industry.
- There are no monetary incentives for participation in this study, however, study participants will receive a certificate of participation should this be eligible as evidence of continuing medical education/continuing professional development credits/hours for the participant's association and/or regulatory/licensing organization.

Limitations of the Study

Limitations include the following:

1. The scanning of pre-selected live subjects (ultrasound models) will occur for the OSCEs, as well as participants scanning each other. This 'pre-selected 'element does not represent the real world of clinical ultrasound as the ultrasound models will be vetted and selected for the suitability of their body-habitus to standardize the subject matter for all research participants. This element will avoid the myriad of variables that present themselves with non-vetted random human subjects and the variations of body habitus and unexpected conditions. Participants cannot expect their scanning experience to fully represent the clinical field where patient conditions vary.
2. Unexpected and/or emerging technical delays with the DE instructional methods. These potential difficulties hope to be prevented by pre-study pilot to test the DE instructional resources and tools and by engaging dedicated technical help during the instructional phase of the study.
3. Convenience sampling: restricting a sample from the allied health sector may limit the generalizability of study results. The sample does not represent the full practitioner demographic of PoCUS environments however, the sample does represent itself. This limitation is somewhat offset by the diversity of multiple p professions in the sample.

4. Potential lack of a viable sample from the recruitment process or drop-outs after the start of the study could affect robust data outcomes, however, even a small sample would be worthy to answer the primary research question. Low participation from a particular allied health professional group would affect the second research sub-question, however, the net is being 'cast wide' in this element with the hopes of a minimum of 3 professions participating from a potential of 8 professional groups on the NAIT campus. The potential of not enough volunteers and/or lack of balance in professions can be offset with a well-planned recruitment strategy.
5. Targeted Ultrasound: The study's PUD scanning experience encompass certain body areas only which does not represent the full scope of PUD and PoCUS practice. Participants will not be proficient in scanning other body organs that could be investigated with PUDs. This factor is both a limitation and delimitation.

Delimitations of the Study

The study encompasses the following delimitations:

1. Participant instruction with a PUD will be restricted. The goal of the study is for participants to attain competency in limited views of the lungs, heart, abdomen, and pelvis. Learning how to perform a complete (comprehensive) lung, heart, abdominal, or pelvic ultrasound will not be possible for the learners. This delimitation is in alignment with the actual practice of PoCUS which is quick and focused with the intention of producing a limited ultrasound study for diagnosis and treatment plan. In addition, learning ultrasound scanning in the study does not represent the full practice of ultrasound in general, a delimitation related to limitation #5 above.
2. The study will not investigate the attainment of PUD competency with DE instruction for physicians (non-allied health) and diagnostic medical sonographers (non-ultrasound-naïve). Despite the restriction to allied health professions the researcher believes that the study's findings will be transferable to other health professions with a PoCUS scope of practice.

Do you have to take part in this project?

As stated earlier in this letter, involvement in this project is entirely voluntary. You are under no obligation to participate; your participation in this research study is entirely voluntary. It is your choice whether to participate or not. Whether you participate or not will have no impact on your employment status. You may change your mind at any time and withdraw from the study even if you agreed earlier. Withdrawal at any time can be without explanation and without prejudice.

If you wish to participate, you'll be asked to sign the consent form (at the end of this document). Informed consent is an ongoing process, which means that at any time you may revoke your consent and withdraw from the study, without consequence. If you wish to withdraw from the study, your information (name and participant code) will be removed.

You may contact anyone you feel comfortable with to discuss the research study prior to signing the certificate of consent. If you do not understand some of the information or concepts you may contact the Principal Investigator, Denise MacIver, or the designated Research Administrative Assistant, Ruvimbo Sakutukwa, at any time for clarification n.

How will your privacy and confidentiality be protected?
The ethical duty of confidentiality includes safeguarding participants' identities, personal information, and data from unauthorized access, use or disclosure.

As an assessor the data collected are the performance scores of the learner participants graded and documented by you the learner's OSCE checklist for assessment. Upon completion of the study the individual grading sheets will be shredded by the research administrative assistant.

The learners will likely recognize you as they will be your peers, however your name does not appear on any of your grading sheets (hard copies); only your participant code will be recorded on these paper copies. The learners will receive an aggregate grade, that is, they will not see each individual grading score but rather they will receive one summary grade based on the average of their three OSCEs. In this way, the learners will not know how you scored them.

The PI will only have access to anonymized data. All anonymized data (paper) will be stored in a locked cabinet in room 508D at NAIT. All anonymized electronic data will be stored on a password-protected and encrypted external hard drive. Data will be kept for five (5) years, after which they will be shredded (paper) and expunged (electronic).

Confidential information will not be shared. The results that are published are anonymized aggregate results from the entire study. The results are being published in order that other interested people may learn from this research and to meet the PIs requirements for a doctoral dissertation.

Who will know you are a participant?
The Pi and the research assistant team (administrative assistants, ultrasound instructors) and learner participants who are your peers will likely know you. Despite any pre-existing relationship, each member of the research assistant team and the learner participants will sign confidentiality agreements which include the non-disclosure of who is participating and who is not or who has withdrawn if that occurs. There are no hierarchical relationships in the research study.

How will my anonymity be protected?
Anonymity refers to protecting participants' identifying characteristics, such as name or description of physical appearance.

When you identify yourself to the research administrative assistant for recruitment you will be given your own participant code. As explained in the previous section, your participation is not anonymous for recruitment, however, all data collected from you is anonymous (OSCE scores).

<u>Every reasonable effort</u> will be made to ensure your anonymity; you will not be identified in publications without your explicit permission.

Should you wish to be identified as participating in the study for future presentations and/or publications please contact the PI directly or the same research assistant who recruited you and this information will be relayed to the PI. Also, as mentioned previously, upon request, a certificate of participation can be issued to you via the same research administrative assistant, and you would insert your name on the certificate of participation.

How will the data collected be stored?

There will be two types of data stored on paper (hard copy data): 1) participant recruitment information (assigned code, all signed consent forms per participant, and participant coded learner OSCE scores), and 2) electronic data (compiled online learner questionnaire data and instructor participant field notes).

Paper data will be stored in a locked filing cabinet in Room 508D (office of the research administrative assistant). Electronic data will be stored on a password-protected and encrypted external hard drive. At the end of the study's data retention period (5 years) paper data will be shredded, and electronic data expunged.

The only data the PI will have access to is the anonymized learner questionnaire data, the anonymized instructor field notes data, and the anonymized learner OSCE results data. These anonymized data will be used for the PIs doctoral dissertation, presentations to the healthcare community and publications in peer-reviewed journals. There is no anticipated/future secondary use of the data and if there was further REB approval would be sought for another project.

Who will receive the results of the research project?

- The existence of the research will be listed in an abstract posted online at the Athabasca University Library's Digital Thesis and Project Room and the final research paper will be publicly available.

- After the project and the PIs doctoral dissertation is completed interested participants will have access to reports and/or presentations on the project available on the NAIT School website. School presentations on the study's results will also provide participants the opportunity to learn of the results as well as the broader healthcare community.

- Application to publish the study results in a professional peer-reviewed journal, e.g. Journal of Allied Health, will also be a form of dissemination.

Who can you contact for more information or to indicate your interest in participating in the research project?

IF YOU DO NOT UNDERSTAND SOME OF THE INFORMATION OR CONCEPTS YOU MAY CONTACT THE PRINCIPAL INVESTIGATOR, DENISE MACIVER, (denisem@nait.ca or 780-471-8422) to discuss the research study prior to signing the certificate of consent.

If you are ready to participate in this project, please complete and sign the attached Consent Form and DMS Waiver Form and return both forms in person to Ruvimbo Sakutukwa at NAIT, room 508D, or scan and e-mail to Ruvimbo Sakutukwa at ruvimbos@nait.ca.

Thank you for considering this invitation.
Denise MacIver

This project has been reviewed by the Athabasca University Research Ethics Board. Should you have any comments or concerns regarding your treatment as a participant in this project, please contact the Research Ethics Office by e-mail at rebsec@athabascau.ca or by telephone at 1-800-788-9041, ext. 6718.

Informed Consent:

Your signature on this form means that:

- You have read the information about the research project.
- You have been able to ask questions about this project.
- You are satisfied with the answers to any questions you may have had.
- You understand what the research project is about and what you will be asked to do.
- You understand that you are free to withdraw your participation in the research project without having to give a reason, and that doing so will not affect you now, or in the future.
- You understand that if you choose to end your participation during data collection, any data collected from you up to that point will be retained by the researcher, unless you indicate otherwise.
- You understand that your data is being collected anonymously, and therefore cannot be removed once the data collection phase has ended.
- You agree to not disclose the names of your fellow participants
- You agree to not disclose any ultrasound findings or course standings about the learner participants.

Your signature confirms:

- You have read what this research project is about and understood the risks and benefits. You have had time to think about participating in the project and had the opportunity to ask questions and have those questions answered to your satisfaction.
- You understand that participating in the project is entirely voluntary and that you may end your participation at any time without any penalty or negative consequences.
- You have read Chapter 7 of the Tri-Council Policy Statement – 2nd version (TCPS2).
- You have read Athabasca University's Conflict of Interest information.
- You have been given a copy of this Informed Consent form for your records; and
- UNDERSTAND THE CONCEPTS OF RESEARCH CONFIDENTIALITY AND CONFLICT OF INTEREST AS PRESENTED IN A REVIEW OF Chapter Seven of the Tri- Council Policy Statement, 2nd version (TCP2) AND RELEVANT DOCUMENTS FROM THE ATHABASCA UNIVERSITY AND NAIT.
- You agree to participate in this research project.

_____________________________ _____________________________

Signature of Participant Date

Principal Investigator's Signature:

I have explained this project to the best of my ability. I invited questions and responded to any that were asked. I believe that the participant fully understands what is involved in participating in the research project, any potential risks and that he or she has freely chosen to participate.

_____________________________ _____________________________

Signature of Principal Investigator Date

Appendix G8: Letter of Information/Informed Consent for Ultrasound Models

You are invited to take part in a research project entitled *Point of Care Ultrasound: Distance Education for the use of Pocket Ultrasound Devices.*

This form is part of the process of informed consent. The information presented should give you the basic idea of what this research is about and what your participation will involve, should you choose to participate. It also describes your right to withdraw from the project. In order to decide whether you wish to participate in this research project, you should understand enough about its risks, benefits and what is required of you to be able to make an informed decision. This is the informed consent process. Take time to read this carefully as it is important that you understand the information given to you. Please contact the principal investigator, *Denise MacIver,* if you have any questions about the project or would like more information before you consent to participate.

It is entirely up to you whether or not you take part in this research. If you choose not to take part, or if you decide to withdraw from the research once it has started, there will be no negative consequences for you now, or in the future.

Introduction

My name is Denise MacIver and I am a doctoral student at Athabasca University. As a requirement to complete my degree, I am conducting a research project about the effectiveness of teaching ultrasound scanning skills to allied health professionals entirely by using distance education methods and technology. I am conducting this project under the supervision of Dr. Susan Bainbridge. I work at the Northern Alberta Institute of Technology (NAIT) where the research project will be conducted.

Why are you being asked to take part in this research project?

You are being invited to participate in this project because you are (or have been) an ultrasound model in the NAIT Diagnostic Medical Sonography (DMS) for the ultrasound practice scanning labs for the DMS students.

What is the purpose of this research project?

Point of care ultrasound (PoCUS), aka 'bedside ultrasound' is growing in user numbers in health and allied health, and it is being performed in a variety of locations – urban, rural, and in geographically isolated remote regions (Dietrich, et al., 2017). This rapid growth has raised concerns on the quality, consistency, and standardization of PoCUS. There is a global call for action to standardize PoCUS training and to provide training by distance education so that all users can access the training, especially those users in remote regions who do not have an option for traditional face-to-face training or guidance (Bowra et al., 2015). A literature review has revealed pockets of training (traditional and distance) for physicians and nurses, however, there is scant evidence of standardized training for the allied health sector, e.g. paramedicine, respiratory therapy, medical radiation technologists, etc.

The primary purpose of the study is to potentially contribute to the standardization and consistency of training in point of care ultrasound using remote training methods, e.g. distance education, to:

1. meet a global need in general, and,
2. meet a current gap of training for the allied health sector, meet a current gap for distance education methods for training

3. gain insights into the training needs of the different allied health professions, and
4. provide recommendations towards effective distance education techniques in PoCUS.

The study will have learner participants recruited from the allied health professional faculty at NAIT. The study will also have NAIT ultrasound instructors to teach or assess the learning outcomes at the end of the learners' training.

At the end of the training the learners will be assessed in the NAIT DMS Lab with ultrasound models serving as simulated "patients". The learners will be tested on how they perform a short ultrasound study entitled: Extended Focused Assessment with Sonography in Trauma (E-FAST) examination which scans the lungs, heart, abdomen, and pelvis areas for signs of trauma (potential spaces for free fluid or blood). Once trained, the E-FAST protocol takes 5-10 minutes to perform in the medical setting.

Each ultrasound model may receive a short script to act upon during the assessments so that the professional and behavioral skills of the learner can be tested in addition to the technical competencies.

What will you be asked to do?

Once all participant consent forms have been signed and once you have been assigned a participant code (for anonymity) your time commitment for the study will be approximately 8-12 hours spread over 2-3 calendar days anticipated for early to mid-June 2019.

Responsibilities will include lying on an ultrasound stretcher so that the learner can scan your chest and abdomen. There will also be an assessor in the room who is credentialed as a diagnostic medical sonographer. Each learner will perform the E-FAST protocol on you.

To note: NO images will be recorded or retained. The ultrasound images are for viewing only by the learner and assessor and once viewed they disappear. Your name will not appear on any of the images or any of the study's documentation.

What are the risks and benefits?

Risks

Part of obtaining consent for this research study involves explaining any real or perceived risks for you as a participant.

- It is important that you know you will be scanned with ultrasound by the learners in the study. This is contact scanning (nothing that is invasive) with the transducer (ultrasound probe) sliding over the skin of the body area with a small amount of non-toxic gel between the skin and the probe. These ultrasound-performing activities do not have any biological risks as ultrasound energy is non-ionizing with no adverse biological effects reported to date. Students/learners scanning standardized patients or live models is a standard practice in medical ultrasound training programs across Canada and other countries, for physicians and technologists. This is the standard practice for NAIT's Diagnostic Medical Sonography (DMS) program.

- Although the scanning practice is not done for diagnostic reasons students sometimes find unexpected findings, e.g. possible gallstone. The ultrasound instructors are trained to deal with this matter, and they will relate the unexpected finding to the person and advise checking it out with the person's physician. The body areas to be scanned for this study are: the chest wall on each side of the breastbone, the lower abdomen in the middle of the pelvis, the right side near the liver, the left side near the spleen and in the midline where the abdomen meets the rib cage (bottom of the breastbone) to check the heart. Participants' modesty and privacy will be maintained at all times as the NAIT DMS Lab is designed like an emergency room or clinic where each scanning station has curtains which can be drawn for the scanning sessions. This study will adhere to the NAIT DMS norm and best practice as described. In the event of any findings discovered during these scans which raise health concerns regarding the participant or model, the participant or model will be advised of the findings and will also be advised to consult their physician. "By consenting, participants have not waived any rights to legal recourse in the event of research-related harm" (TriCouncil Research Policy, 2014).

- Another best practice related to students scanning each other in DMS programs is that what the student sees on anyone's scan remains confidential; this is part of the medical profession's code of conduct and this is applied in ultrasound training as well, even though the persons being scanned are not real patients. This means that all students sign a confidentiality agreement, as do the instructors and assessors. This study will adhere to the NAIT DMS norm and best practice as described. As a participant you will be asked to agree to confidentiality as part of the informed consent process.

Benefits
If you participate in this research study, you will have the following perceived benefits:

- You will be part of a study that potentially identifies point of care ultrasound needs of different allied health professionals,
- You will be part of a study that potentially contributes to future instructional design for distance education in point of care education and techniques for using pocket ultrasound devices,
- You will contribute to the potential standardization of point of care ultrasound education for the global ultrasound community, including distance education methods, which in turn will benefit patients and the health care industry.
- There are no monetary incentives for participation in this research study.
- If applicable, study participants will receive a certificate of participation should this be eligible as evidence of continuing medical education/continuing professional development credits/hours for the participant's association and/or regulatory/licensing organization.

Do you have to take part in this project?
As stated earlier in this letter, involvement in this project is entirely voluntary. You are under no obligation to participate; your participation in this research study is entirely voluntary. It is your choice whether to participate or not. Whether you participate or not will have no impact on your employment status. You may change your mind at any time and withdraw from the study even if you agreed earlier. Withdrawal at any time can be without explanation and without prejudice.

If you wish to participate, you'll be asked to sign the consent form (at the end of this document). Informed consent is an ongoing process, which means that at any time you may revoke your consent and withdraw from the study, without consequence. If you wish to withdraw from the study, your information will be removed (name and participant code) upon your request.

After the data collection phase of the study is completed anonymized data will be in an aggregate form for analysis and at this time it will not be possible to remove individual participant code data from its aggregate form.

You may contact anyone you feel comfortable with to discuss the research study prior to signing the certificate of consent. If you do not understand some of the information or concepts you may contact the Principal Investigator, Denise MacIver, or the designated Research Administrative Assistant, Ruvimbo Sakutukwa, at any time for clarification.

How will your privacy and confidentiality be protected?
The ethical duty of confidentiality includes safeguarding participants' identities, personal information, and data from unauthorized access, use or disclosure.

Your name will not appear on the data collected; instead a participant code will be used on all collected data. Only one research administrative assistant will know your participant code and your name and assigned code will be recorded on a paper document to be locked and only accessible to said research assistant. Upon completion of the study the paper document will be shredded by the research assistant.

The PI will only have access to anonymized data. All anonymized data (paper) will be stored in a locked cabinet in room 508D at NAIT. Similarly, anonymized electronic data will be stored on a password-protected and encrypted external hard drive. Data will be kept for five (5) years, after which they will be shredded (paper) and expunged (electronic).

Confidential information will not be shared. The results that are published are anonymized aggregate results from the entire study. The results are being published in order that other interested people may learn from this research and to meet the PIs requirements for a doctoral dissertation.

How will my anonymity be protected?
Anonymity refers to protecting participants' identifying characteristics, such as name or description of physical appearance.

When you are recruited as an ultrasound model you will be given your own participant code.

Every reasonable effort will be made to ensure your anonymity; you will not be identified in publications without your explicit permission.

Should you wish to be identified as participating in the study for future presentations and/or publications please contact the PI directly or the same research assistant who recruited you and this information will be relayed to the PI. Also, as mentioned previously, upon request, a certificate of participation can be issued to you via the same research administrative assistant, and you would insert your name on the certificate of participation.

How will the data collected be stored?
There will be two types of data stored on paper (hard copy data): 1) participant recruitment information (assigned code, all signed consent forms per participant, and learner participant coded OSCE scores), and 2) electronic data (compiled online learner questionnaire data and instructor participant field notes). No data will be collected from you for analysis.

Paper data will be stored in a locked filing cabinet in Room 508D (office of the research administrative assistant). Electronic data will be stored on a password-protected and encrypted external hard drive. At the end of the study's data retention period (5 years) paper data will be shredded, and electronic data expunged.

The only data the PI will have access to is the anonymized learner questionnaire data, the anonymized instructor field notes data, and the anonymized learner OSCE results data. These anonymized data will be used for the PIs doctoral dissertation, presentations to the healthcare community and publications in peer-reviewed journals. There is no anticipated/future secondary use of the data and if there was further REB approval would be sought for another project.

Who will receive the results of the research project?

- The existence of the research will be listed in an abstract posted online at the Athabasca University Library's Digital Thesis and Project Room and the final research paper will be publicly available.

- After the project and the PIs doctoral dissertation is completed interested participants will have access to reports and/or presentations on the project available on the NAIT School website. School presentations on the study's results will also provide participants the opportunity to learn of the results as well as the broader healthcare community.

- Application to publish the study results in a professional peer-reviewed journal, e.g. Journal of Allied Health, will also be a form of dissemination.

Who can you contact for more information or to indicate your interest in participating in the research project?

IF YOU DO NOT UNDERSTAND SOME OF THE INFORMATION OR CONCEPTS YOU MAY CONTACT THE PRINCIPAL INVESTIGATOR, DENISE MACIVER, (denisem@nait.ca or 780-471-8422) to discuss the research study prior to signing the certificate of consent.

If you are ready to participate in this project, please complete and sign the attached Consent Form and DMS Waiver Form and return both forms in person to Ruvimbo Sakutukwa at NAIT, room 508D, or scan and e-mail to Ruvimbo Sakutukwa at ruvimbos@nait.ca.

Thank you for considering this invitation.

Denise MacIver

This project has been reviewed by the Athabasca University Research Ethics Board. Should you have any comments or concerns regarding your treatment as a participant in this project, please contact the Research Ethics Office by e-mail at rebsec@athabascau.ca or by telephone at 1-800-788-9041, ext. 6718.

Informed Consent:

Your signature on this form means that:

- You have read the information about the research project.
- You have been able to ask questions about this project.
- You are satisfied with the answers to any questions you may have had.
- You understand what the research project is about and what you will be asked to do.
- You understand that you are free to withdraw your participation in the research project without having to give a reason, and that doing so will not affect you now, or in the future.
- You agree to not disclose the names of any participants.

Your signature confirms:

- You have read what this research project is about and understood the risks and benefits. You have had time to think about participating in the project and had the opportunity to ask questions and have those questions answered to your satisfaction.
- You understand that participating in the project is entirely voluntary and that you may end your participation at any time without any penalty or negative consequences.
- You have read Chapter 7 of the Tri-Council Policy Statement – 2nd version (TCPS2).
- You have read Athabasca University's Conflict of Interest information.
- You have been given a copy of this Informed Consent form for your records; and
- UNDERSTAND THE CONCEPTS OF RESEARCH CONFIDENTIALITY AND CONFLICT OF INTEREST AS PRESENTED IN A REVIEW OF Chapter Seven of the Tri- Council Policy Statement, 2nd version (TCP2) AND RELEVANT DOCUMENTS FROM THE ATHABASCA UNIVERSITY AND NAIT.
- You agree to participate in this research project.

________________________________ ________________________________

Signature of Participant Date

Principal Investigator's Signature:

I have explained this project to the best of my ability. I invited questions and responded to any that were asked. I believe that the participant fully understands what is involved in participating in the research project, any potential risks and that he or she has freely chosen to participate.

________________________________ ________________________________

Signature of Principal Investigator Date

Appendix G9: Confidentiality and Conflict of Interest Document

Confidentiality Agreement for Principal Investigator and Research Assistants (all participants sign confidentiality agreement on Informed Consent Form)
and
Confirmation of Review of Conflict of Interest Documents

I ____ agree that I will not disclose the identity of any participant, nor will I discuss/disclose any participant ultrasound findings or information that I may happen to learn from the ultrasound activities that the participants undertake, during and after the above entitled research project. **To note**: participants will be notified of any/all unexpected findings.

I ____ confirm that I UNDERSTAND THE CONCEPTS OF RESEARCH CONFIDENTIALITY AND CONFLICT OF INTEREST AS PRESENTED IN A REVIEW OF Chapter Seven of the Tri-Council Policy Statement, 2nd version (TCP2) AND RELEVANT DOCUMENTS FROM THE ATHABASCA UNIVERSITY AND NAIT.

Signature of PI or Research Assistant ______________________________ Date ________________

Printed name of PI or Research Assistant ____

Signature of Witness _____ ______________________________ Date ________________

Printed name of Witness ____

Appendix H: NAIT Research Team and Research Assistant Plan

RA#	Role Title	Primary Function	Pre-Study Pilot Role	Data Collection Tool
1 and 2	Instructors (data contributors)	Team teaching as facilitators in Moodle course & hands-on instructors in scanning labs	Co-create & validate instructional resources & OSCE rubric	Instructor Field Notes (electronic) Appendix
3, 4, 5	OSCE Assessors (non-contributors to data)	Independent assessments of OSCEs – 3 per learner	Review instructional resources & OSCE rubric & plan	Learner OSCE scores (recorded on paper) Appendix F1
6, 7 & 8	Administrative Assistants (non-contributors to data)	Participant Recruitment, Coding Procedures; Moodle course enrolment, deployment & collection of questionnaires and field notes, scheduling & coordination of Labs and OSCEs		N/A
9	Information Technology (IT) Assistant (non-contributors to data)	Technical Assistance, primarily for REACTS support in scanning labs (as informed by Field Test)		N/A
10	Co-Coder	Assist PI*		N/A

*PI = Researcher as Principal Investigator

Research Assistant Criteria

RAs 1 and 2	Credentialed in sonography education
RAs 3-5	Credentialed in sonography education and experienced in OSCE assessments
RA 6 – 8	Experienced in administrative support procedures
RA 9	Experienced in Information Technology (IT) support
RA 10	Experienced in coding and neutral to project

Appendix I: NAIT Executive Approval for Proposed Action Research [Case Study]

December 13, 2018
NAIT Research Ethics Board
Attention: Dr. Melissa Dobson,
Chair mdob son@nait.ca

Dear Dr. Dobson,

Re: Letter of Support for Denise Maclver's Application for Research Ethics Review of Research Involving Humans - Proposed Research Project: Point of Care Ultrasound: Distance Education in the use of Pocket Ultrasound Devices

Please accept this letter in support of Denise Maclver's application to conduct her proposed research project in pursuit of her doctoral dissertation with Athabasca University.

Ms. Maclver has provided a description of her project and the resources required for the study and this letter will confirm my support for this research project to be conducted at NAIT, as proposed.

If yourequire further information, please do not hesitate to contact me.

Yours truly,

Kevin Shufflebotham, Provost
NAIT
P. 780.491.5425
E kevins@nait.ca

Appendix J1: Certification of Ethical Approval from Athabasca University

Athabasca University
RESEARCH CENTRE

CERTIFICATION OF ETHICAL APPROVAL

The Athabasca University Research Ethics Board (AUREB) has reviewed and approved the research project noted below. The AUREB is constituted and operates in accordance with the current version of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS) and Athabasca University Policy and Procedures.

Ethics File No.: 23337

Principal Investigator:
Mrs. Denise MacIver, Graduate Student
Centre for Distance Education\Doctor of Education in Distance Education

Supervisor:
Dr. Susan Bainbridge (Supervisor)

Project Title:
Point of Care Ultrasound: Distance Education for the use of Pocket Ultrasound Devices

Effective Date: March 22, 2019 **Expiry Date**: March 21, 2020

Restrictions:

Any modification or amendment to the approved research must be submitted to the AUREB for approval.

Ethical approval is valid *for a period of one year*. An annual request for renewal must be submitted and approved by the above expiry date if a project is ongoing beyond one year.

A Project Completion (Final) Report must be submitted when the research is complete *(i.e. all participant contact and data collection is concluded, no follow-up with participants is anticipated and findings have been made available/provided to participants (if applicable))* or the research is terminated.

Approved by: **Date:** March 22, 2019

Connie Blomgren, Chair
Centre for Distance Education, Departmental Ethics Review Committee

Athabasca University Research Ethics Board
University Research Services, Research Centre
1 University Drive, Athabasca AB Canada T9S 3A3 E-mail rebsec@athabascau.ca
Telephone: 780.675.6718

Appendix J2: Research Ethics Board Approval from NAIT

The Northern Alberta Institute of Technology
Research Ethics Board
Certificate of Ethics Approval for Research Proposal

Principal Investigator: Denise MacIver

Organization: NAIT

Project Title: Distance Education for the use of Pocket Ultrasound Devices

Grant/Contract Agency: none

Research Ethics Application #: 2019-05

Research Ethics Certificate Expiry Date: April 12, 2020

Certification of the Northern Alberta Institute of Technology
Research Ethics Approval

NAIT REB has received your application for research ethics review and concluded that your proposed research meets the Northern Alberta Institute of Technology Policy for *Research Involving Human Subjects* (IR 10.0) and *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (TCPS 2). On behalf of the Northern Alberta Institute of Technology's Research Ethics Board (NAIT REB), we are providing research ethics approval for your proposed project.

This research ethics approval is valid for one year. To request a renewal, please contact NAIT REB or Jodi Lommer (REB Co-chair) and explain the circumstances and reference the Research Ethics Application # assigned to this project (see above). Also, if there are significant changes that need to be reviewed, or if any adverse effects to human participants are encountered in your research, please contact REB@nait.ca immediately.

Co-chair, Research Ethics Board

Printed Name: Jodi Lommer **Signature:**

Date: April 12, 2019

Appendix K: Research Timeline

Principal Investigator (Researcher): Denise MacIver
Co-Supervisors: Dr. Susan Bainbridge and Dr. Rory McGreal

Action	Who/How	When
Research Ethics Approval, Participant Recruitment Process and Pre-Study Field Test		
Research Ethics Board (REB) approval attained: AU and NAIT	Principal Investigator (PI)	February-April 2019
Recruit Participants: Learners, Instructors, Assessors, Ultrasound Models	Research Administrative Assistant (RAA) via Informed Consent process & REB approved advertisement posters/e-mails	After REB approvals: April, 2019
Orient recruited instructors, assessors, research administrative assistant & other assistants (project team) to research sequence, process and logistics	PI & RAA	April 2019
Conduct Pre-Study Field Test	PI and Project Team	April 2019
Assign and document participant codes	RAA	April 2019
Enroll participants into Moodle course site	RAA	May 2019
Data Collection Process: May to June 2019		
Learner Pre-Study Online Questionnaire	RAA	Early May 2019
Learner Mid-Study Questionnaire	RAA	Last week of May 2019
OSCE Scores of learner participants (after scanning labs)	RAA	June 2019
Learner End-Study Questionnaire (after a learner's OSCEs)	RAA	June 2019
Instructor Field Notes	RAA	June - July
Data Analysis & Dissertation Writing – Data Set		
Co-Coding (iterative process)	PI and Co-Coder	Aug-Dec 2019
Data analysis, writing of draft #1	PI	Sep 2019 – June 2020
Draft #1 submission to co-supervisors		June 2020
Writing/oversight of dissertation (iterative drafts)	PI & AU Co-Supervisors	June-Aug/Sep 2020
Final submission of dissertation; anticipated defense	PI	Fall 2020

Appendix L: Co-coder Guidelines for Learner Narrative Analysis

(Guidelines developed in alignment with Appendix D - Data collection and analysis framework)

Learner narratives (words and phrases) to be assessed and assigned to a:

1. New World Kirkpatrick Model (NWKM) level(s), and
2. Learning domain and respective hierarchy - Cognitive, Psychomotor, Affective

Data for narrative analysis: Three Questionnaire Reports generated by *Qualtrics* and two Instructor Field Notes submitted on *MSWord* documents

- Sections for narrative analysis:
- Pre-study questionnaire report – question #10
- Mid-study questionnaire report – questions #6 though #14
- End-study questionnaire report – questions #9 and #10

Reference for NWKM:

Kirkpatrick, J., & Kirkpatrick, W. (2010-2019). An Introduction to the New World Kirkpatrick Model. Kirkpatrick Partners, LLC, Newman: GA

Kirkpatrick, J.D., & Kirkpatrick, W.K. (2016). *Kirkpatrick's Four Levels of Training Evaluation.* Association for Talent Development: Alexandria, VA

NWKM Level 1: REACTION - The degree to which the participants find the training favorable, engaging and relevant to their jobs.

- How did the learners feel about the proposed study and distance education training, even before they started? Was it relevant to their scopes of practice? What were their beliefs in distance education for hands-on learning before and after the training?
- Did the learners like the EFAST training overall (theory and practical)? Were they satisfied? Did the learners remain engaged throughout the study?

Data analysis to assess:

1. <u>Engagement</u>: the degree to which participants are actively involved in and contributing to the learning experience
   a. attitude at onset of study
   b. retention of interest throughout the study
2. <u>Relevance</u>: the degree to which training participants will have the opportunity to use or apply what they learned in training on the job
   a. Why interested in the training?
   b. Intentions to apply the training after the learning event
3. <u>Satisfaction</u> with the training
   a. Theory – *Moodle* content (self-directed) to prepare for practical training
   b. Practical – Hands-on training (remote interactive instruction) with *REACTS*
   c. OSCE experience – prior to OSCEs and after

NWKM Level 2: LEARNING - The degree to which participants acquire the intended knowledge, skills, attitude, confidence, and commitment based on their participation in the training.

Knowledge: "I know it"
Skill: "I can do it right now"

*Attitude: "I believe this will be worthwhile to do on the job"
*Confidence: "I think I can do it on the job"
*Commitment: "I intend to do it on the job"

- Did theoretical knowledge transfer occur with engagement in the Moodle course before the practical training – did learners feel prepared for their scanning labs?
- Did theoretical knowledge transfer occur over the 3 scanning labs? (application of theory to practical training)
- How did learners evaluate their training experience?

*PI's caveat: In the context of this study "on the job" is related to the OSCE experience, a simulation of performing an EFAST examination "on the job"

NWKM Level 3: BEHAVIOURS - The degree to which participants apply what they learned during training when they are back on the job.

Required Drivers: Processes and systems that reinforce, encourage and reward performance of critical behaviors on the job

- Did the OSCE results (competency skills and scores) demonstrate that theoretical knowledge, practical skills, and professional behaviors were transferred, resulting in a behavior change 'on the job'? (narratives relating to learner performance on OSCEs, e.g. comments on their scores and OSCE experience)?
- Were the core skills attained (critical behaviors), that is, learner's ability to demonstrate hands-on scanning skills and required professional behaviors as an ultrasound-naïve learner?
- How did learners feel about their OSCE scores (reward of performance)?

NWKM Level 4: RESULTS* – The degree to which targeted outcomes occur, as a result of the training and the support and accountability package.

Leading Indicators: short-term observations and measurements suggesting that critical behaviors are on track to create a positive impact on desired results
*PI's caveat: In the context of this study, the "Results" level of the NWKM are framed in those learner and instructor recommendations for future instructional design, i.e. continuance of targeted outcomes in standardized POCUS training; standardization is intended to create a positive impact on desired consistency of POCUS training and practice.

- What did learners recommend for future POCUS training via a remote distance education setting based on their learning experience in the study?
- What advice did learners provide for future DE POCUS instructional design at the mid-study point (before their OSCEs)?
- What recommendations for future DE POCUS instructional design at the end-study point? (after their OSCEs)?
- What did instructors recommend for future POCUS training via a remote distance education setting based on their teaching experience in the study?
- How do the study results inform future DE POCUS instructional design?
- How does the study's interpretive case study research model inform future research?
- How did the study's research experience impact the organization (NAIT)?

Learning Domains

- Cognitive Domain: Did the learners apply their theoretical knowledge from their self-directed Moodle course in their scanning labs and OSCEs?

    - *Remember* to *Understand* to *Apply* to *Analyze* to *Evaluate* to *Create* (Anderson et al., 2001)
- Psychomotor Domain: Did the learners apply their practical training (knowledge, skills, attitudes) in their interactive remote hands-on scanning labs with their instructors and in their OSCEs?
    - *Perception* to *Set* to *Guided Response* to *Mechanism*, to *Complex Overt Response* to *Adaptation* to *Origination* (Simpson, 1966)
- Affective Domain: Did the learners demonstrate their professional behaviors during their scanning labs and OSCEs?
    - *Receiving* to *Responding* to *Valuing* to *Organization* to *Characterization*
- Were the learners successful in applying their cognitive, psychomotor, and affective learning skills (synthesis of performance) during their OSCE sessions?
- Was there hierarchical progression in each of the learning domain taxonomies from pre to end study?

References for Learning Domains

Anderson, L.W., Krathwohl, D.R. & Bloom, B.S. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives* (Complete ed.). Longman

Simpson, E. J., & Illinois Univ., (1966). *The Classification of Educational Objectives in the Psychomotor Domain.* https://eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED010368

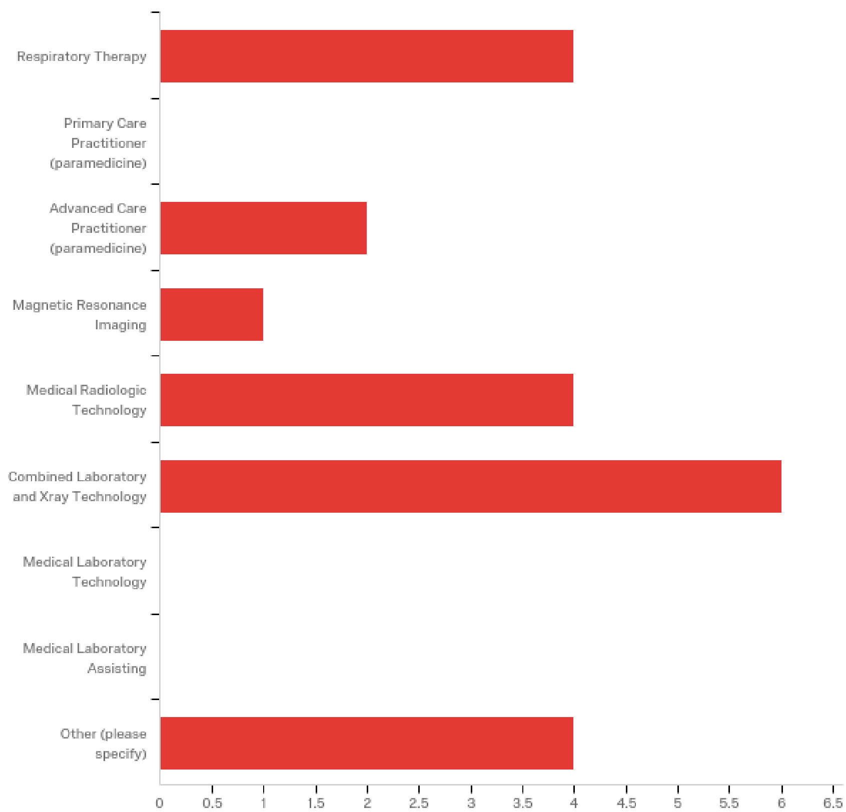
Wilson, L.Q. (2020). *The Three domains of learning: Cognitive, Affective, and Psychomotor/Kinesthetic.* The Second Principle. http://thesecondprinciple.com/instructional-design/threedomainsoflearning/

Appendix M1: Pre-study Questionnaire Report

1. Participant Code Number:

L22	L17	L04	L18
L19	L15	L20	L03
L09	L12	L06	L13
L21	L08	L14	L16
L07	L10	L01	L05

2. Which health professional group are you from? (select all that apply)

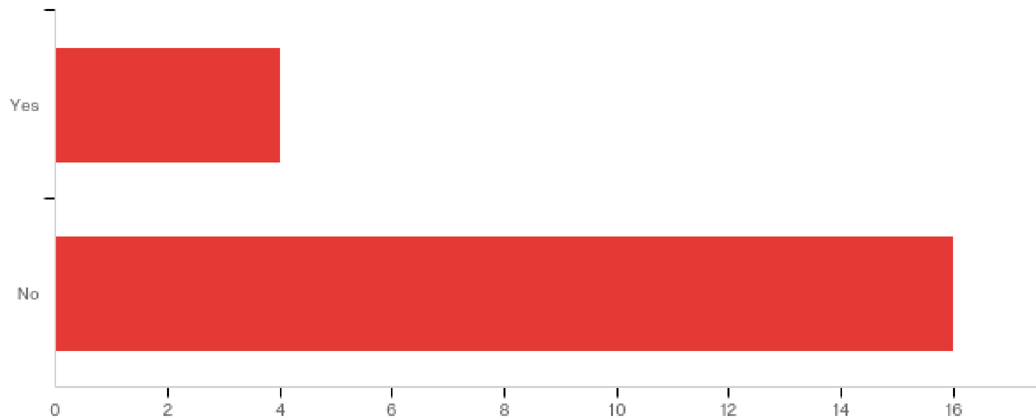


Answer	%	Count
Respiratory Therapy	19.05%	4
Primary Care Practitioner (paramedicine)	0.00%	0
Advanced Care Practitioner (paramedicine)	9.52%	2
Magnetic Resonance Imaging	4.76%	1
Medical Radiologic Technology	19.05%	4
Combined Laboratory and Xray Technology	28.57%	6
Medical Laboratory Technology	0.00%	0
Medical Laboratory Assisting	0.00%	0
Other (please specify)	19.05%	4
Total	100%	21

Other (please specify):

- Exercise professional
- Biomedical Engineering Technology
- Veterinarian, previously nursing
- Personal Fitness Trainer

3. Have you had any training or experience with ultrasound scanning?



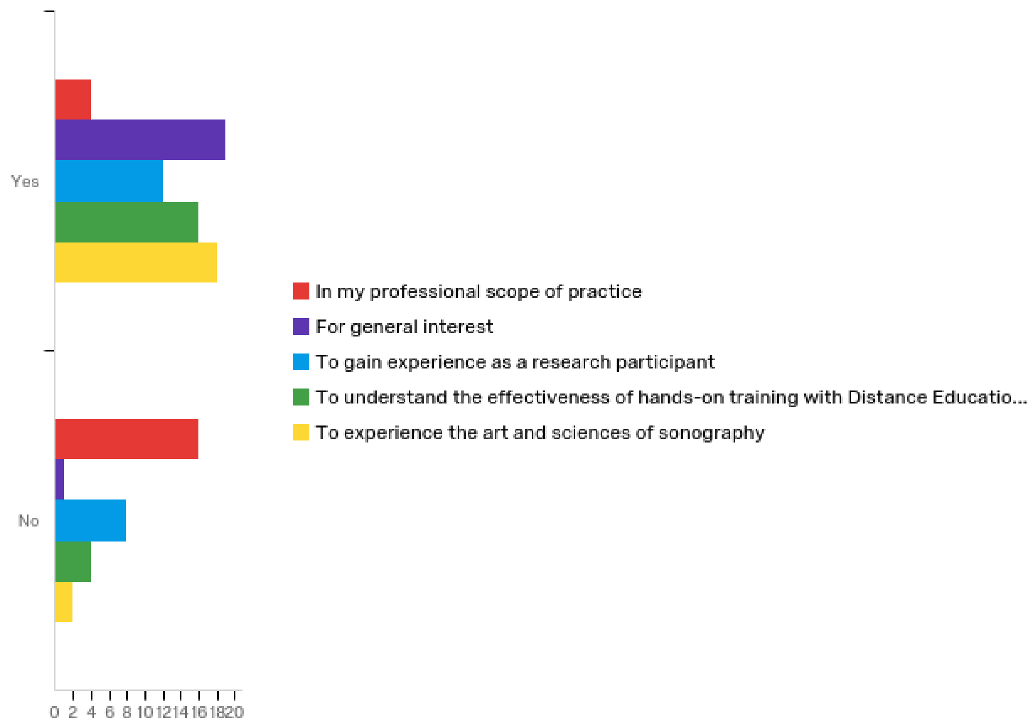
Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Have you had any training, or experience with ultrasound scanning?	1.00	2.00	1.80	0.40	0.16	20

Answer	%	Count
Yes	20.00%	4
No	80.00%	16
Total	100%	20

4. If yes, please describe the ultrasound scanning experience you had (if no, please type N/A):

• Modeled as a DMS patient.
• N/A
• I answered No
• N/A
• N/A
• N/A
• NA
• no experience
• n/a
• Very basic usage of an ultrasound scanner, and imaging geometric phantoms
• N/A
• N/A
• N/A
• N/A
• N/A
• N/A
• N/A
• Femoral artery blood velocity and vessel diameter, subject for ventricular filling experiments
• As part of my ESWL training in the past I have used the US transducer built-in our therapy head alongside C-Arm to localize radiolucent renal calculi with small portion of our patients as the majority had radiopaque calculi and normally, we use only the C-Arm for localization
• N/A

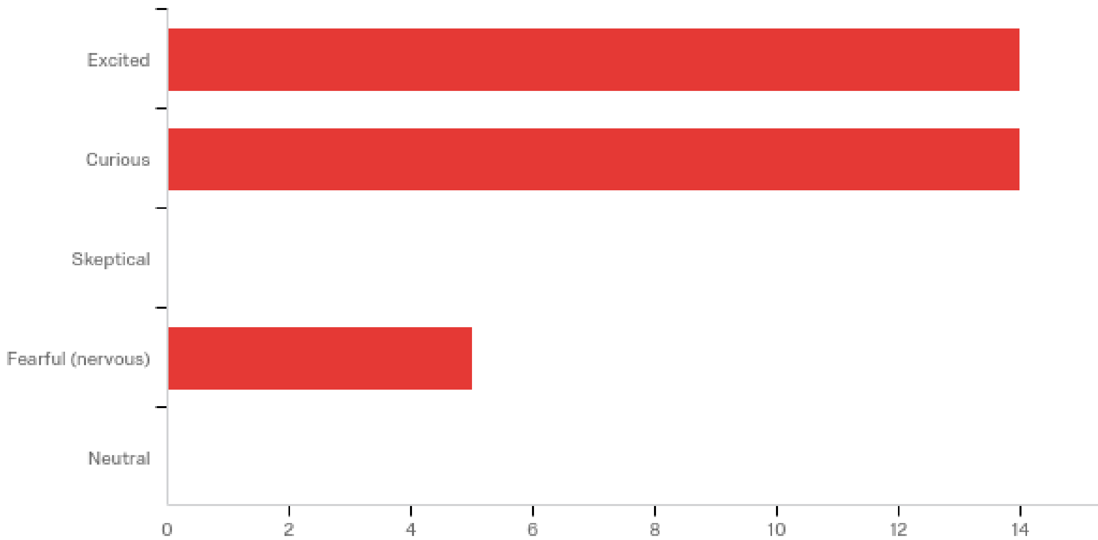
5. For each of the following statements please answer Yes or No: From the description of the study (Informed Consent Form) I expect to use the learning experience:



Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
In my professional scope of practice	1.00	2.00	1.80	0.40	0.16	20
For general interest	1.00	2.00	1.05	0.22	0.05	20
To gain experience as a research participant	1.00	2.00	1.40	0.49	0.24	20
To understand the effectiveness of hands-on training with Distance Education	1.00	2.00	1.20	0.40	0.16	20
To experience the art and sciences of sonography	1.00	2.00	1.10	0.30	0.09	20

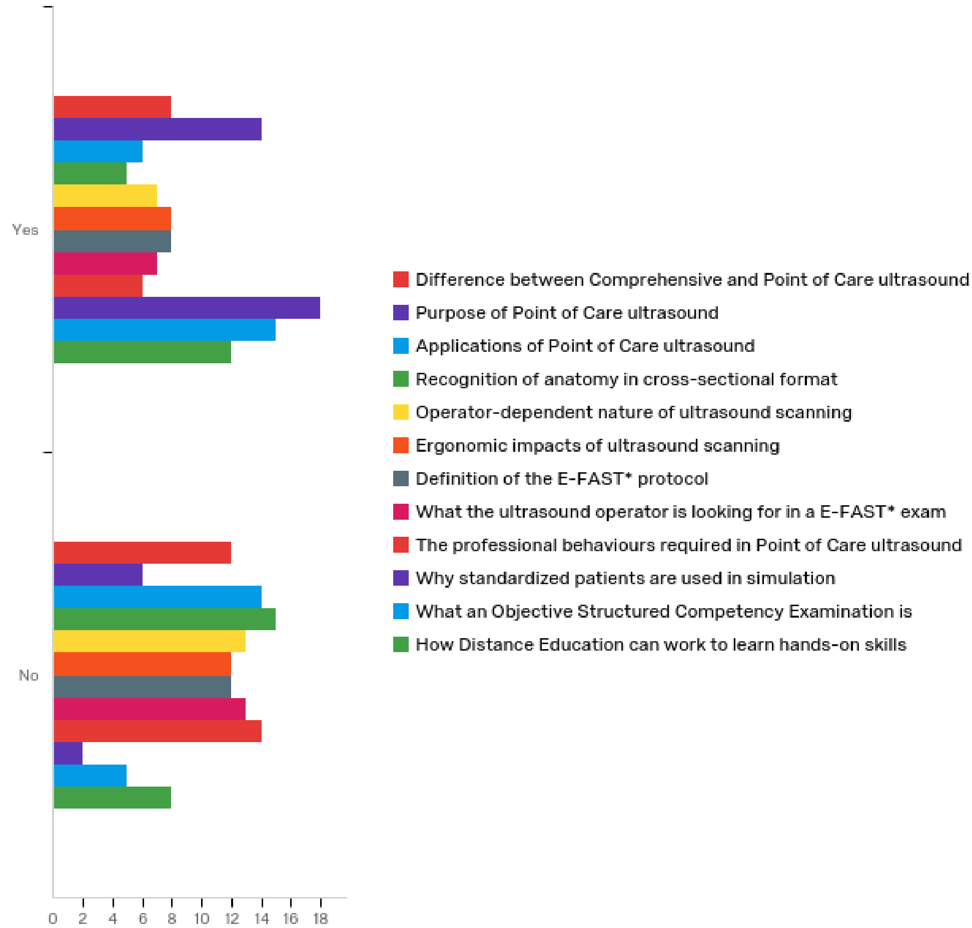
Question	Yes		No		Total
In my professional scope of practice	20.00%	4	80.00 %	16	20
For general interest	95.00%	19	5.00%	1	20
To gain experience as a research participant	60.00%	12	40.00 %	8	20
To understand the effectiveness of hands-on training with Distance Education	80.00%	16	20.00 %	4	20
To experience the art and sciences of sonography	90.00%	18	10.00 %	2	20

6. From the description of the study (Informed Consent Form) my overall engagement with the study is (select all that apply):



Answer	%	Count
Excited	42.42%	14
Curious	42.42%	14
Skeptical	0.00%	0
Fearful (nervous)	15.15%	5
Neutral	0.00%	0
Total	100%	33

7. For each of the following statements please answer Yes or No: At this point of the study I am knowledgeable in the following:

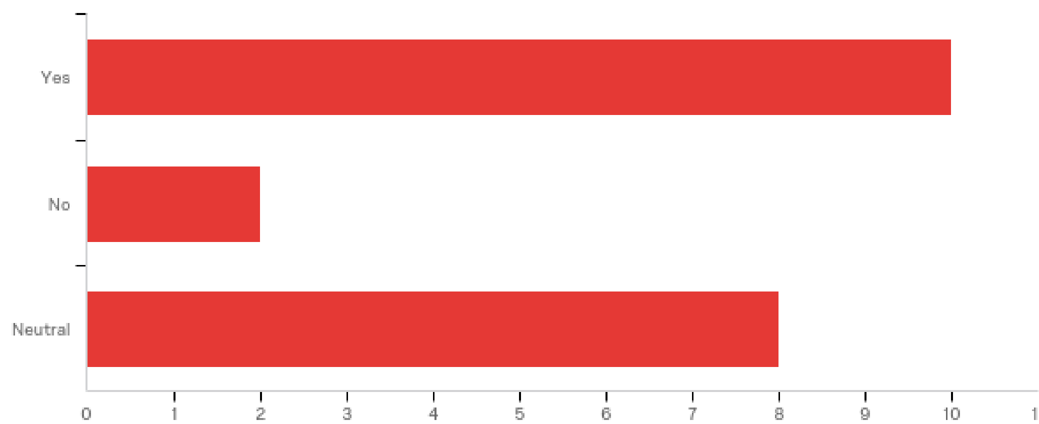


Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Difference between Comprehensive and Point of Care ultrasound	1.00	2.00	1.60	0.49	0.24	20
Purpose of Point of Care ultrasound	1.00	2.00	1.30	0.46	0.21	20
Applications of Point of Care ultrasound	1.00	2.00	1.70	0.46	0.21	20
Recognition of anatomy in cross- sectional format	1.00	2.00	1.75	0.43	0.19	20
Operator-dependent nature of ultrasound scanning	1.00	2.00	1.65	0.48	0.23	20
Ergonomic impacts of ultrasound scanning	1.00	2.00	1.60	0.49	0.24	20
Definition of the E-FAST* protocol	1.00	2.00	1.60	0.49	0.24	20
What the ultrasound operator is looking for in a E-FAST* exam	1.00	2.00	1.65	0.48	0.23	20
The professional behaviours required in Point of Care ultrasound	1.00	2.00	1.70	0.46	0.21	20
Why standardized patients are used in simulation	1.00	2.00	1.10	0.30	0.09	20

What an Objective Structured Competency Examination is	1.00	2.00	1.25	0.43	0.19	20
How Distance Education can work to learn hands-on skills	1.00	2.00	1.40	0.49	0.24	20

Question	Yes		No		Total
Difference between Comprehensive and Point of Care ultrasound	40.00%	8	60.00%	12	20
Purpose of Point of Care ultrasound	70.00%	14	30.00%	6	20
Applications of Point of Care ultrasound	30.00%	6	70.00%	14	20
Recognition of anatomy in cross-sectional format	25.00%	5	75.00%	15	20
Operator-dependent nature of ultrasound scanning	35.00%	7	65.00%	13	20
Ergonomic impacts of ultrasound scanning	40.00%	8	60.00%	12	20
Definition of the E-FAST* protocol	40.00%	8	60.00%	12	20
What the ultrasound operator is looking for in a E-FAST* exam	35.00%	7	65.00%	13	20
The professional behaviours required in Point of Care ultrasound	30.00%	6	70.00%	14	20
Why standardized patients are used in simulation	90.00%	18	10.00%	2	20
What an Objective Structured Competency Examination is	75.00%	15	25.00%	5	20
How Distance Education can work to learn hands-on skills	60.00%	12	40.00%	8	20

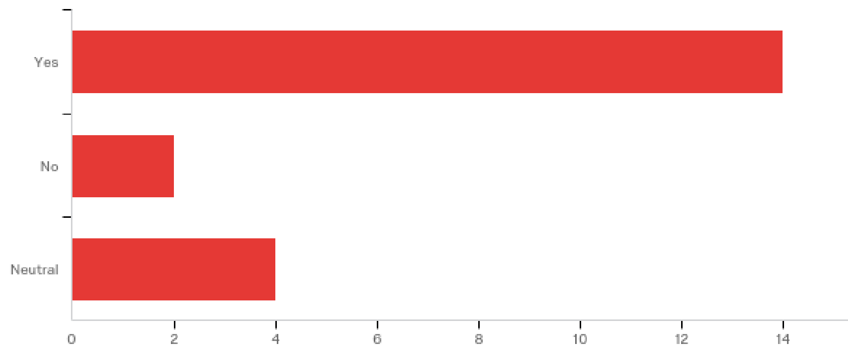
8. Do you believe that hand-on training (psychomotor skills) can be taught entirely via Distance Education? (If No or Neutral please explain in final question/comment section)



Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Do you believe that hand-on training (psychomotor skills) can be taught entirely via Distance Education? (If No or Neutral please explain in final question/comment section)	1.00	3.00	1.90	0.94	0.89	20

Answer	%	Count
Yes	50.00%	10
No	10.00%	2
Neutral	40.00%	8
Total	100%	20

9. Do you believe that attitudes and professional behaviours (affective skills) can be taught entirely via Distance Education? (If No or Neutral please explain in the final question/comment section)



Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Do you believe that attitudes and professional behaviours (affective skills) can be taught entirely via Distance Education? (If No or Neutral please explain in the final question/comment section)	1.00	3.00	1.50	0.81	0.65	20

Answer	%	Count
Yes	70.00%	14
No	10.00%	2
Neutral	20.00%	4
Total	100%	20

10. Do you have any concerns, questions, or comments?

- I am very excited for this research project. I think distance Education will have a great positive impact for the future of learning. I am hesitant though to see how some skills that require fine detail will be taught from a distance.
- Psychomotor skills: unsure that distance delivery alone would have the same effect as face to face
- No.
- I'm uncertain about whether these could be taught entirely via distance education.
- no
- n/a
- Unsure if all of the skills can be transferred during distance education...
- The success of hands-on training via entirely distance education would, in my opinion, be somewhat dependent on the complexity of the task that is being taught.
- I put neutral for the question above as I'm skeptical professional behaviours can be taught at all, whether face to face or distance. I think they are something you have, or you do not, though I do believe an instructor creating a safe environment helps enable learners to have the correct behaviours.
- I have never delivered or received psychomotor training through distant education, so I have unsure of its effectiveness.

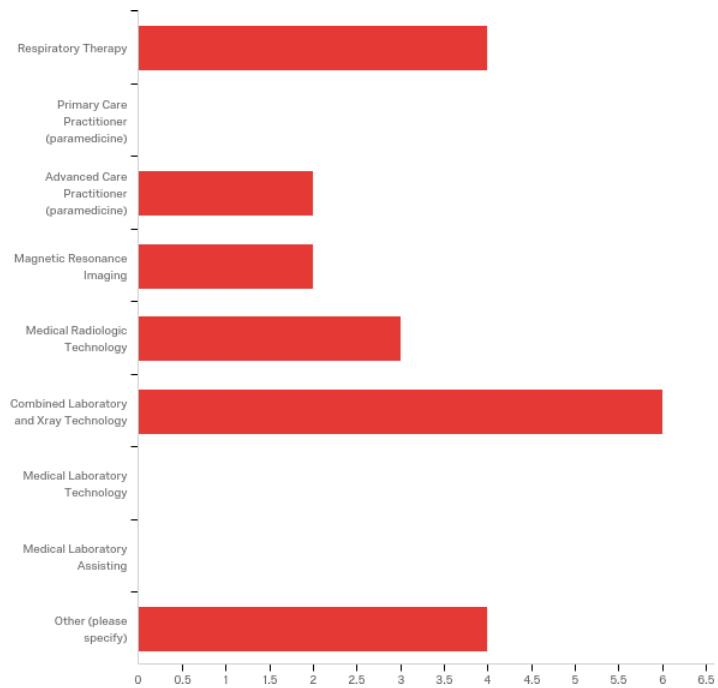
I am not skeptical that psychomotor skills can be taught via distance education. I am curious how these skills would transfer to real patients in a clinical environment. In my experience some level of mentoring and coaching are needed when faced with real patients and all their unique presentations.

Appendix M2: Mid-study Questionnaire Report

1. Participant Code Number:

L22	L17	L04	L18
L19	L15	L20	L03
L09	L12	L06	L13
L21	L08	L14	L16
L07	L10	L01	L05

2. Which health professional group are you from? (select all that apply)

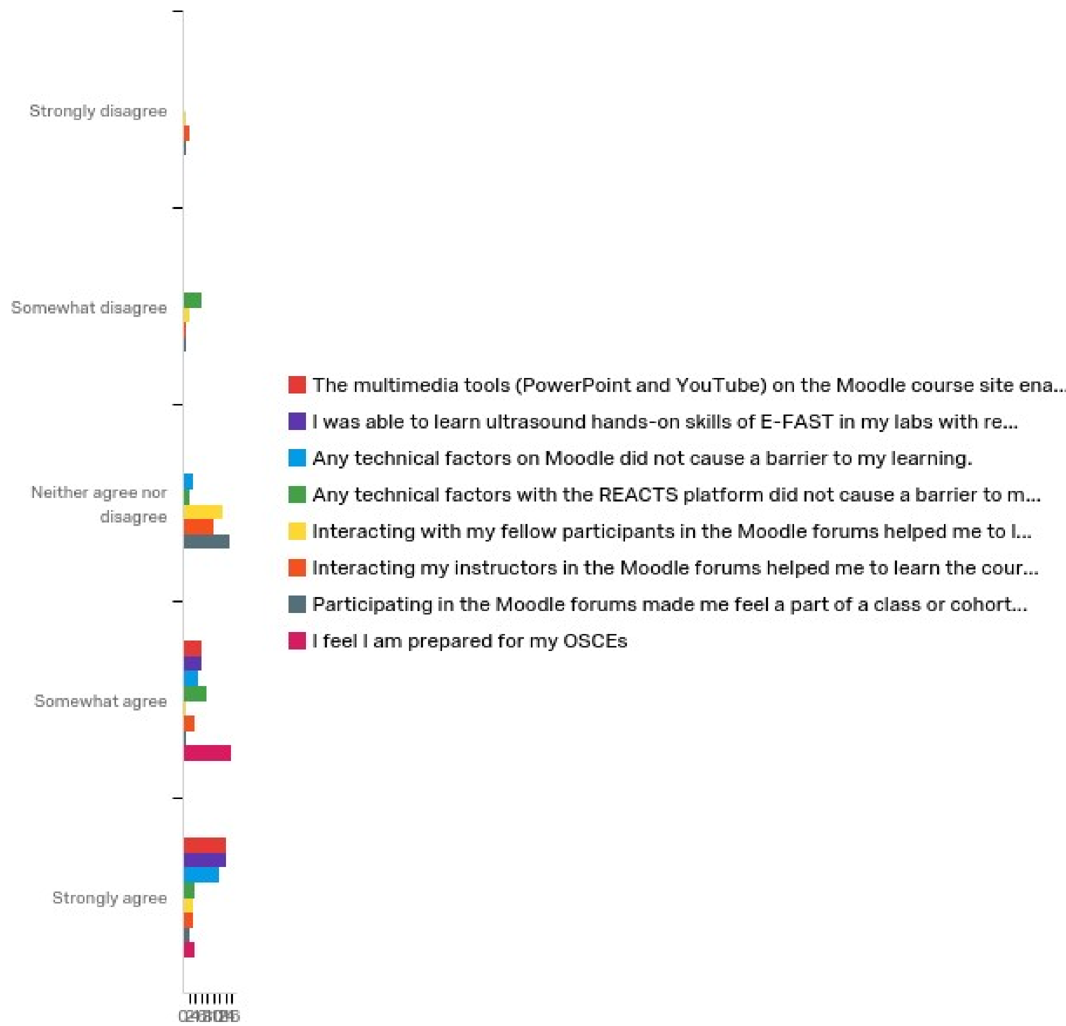


Answer	%	Count
Respiratory Therapy	19.05%	4
Primary Care Practitioner (paramedicine)	0.00%	0
Advanced Care Practitioner (paramedicine)	9.52%	2
Magnetic Resonance Imaging	9.52%	2
Medical Radiologic Technology	14.29%	3
Combined Laboratory and Xray Technology	28.57%	6
Medical Laboratory Technology	0.00%	0
Medical Laboratory Assisting	0.00%	0
Other (please specify)	19.05%	4

Other please specify:

- Veterinarian
- Biomedical Engineering Technologist
- Exercise professional
- Personal Fitness Trainer

3. On a scale of 1 - 5 with 1 = strongly disagree and 5 = strongly agree how would you rate the following statements regarding your distance education learning experience?



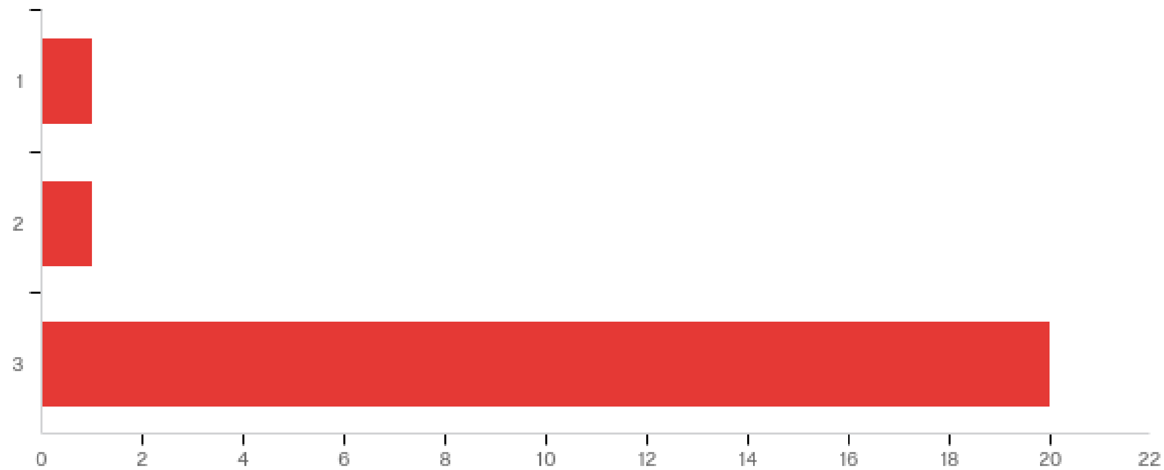
Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
The multimedia tools (PowerPoint and YouTube) on the Moodle course site enabled me to learn the theory of ultrasound principles.	11.00	12.00	11.70	0.46	0.21	20
I was able to learn ultrasound hands-on skills of	11.00	12.00	11.70	0.46	0.21	20

E-FAST in my labs with remote instruction.						
Any technical factors on Moodle did not cause a barrier to my learning.	10.00	12.00	11.45	0.74	0.55	20
Any technical factors with the REACTS platform did not cause a barrier to my learning.	9.00	12.00	10.50	1.12	1.25	20
Interacting with my fellow participants in the Moodle forums helped me to learn the course material.	8.00	12.00	10.15	0.96	0.93	20
Interacting my instructors in the Moodle forums helped me to learn the course material.	8.00	12.00	10.25	1.09	1.19	20
Participating in the Moodle forums made me feel a part of a class or cohort.	8.00	12.00	10.10	0.83	0.69	20
I feel I am prepared for my OSCEs	11.00	12.00	11.20	0.40	0.16	20

Question	Strongly disagree		Somewhat disagree		Neither agree nor disagree		Somewhat agree		Strongly agree		Total
The multimedia tools (PowerPoint and YouTube) on the Moodle course site enabled me to learn the theory of ultrasound principles.	0.00%	0	0.00%	0	0.00%	0	30.00%	6	70.00%	14	20
I was able to learn ultrasound hands-on skills of E-FAST in my labs with remote instruction.	0.00%	0	0.00%	0	0.00%	0	30.00%	6	70.00%	14	20
Any technical factors on Moodle did not cause a barrier to my learning.	0.00%	0	0.00%	0	15.00%	3	25.00%	5	60.00%	12	20
Any technical factors with the REACTS platform did not cause a barrier to my learning.	0.00%	0	30.00%	6	10.00%	2	40.00%	8	20.00%	4	20
Interacting with my fellow participants in the Moodle forums helped me to learn the course material.	5.00%	1	10.00%	2	65.00%	13	5.00%	1	15.00%	3	20
Interacting my instructors in the Moodle forums helped me to learn the course material.	10.00%	2	5.00%	1	50.00%	10	20.00%	4	15.00%	3	20
Participating in the Moodle forums made me feel a part of a class or cohort.	5.00%	1	5.00%	1	75.00%	15	5.00%	1	10.00%	2	20

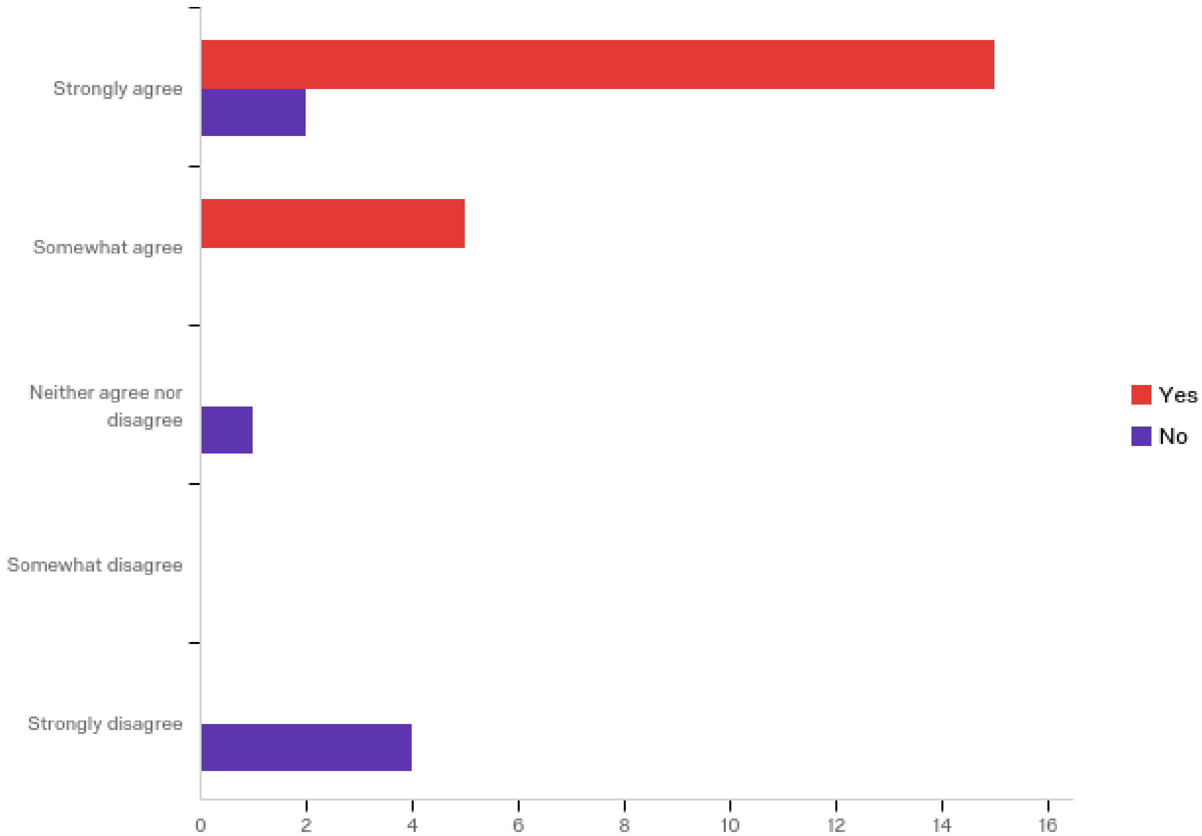
I feel I am prepared for my OSCEs	0.00%	0	0.00%	0	0.00%	0	80.00%	16	20.00%	4	20

4. How many scanning labs were you able to complete? (Choose one only)



Answer	%	Count
1	4.55%	1
2	4.55%	1
3	90.91%	20

5. The theory portion of Moodle instruction prepared me for my hands-on scanning labs.



Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Yes	11.00	12.00	11.25	0.43	0.19	20
No	11.00	15.00	13.57	1.76	3.10	7

Question	Strongly agree		Somewhat agree		Neither agree nor disagree		Somewhat disagree		Strongly disagree		Total
Yes	75.00%	15	25.00%	5	0.00%	0	0.00%	0	0.00%	0	20
No	28.57%	2	0.00%	0	14.29%	1	0.00%	0	57.14%	4	7

6. What was MOST helpful for your learning experience in the Moodle course site?

• audio within the video
• YouTube
• Supplemental YouTube videos showing the whole scan
• The PowerPoint and two of the videos in particular - the shorter ones, one with a woman performing the FAST exam and one with a man performing the EFAST exam with the drawings on his patient.
• The narrated PowerPoint
• PPTs with voice over and videos
• The PowerPoints
• The narrated PowerPoints were helpful combined with the video demonstrations.
• Most helpful were the narrated PPTs and the videos.
• Narrated PowerPoint slides. Multiple examples of good/bad pathology. YouTube videos were great supplements.
• Voice over on PowerPoints
• The YouTube videos were extremely helpful. I'd recommend that students watch those first before tackling the PowerPoint presentations, as it provided some visual clarity to the content. Having an instructor give an online lecture helped prevent any misunderstandings in terms of content (Brent's was especially helpful).
• Videos showing US image and hand/probe placement at same time
• Both the PPT and videos.
• PowerPoints and images
• YouTube videos
• The narrated PowerPoint provided great explanation and tips
• All the images in the PowerPoint presentations
• Videos of E-FAST scans being done
• Guided PPTs

7. What was LEAST helpful for your learning experience in the Moodle course site?

• none
• Forums
• Forums
• I didn't use the forums though maybe they would have been helpful if I had.
• I didn't use any discussion forums or watch most of the videos.
• Forums
• Nothing. Everything was helpful
• There were a couple variances of technique in the videos which is a little confusing for a new learner, but they were rectified in the labs.
• I did not use the glossary.
• No negative experiences on Moodle.
• Forums didn't get used
• The forums were not really utilized by students. If there were more questions, there would have been more of a use, but we all just worked through the material and didn't really get to the point of needing the forums.
• Nothing comes to mind
• Nothing.
• more images with markers identifying what I am looking for
• Narrated slides
• The forums were not used by the group very much. I didn't find the instructors answer helpful- but I also probably didn't ask a very good question!
• Some of the talking slides just repeated the word content. I would only like talking when it adds to the visual content
• Forums
• n/a

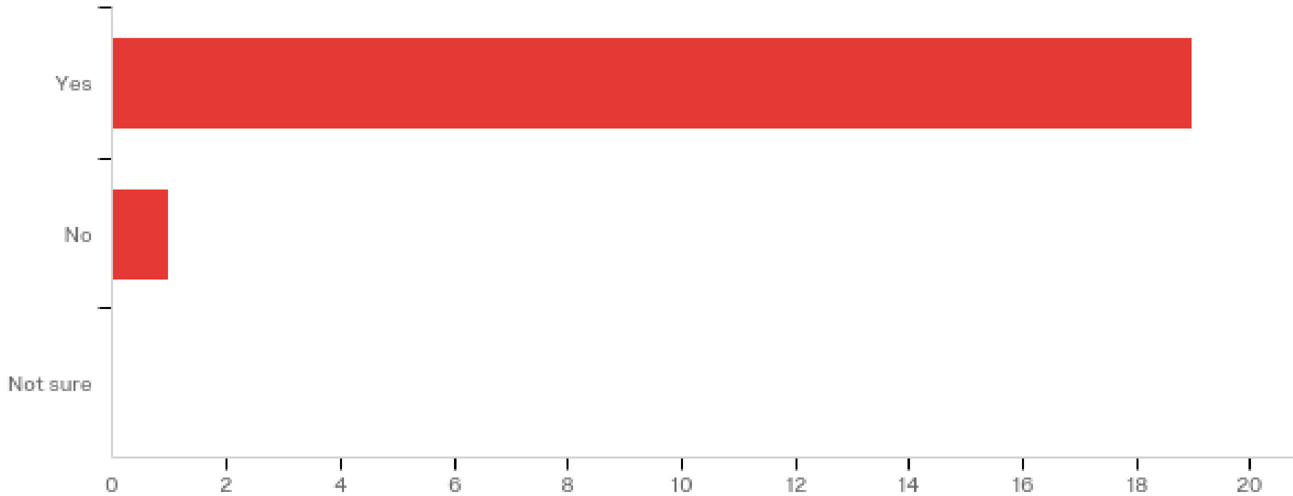
8. What was MOST helpful for your learning experience in the scanning labs?

• interaction with instructor
• Instructor in "real time;" and being able to see my pointer.
• Video chat with instructor
• I liked having more than one instructor, it helped me to learn more than one approach.
• Having the instructor confirm what I was seeing and being able to see the instructor demonstrate how to manipulate the probe to get a better image.
• Screen-sharing with my instructors
• Having the instructor to help with the scans and teach us the proper anatomy
• The hands-on labs with real-time instructor feedback.
• The guidance provided by the instructors to position to the probe and adjust depth/gain to capture the image. It was also very helpful when they pointed out anatomy.
• The instructors were great, and having two of them was beneficial, because they each stressed different points.
• Awesome instructors
• Having back-to-back labs for the first two sessions was excellent. It gave me a break to digest the feedback I received, and then I got to try again while the information was still fresh.
• Being able to see what images were produced based on my hand/probe placement
• Being able to scan.
• very patient and helpful remote instructors.
• Getting the hands on and one on one instruction.
• The remote instructors were very helpful and knowledgeable
• Wonderful to have the remote instructor and that they can see your monitor, great to be able to turn camera so they can see your transducer position
• Instructor guidance
• Real time instructor feedback

9. What was LEAST helpful for your learning experience in the scanning labs?

• none
• Poor connection and one lab had a loose iPad stand.
• I only had female patients, so I'm not as confident scanning a male patient for the pelvic portion. I think it would be easier, but since I haven't done it, I'm not sure.
• The software had some technical issues.
• Connectivity issues with Reacts losing voice and call dropping
• Everything was helpful
• Unsure.
• All instruction and information provide was helpful. Least helpful was the technical issues that came up (video call kept freezing making it difficult to hear what the instructor was saying at times - information was lost).
• The video stream (of the instructor) would frequently freeze. This was problematic when they were trying to demonstrate how I should be adjusting the probe position. We also experienced dropped calls.
• Nothing
• There was no way for the instructor to properly assess my ergonomics while scanning and I felt like I was constantly readjusting when I'd feel any pain in my shoulder.
• 3rd lab. Would have liked it to have been less directed and more self-directed
• Not being able to learn from my partner when they were scanning me as I couldn't hear the discussion due to the headphones.
• would have liked more time
• When the computer would freeze.
• Technical difficulties with the REACTS software
• Could be difficult to know what was meant by some of the verbal directions given, I guess not used to the terminology
• Trying to position camera on tablet for instructor to see, and maintain ergonomic position
• The screens were small, and it was hard to see the screen and scan at the same time at certain points of the labs

10. You learned how to scan using the Remote Education, Augmented Communication Training and Supervision (REACTS) as distance education method. Would you recommend this method for learning pocket ultrasound? If yes, why? If not, why not? If unsure, please expand.



Answer	%	Count
Yes	95.00%	19
No	5.00%	1
Not sure	0.00%	0

Yes: Text

- easy and at your own pace
- It was user-friendly and had a clean design.
- Allowed instructor to see what you are doing and redirect
- It was more effective than I anticipated.
- Effectiveness with no geographic limitation
- Great way to learn the basics of ultrasound
- Yes, it seemed to work well.
- I found the system easy to use and when it was working well it was effective. I would recommend having a backup communication method for when the video call is having problems with connectivity.
- It wouldn't be my preferred choice, but I was able to adequately learn how to scan.
- It was awesome! I was nervous going it but with other medical imaging knowledge it was not bad
- I would say that this can definitely work in certain contexts (ex. physicians in remote rural sites). However, there needs to be parameters worked out (such as ergonomics) and consistent labs to ensure regular evaluation and competency at the end.
- Worked well for me; variety of teaching modalities
- I was able to learn via this method.
- it would be a valuable tool in assessing trauma
- It seems like a very practical way to learn and the one on one was great.
- I think the course is very well set up, easy to access and thorough. I think the REACTS software is easy to use, the access to a mentor is easy as well, which is a crucial piece. I would not feel comfortable scanning without a mentor without more experience.
- I would need more practice; I think to try it on an injured person. I expected my lab partner NOT to

have fluid where it was not supposed to be!
• Seemed effective, and I feel I grasped the main concepts with understanding that mastery may take more time.
• I believe it was a good learning tool to learn with, but we'll see how I perform in my OSCE!

No text

- The software had several technical issues. I didn't have a single lab where there wasn't a connection problem. Even with IT support right there it was frustrating as the video would freeze, or the audio would be choppy. Several times we had to stop and re-start the call. When it was working the tool was great and I learned, but the technical glitches were a barrier.

11. What is your advice for future distance educational instructional design for remote skill acquisition?

• be aware of timelines and it is very easy
• Ensure you have a good connection for the REACTS labs to prevent technical difficulties.
• .
• One more lab. (4 instead of 3, and for the fourth mimic the OSCE, scanning the patient in a 15-minute timeframe twice).
• Ensure perfect connectivity.
• Add and option to be able to call instructor using regular phone call if Reacts failed
• Review the PowerPoints before the labs.
• Perhaps using a camera focused on my technique separate from the device displaying the US image; aiming the camera at my scanning hand (to assist the instructor when I was having technique issues) made some scan ergonomics awkward for me.
• I found the material engaging so having a variety of learning tools is beneficial. I also found the concept of sharing the scanning image with the instructor and the camera so that they can see how you are position the probe to be very helpful. It was great to have technical support on hand when issues did arise.
• Trying to communicate how one should hold a probe is difficult at a distance. Future studies need to look into how to break down the barriers that result from an instructor not being able to physically interact with the student.
• Practice quizzes, more hands-on learning of the equipment and settings
• I do think there is a need for it. I think this form of remote skill education should be focused in environments where it is appropriate (again, such as northern rural hospitals).
• The long PowerPoint (~90 minutes) was very difficult to sit through
• Reacts software requires some improvement in connectivity.
• more practice scanning labs.
• More videos showing examples - shorter videos
• Longer lab sessions. Even an increase to 45 min per session would allow more time to “play”; and gain a better sense of how my movements with the transducer change the anatomy appearance.
• It seems an efficient and good way to learn the skills required. I would suggest more practice time and more exam practice time…
• Better video capture devices

12. Were there any surprises in your learning experience in this research project?

• no
• How quickly I could learn this skill in 3 short labs.
• .

• I was surprised at how effective the remote system was for learning. I began as a bit of a skeptic.
• no
• How easy was the very first lab
• None
• Not sure.
• I found it surprising that someone without sonography experience could learn the E-FAST scan so quickly.
• I'm amazed that I'm able to complete an E-FAST scan after only an hour's worth of instruction!
• No
• I was surprised how thorough the content was before the labs began. It was a great surprise. I expected to feel more blind heading into them. It definitely helped ease the nerves.
• Having to be a patient also
• How easy it actually was with the right instruction.
• Seeing live images was amazing.
• How fun it was
• I was surprised how easy it was to find the correct anatomy
• I was surprised how quickly I became familiar with the anatomy in the US image.
• Amount of videos available to see technique
• no

13. Did anything NOT surprise you in your learning experience?

• no
• No
• Some of the routine patient care principles are quite standardized, so that was not surprising.
• no
• Instructors ability to coach and teach along
• Nothing surprised me. Everything was well explained beforehand.
• I was not surprised that the learning could be effective if technology was used effectively (and if there were no technical issues).
• I was not surprised that I could learn the theory component of E-FAST through Moodle - distance delivery.
• Technical difficulties (dropped calls, etc.).
• No
• The quality of instruction. Everyone stuck to what we needed to know and kept the message consistent. It was very easy to use as well!
• no
• No.
• I was not surprised at my clumsy handling of the transducer.
• How great the instructors were in the labs.
• I knew the NAIT mentors would be amazing
• I am not perfect at EFAST but getting pretty good.
• Unsure
• no

14. Do you have any other comments to share?

• no
• Please embed narration and slide timing into slides and consider saving as a PowerPoint show file. Having to click on each individual sound file took me out of the flow of learning the material.
• no
• Thanks :)
• Great experience, learned a lot, and I am happy to have taken part of this research project!
• I enjoyed the experience.
• I really enjoyed participating in the study and learning the E-FAST scan!
• That was fun!
• No
• no
• This was a great experience to participate in.
• This was a fun experience.
• No
• It was very interesting to be a participant. My EFAST training works well with the uninjured patient, but it may be quite different, and more difficult with patients who may be in pain, etc., and potentially have injuries and fluid.
• Thanks, this was an interesting study and I was glad to be a participant.

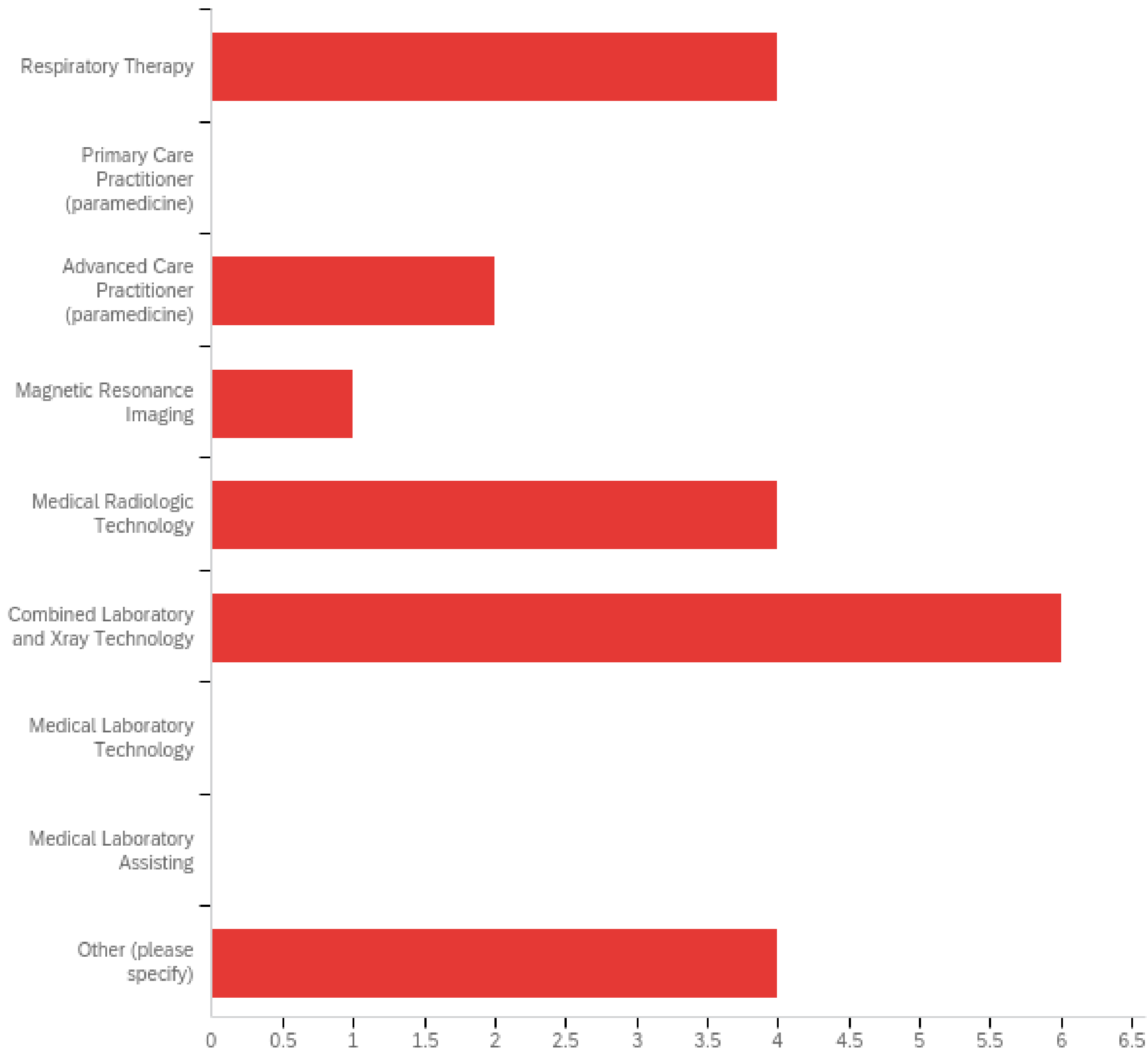
Appendix M3: End-study Questionnaire Report

END STUDY QUESTIONNAIRE

Participant Code:

L01	L07	L13	L18
L03	L08	L14	L19
L04	L09	L15	L20
L05	L10	L16	L21
L06	L12	L17	L22

1. Which health professional group are you from? (select all that apply)

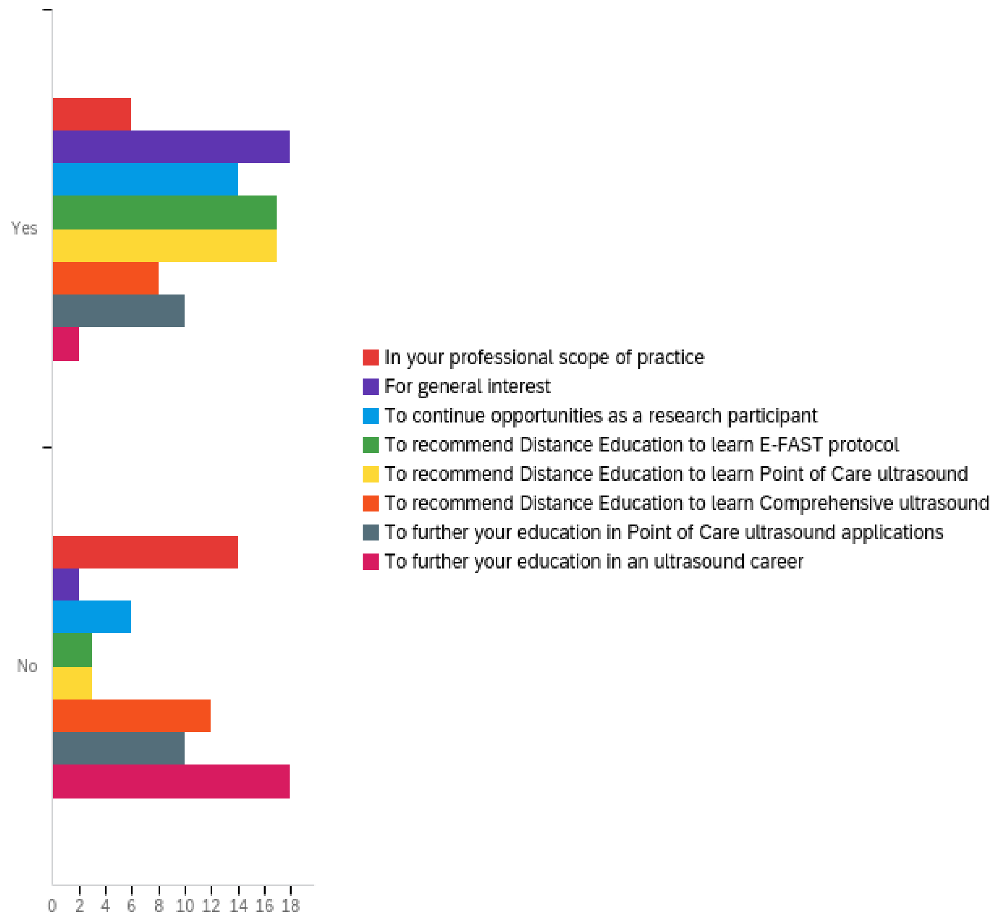


Answer	%	Count	*Adjusted*
Respiratory Therapy	19.05%	4	
Primary Care Practitioner (paramedicine)	0.00%	0	
Advanced Care Practitioner (paramedicine)	9.52%	2	
Magnetic Resonance Imaging	4.76%	1	
Medical Radiologic Technology	19.05%	4	*3 (14.29%)*
Combined Laboratory and X-ray Technology	28.57%	6	
Medical Laboratory Technology	0.00%	0	
Medical Laboratory Assisting	0.00%	0	
Other (please specify)	19.05%	4	
Total	100%	21	*20*

Other (please specify):

• Biomedical Engineering Technologist
• Personal Fitness Trainer
• Exercise Professional
• Veterinarian

2. For each of the following statements please answer Yes or No:
Now that you have completed the research study do you expect to use the learning experience:

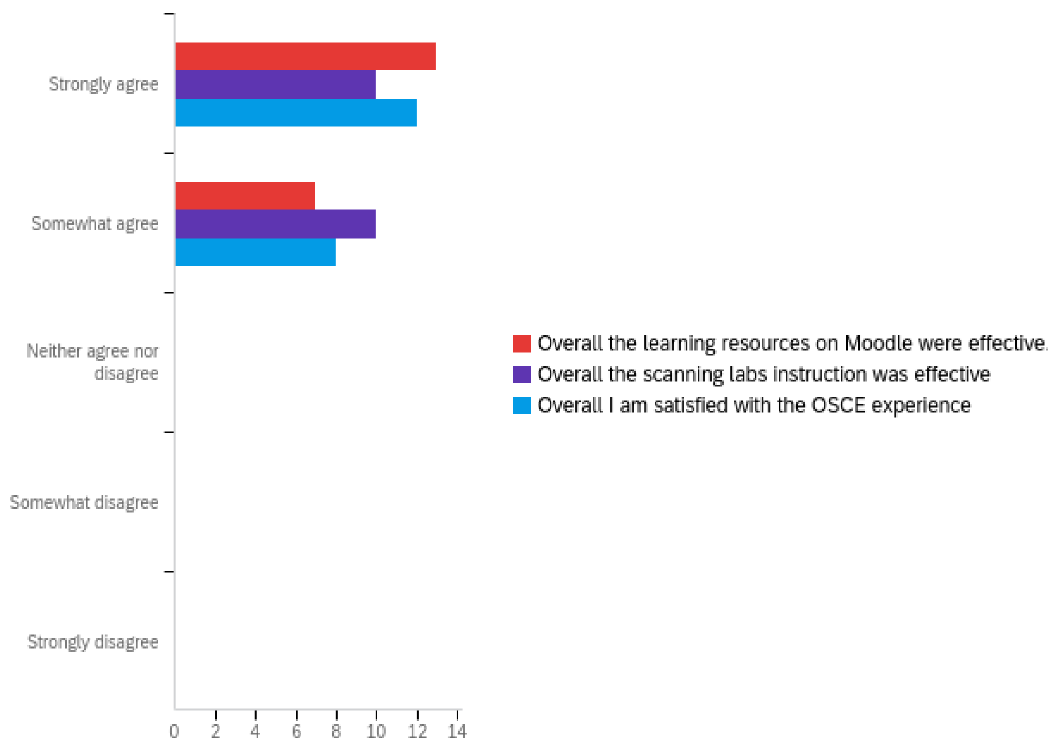


Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
In your professional scope of practice	1.00	2.00	1.70	0.46	0.21	20
For general interest	1.00	2.00	1.10	0.30	0.09	20
To continue opportunities as a research participant	1.00	2.00	1.30	0.46	0.21	20
To recommend Distance Education to learn E-FAST protocol	1.00	2.00	1.15	0.36	0.13	20
To recommend Distance Education to learn Point of Care ultrasound	1.00	2.00	1.15	0.36	0.13	20
To recommend Distance Education to learn Comprehensive ultrasound	1.00	2.00	1.60	0.49	0.24	20
To further your education in Point of Care ultrasound applications	1.00	2.00	1.50	0.50	0.25	20
To further your education in an ultrasound career	1.00	2.00	1.90	0.30	0.09	20

Question	Yes		No		Total
In your professional scope of practice	30.00%	6	70.00%	14	20

For general interest	90.00%	18	10.00%	2	20
To continue opportunities as a research participant	70.00%	14	30.00%	6	20
To recommend Distance Education to learn E-FAST protocol	85.00%	17	15.00%	3	20
To recommend Distance Education to learn Point of Care ultrasound	85.00%	17	15.00%	3	20
To recommend Distance Education to learn Comprehensive ultrasound	40.00%	8	60.00%	12	20
To further your education in Point of Care ultrasound applications	50.00%	10	50.00%	10	20
To further your education in an ultrasound career	10.00%	2	90.00%	18	20

3. Now that you have completed the learning activities and your OSCEs, how would you rate the following statements on a scale of 1-5, with 1= strongly disagree, and 5 = strongly agree?

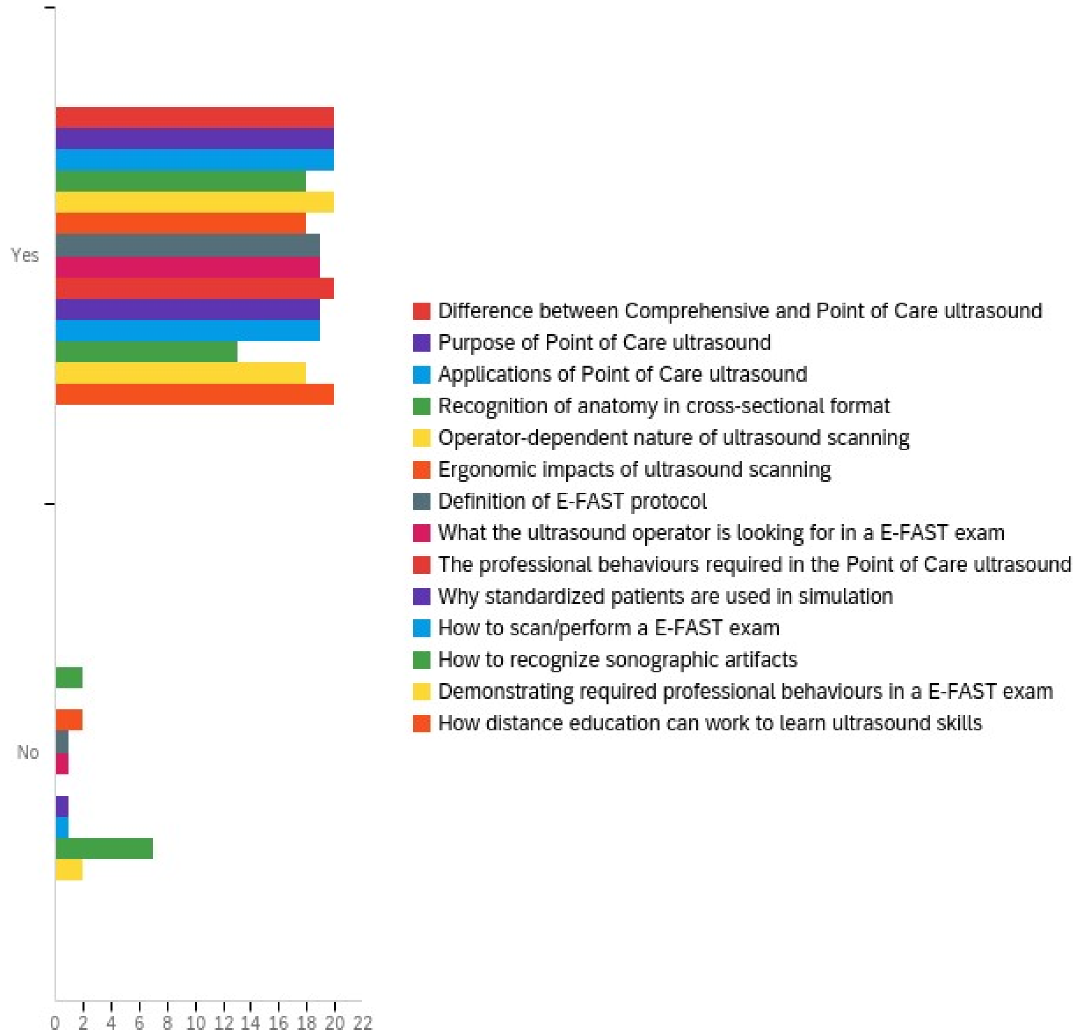


Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Overall, the learning resources on Moodle were effective.	49.00	50.00	49.35	0.48	0.23	20
Overall, the scanning labs instruction was effective	49.00	50.00	49.50	0.50	0.25	20
Overall, I am satisfied with the OSCE experience	49.00	50.00	49.40	0.49	0.24	20

Question	Strongly agree		Somewhat agree		Neither agree nor disagree		Somewhat disagree		Strongly disagree		Total
Overall the learning resources on Moodle were effective.	65.00%	13	35.00%	7	0.00%	0	0.00%	0	0.00%	0	20
Overall the	50.00%	1	50.00%	10	0.00%	0	0.00%	0	0.00%	0	20

scanning labs instruction was effective		0									
Overall, I am satisfied with the OSCE experience	60.00%	12	40.00%	8	0.00%	0	0.00%	0	0.00%	0	20

4. For each of the following statements please answer Yes or No: At this end point of the study, I feel knowledgeable in the following:

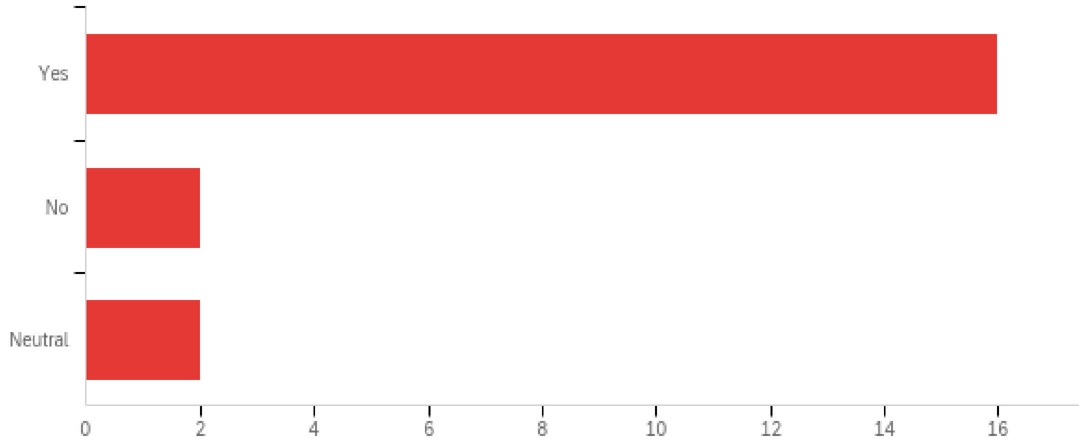


Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Difference between Comprehensive and Point of Care ultrasound	1.00	1.00	1.00	0.00	0.00	20
Purpose of Point of Care ultrasound	1.00	1.00	1.00	0.00	0.00	20
Applications of Point of Care ultrasound	1.00	1.00	1.00	0.00	0.00	20
Recognition of anatomy in cross-sectional format	1.00	2.00	1.10	0.30	0.09	20

Operator-dependent nature of ultrasound scanning	1.00	1.00	1.00	0.00	0.00	20
Ergonomic impacts of ultrasound scanning	1.00	2.00	1.10	0.30	0.09	20
Definition of E-FAST protocol	1.00	2.00	1.05	0.22	0.05	20
What the ultrasound operator is looking for in a E-FAST exam	1.00	2.00	1.05	0.22	0.05	20
The professional behaviours required in the Point of Care ultrasound	1.00	1.00	1.00	0.00	0.00	20
Why standardized patients are used in simulation	1.00	2.00	1.05	0.22	0.05	20
How to scan/perform a E-FAST exam	1.00	2.00	1.05	0.22	0.05	20
How to recognize sonographic artifacts	1.00	2.00	1.35	0.48	0.23	20
Demonstrating required professional behaviours in a E-FAST exam	1.00	2.00	1.10	0.30	0.09	20
How distance education can work to learn ultrasound skills	1.00	1.00	1.00	0.00	0.00	20

Question	**Yes**		**No**		**Total**
Difference between Comprehensive and Point of Care ultrasound	100.00%	20	0.00%	0	20
Purpose of Point of Care ultrasound	100.00%	20	0.00%	0	20
Applications of Point of Care ultrasound	100.00%	20	0.00%	0	20
Recognition of anatomy in cross-sectional format	90.00%	18	10.00%	2	20
Operator-dependent nature of ultrasound scanning	100.00%	20	0.00%	0	20
Ergonomic impacts of ultrasound scanning	90.00%	18	10.00%	2	20
Definition of E-FAST protocol	95.00%	19	5.00%	1	20
What the ultrasound operator is looking for in a E-FAST exam	95.00%	19	5.00%	1	20
The professional behaviours required in the Point of Care ultrasound	100.00%	20	0.00%	0	20
Why standardized patients are used in simulation	95.00%	19	5.00%	1	20
How to scan/perform a E-FAST exam	95.00%	19	5.00%	1	20
How to recognize sonographic artifacts	65.00%	13	35.00%	7	20
Demonstrating required professional behaviours in a E-FAST exam	90.00%	18	10.00%	2	20
How distance education can work to learn ultrasound skills	100.00%	20	0.00%	0	20

5. Do you believe that hands-on training (psychomotor skills) can be taught entirely via Distance Education? (If No or Neutral please comment)



Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Do you believe that hands-on training (psychomotor skills) can be taught entirely via Distance Education? (If No or Neutral please comment) - Selected Choice	1.00	3.00	1.30	0.64	0.41	20

Answer	%	Count
Yes	80.00%	16
No	10.00%	2
Neutral	10.00%	2
Total	100%	20

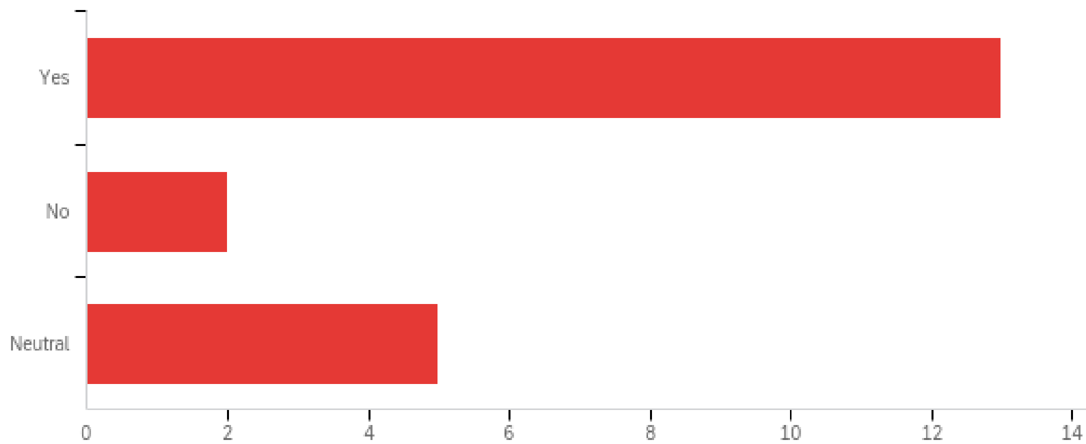
No (comments):

- There's not a way to sufficiently assess ergonomics (which could have a long-term impact on the HCP scanning), nor the patient's reaction to things that the scanner does or says.
- Need hands on learning

Neutral (comments):

- Yes, but not as efficiently as in-person training. For example, the instructor was limited to a small field of view and couldn't see my posture.
- Depends on the type of hands-on skills you are trying to teach

6. Do you believe that attitudes and professional behaviours (affective skills) can be taught entirely via Distance Education? (If No or Neutral please comment)



Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Do you believe that attitudes and professional behaviours (affective skills) can be taught entirely via Distance Education? (If No or Neutral please comment) - Selected Choice	1.00	3.00	1.60	0.86	0.74	20

Answer	%	Count
Yes	65.00%	13
No	10.00%	2
Neutral	25.00%	5
Total	100%	20

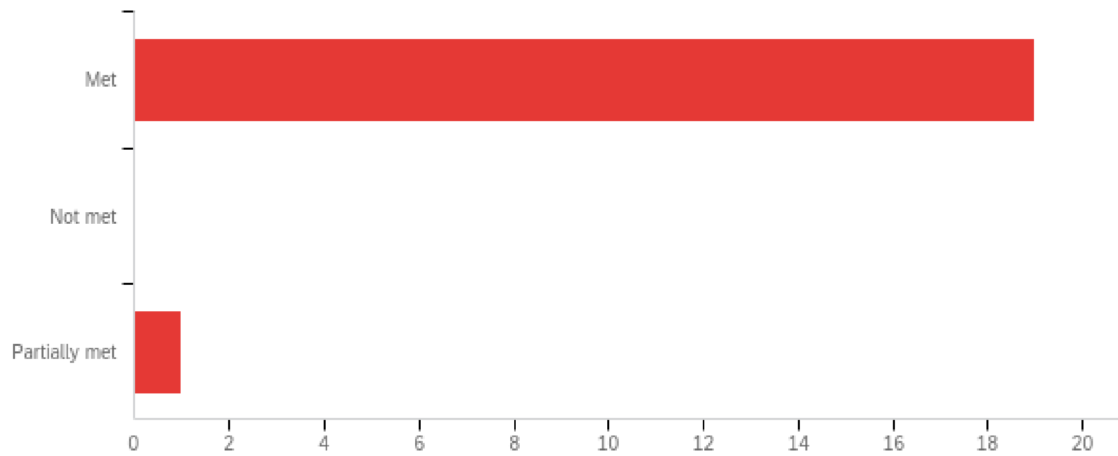
No (comments):

- Need hand on practice
- I think this course assumed I had basic professional behaviors; they were not taught

Neutral (comments):

- If the headphones were off and the facilitator could hear what the patient was indicating (pain, questions, etc.), then yes.
- I think that attitudes and professionalism can only be taught to a limited extent regardless of whether it's in person or by distance. I think they are primarily intrinsic qualities.
- If combined with prior experience in healthcare, then yes!
- Depends on the students you have
- if participants are already professionals, it is easy, however I am not convinced with general public

7. Overall, my expectations from this research study were: (please explain your choice in final question/comment section).



Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Overall, my expectations from this research study were: (please explain your choice in final question/comment section).	1.00	3.00	1.10	0.44	0.19	20

Answer	%	Count
Met	95.00%	19
Not met	0.00%	0
Partially met	5.00%	1
Total	100%	20

8. If you could change one thing, in your learning experience what would it be?

- During training, I was scanning on male patients; however, in the exam, all SPs were female. Landmarking was different enough that I wish I'd been able to practice on patients of both genders.
- One more lab to practice. The OSCE went just fine, but I would like more exposure to really feel competent.
- I would have liked to scan 3 different patients during the practice labs to get experience with various body habitus. During the OSCE I was a bit confused when I could not find the required anatomy - questioning whether it was due to probe placement or incorrect gain and/or depth. Different body habitus during labs may have helped me understand the gain/depth a bit better.
- Although I read about it on Moodle, I don't recall reverberation being mentioned in labs (though it's possible I forgot). I'd also like to have a mock OSCE during the last lab. Ex. 15-minute OSCE, remainder is going over what could be improved etc.
- less outright direction in labs 2 and 3. let me make my mistakes and correct me as I go.
- More than 1-2 patient body habitus
- More time to learn material on Moodle, last lab completely participant lead with feedback from instructor
- Variety of partners to practice on, prior to OSCE
- No headphones: then I could have learnt from my partner as well. I couldn't hear what the instructor was saying to her.

• Less glitchy technology.
• Not sure if this is possible but an additional OSCE station using a phantom or mannequin that simulate certain pathology
• Practical labs with different patients for each lab, with both males and females.
• Maybe a little more lab time
• Nothing
• Use patient models in at least one of the practice sessions. During my practice sessions I was only paired with males who tended to have a larger stature or body type. In comparison during the OSCE I only had female patients who tended to be more "petite." This proved challenging especially during bladder scanning both in terms of finding the bladder (which tended to be much smaller) and, also identifying other surrounding structures.
• I would have different partners for the lab component, so that I would see more than one person's anatomy in the practice sessions.
• n/a
• more time in the hands-on labs
• Longer lab time with the instructor. I don't feel confident I could trouble shoot how to find the anatomy with a difficult patient
• I would be more attentive in how to use the transducer. I was lost without the "voice in my ear.".

9. Do you have any concerns, questions or comments? If none, enter "not applicable"

• not applicable
• Nothing beyond what I stated earlier. Thank you for the fun and informative opportunity!
• I truly enjoyed the experience!
• It was a pleasure to be a part of this research project!
• make the timer on these surveys longer
• I did not learn the artifacts in the lab and could not locate the artifacts in the OSCE (never heard of the term reverb). After the OSCE I review the Moodle PowerPoint and could not locate the tern reverb. After seeing my results, I feel this affected my OSCE score as I was asked to show reverb.
• Not applicable
• not applicable
• NA
• not applicable
• not applicable
• Not applicable.
• not applicable
• N/A
• not applicable
• During the practice labs, I did NOT expect to find fluid, on my healthy partner, so things may be different and more difficult if the patient MAY have blood or free fluid...
• not applicable
• Not applicable
• I would like to see the inclusion of more robust Image critique. I believe I could find most of the structures, but I am not confident I was imaging them in the most accurate way to make diagnosis
• not applicable

Appendix M4: Sample Qualtrics Report from Individual Learner (participant data collection code is L01)

Q1. Point of Care Ultrasound: Distance Education for the Use of Pocket Ultrasound Devices

Q2. Participant Code Number:

L01

Q3. Which health professional group are you from? (select all that apply)

- [x] Respiratory Therapy
- [ ] Primary Care Practitioner (paramedicine)
- [ ] Advanced Care Practitioner (paramedicine)
- [ ] Magnetic Resonance Imaging
- [ ] Medical Radiologic Technology
- [ ] Combined Laboratory and Xray Technology
- [ ] Medical Laboratory Technology
- [ ] Medical Laboratory Assisting
- [ ] Other (please specify)

Q4. Have you had any training or experience with ultrasound scanning?

- ( ) Yes
- (•) No

Q5. If yes, please describe the ultrasound scanning experience you had (if no, please type N/A):

N/A

Q6. For each of the following statements please answer Yes or No: From the description of the study (Informed Consent Form) I expect to use the learning experience:

	Yes	No
In my professional scope of practice	(•)	( )
For general interest	( )	(•)

To gain experience as a research participant	○	●
To understand the effectiveness of hands-on training with Distance Education	○	●
To experience the art and sciences of sonography	●	○

Q7. From the description of the study (Informed Consent Form) my overall engagement with the study is (select all that apply):

- [ ] Excited
- [x] Curious
- [ ] Skeptical
- [ ] Fearful (nervous)
- [ ] Neutral

Q8. For each of the following statements please answer Yes of No:
At this point of the study I am knowledgable in the following:

	Yes	No
Difference between Comprehensive and Point of Care ultrasound	○	●
Purpose of Point of Care ultrasound	●	○
Applications of Point of Care ultrasound	●	○
Recognition of anatomy in cross-sectional format	○	●
Operator-dependent nature of ultrasound scanning	○	●
Ergonomic impacts of ultrasound scanning	●	○
Definition of the E-FAST* protocol	○	●
What the ultrasound operator is looking for in a E-FAST* exam	●	○
The professional behaviours required in Point of Care ultrasound	○	●
Why standardized patients are used in simulation	●	○
What an Objective Structured Competency Examination is	●	○
How Distance Education can work to learn hands-on skills	●	○

Q9. Do you believe that hand-on training (psychomotor skills) can be taught entirely via Distance Education? (If No or Neutral please explain in final question/comment section)

- ○ Yes
- ○ No
- ● Neutral

Q10. Do you believe that attitudes and professional behaviours (affective skills) can be taught entirely via Distance Education? (If No or Neutral please explain in the final question/comment section)

- ○ Yes
- ◉ No
- ○ Neutral

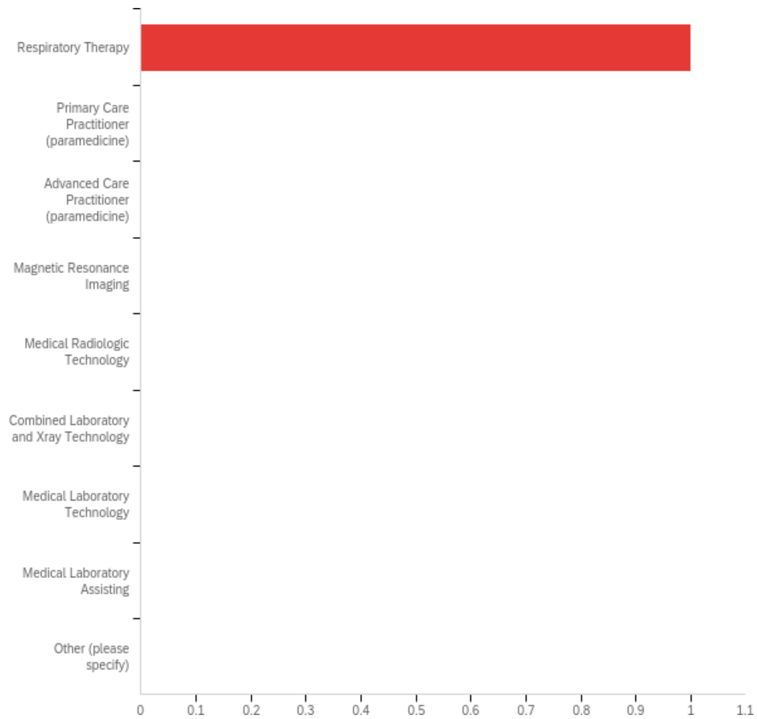
Q11. Do you have any concerns, questions, or comments?

Appendix M5: Sample Qualtrics Report from Individual Learner (data analysis code)

Point of Care Ultrasound Research Study: Pre-study online questionnaire results report

1. Participant Code Number: L01RET

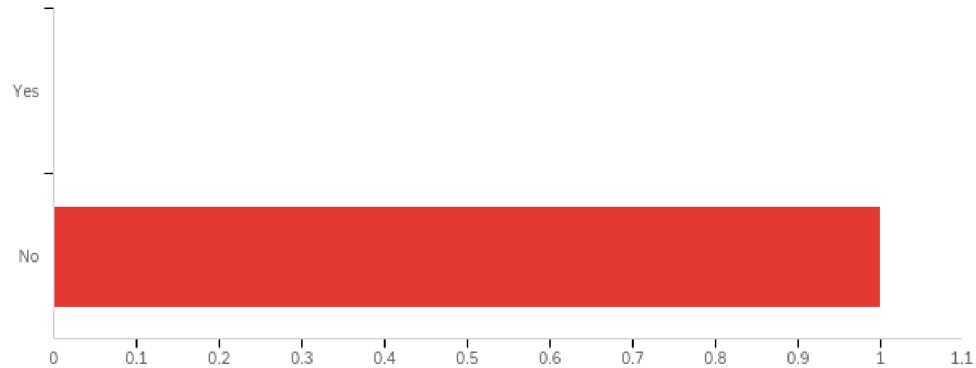
2. Which health professional group areyou from? (select all that apply)



Answer	%	Count
Respiratory Therapy	100.00%	1
Primary Care Practitioner (paramedicine)	0.00%	0
Advanced Care Practitioner (paramedicine)	0.00%	0
Magnetic Resonance Imaging	0.00%	0
Medical Radiologic Technology	0.00%	0
Combined Laboratory and Xray Technology	0.00%	0
Medical Laboratory Technology	0.00%	0
Medical Laboratory Assisting	0.00%	0
Other (please specify)	0.00%	0
Total	100%	1

Other (please specify):

3. Have you had any training or experience with ultrasound scanning?



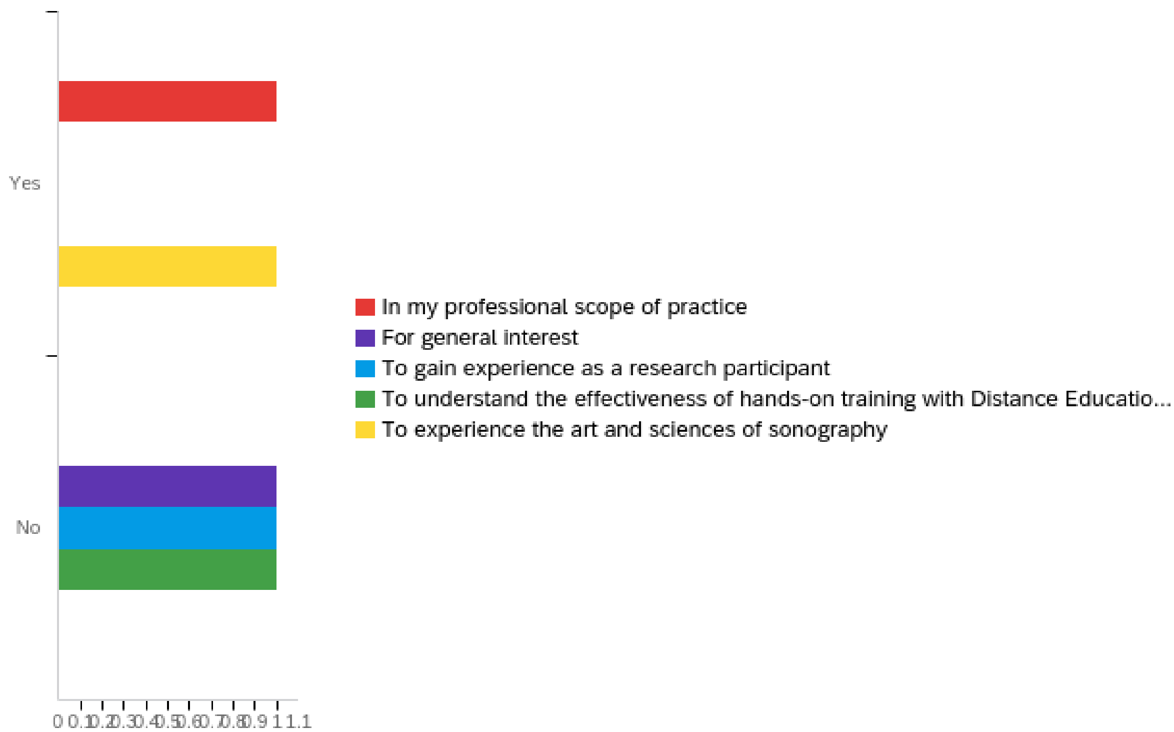
Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Have you had any training or experience with ultrasound scanning?	2.00	2.00	2.00	0.00	0.00	1

Answer	%	Count
Yes	0.00%	0
No	100.00%	1
Total	100%	1

4. If yes, please describe the ultrasound scanning experience you had (if no, please type N/A):

- N/A

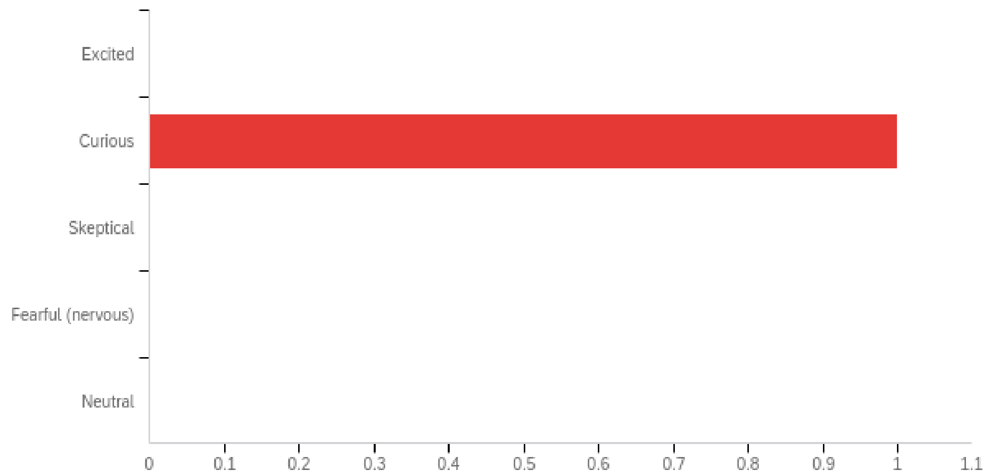
5. For each of the following statements please answer Yes or No: From the description of the study (Informed Consent Form) I expect to use the learning experience:



Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
In my professional scope of practice	1.00	1.00	1.00	0.00	0.00	1
For general interest	2.00	2.00	2.00	0.00	0.00	1
To gain experience as a research participant	2.00	2.00	2.00	0.00	0.00	1
To understand the effectiveness of hands-on training with Distance Education	2.00	2.00	2.00	0.00	0.00	1
To experience the art and sciences of sonography	1.00	1.00	1.00	0.00	0.00	1

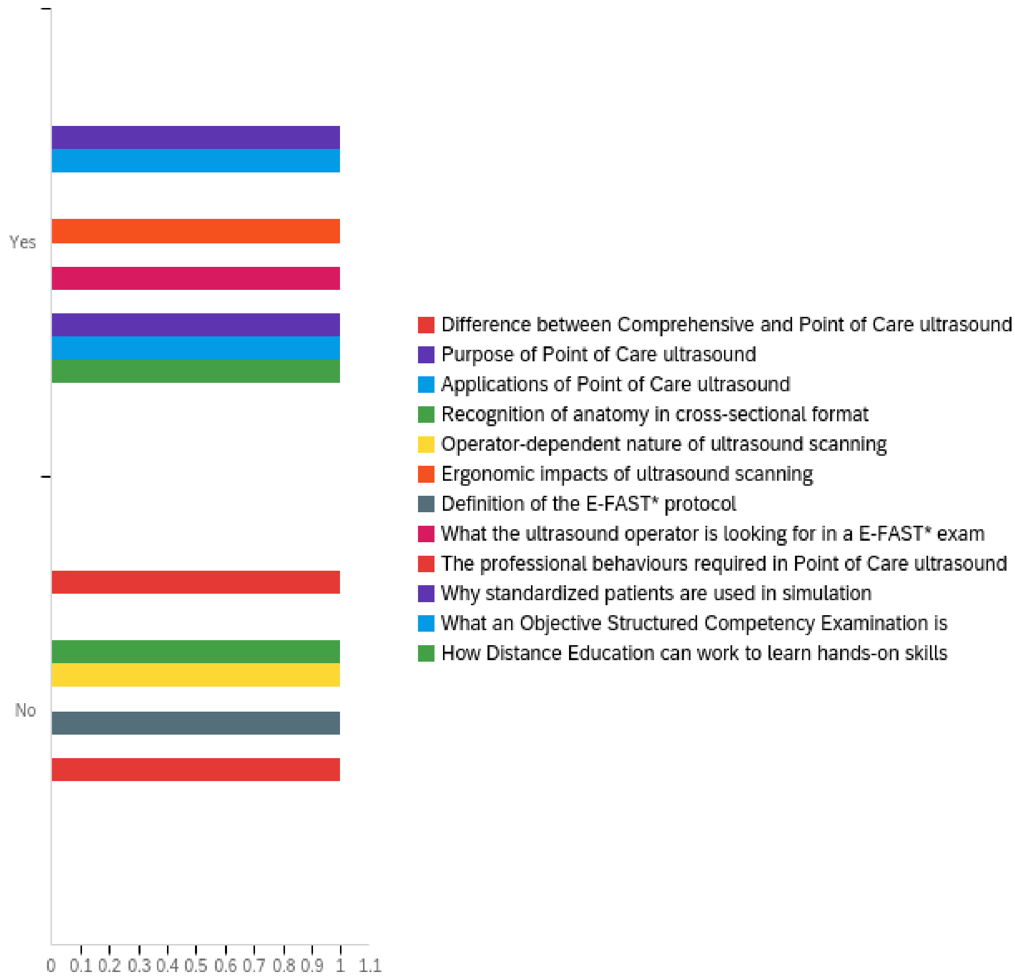
Question	Yes		No		Total
In my professional scope of practice	100.00%	1	0.00%	0	1
For general interest	0.00%	0	100.00%	1	1
To gain experience as a research participant	0.00%	0	100.00%	1	1
To understand the effectiveness of hands-on training with Distance Education	0.00%	0	100.00%	1	1
To experience the art and sciences of sonography	100.00%	1	0.00%	0	1

6. From the description of the study (Informed Consent Form) my overall engagement with the study is (select all that apply):



Answer	%	Count
Excited	0.00%	0
Curious	100.00%	1
Skeptical	0.00%	0
Fearful (nervous)	0.00%	0
Neutral	0.00%	0
Total	100%	1

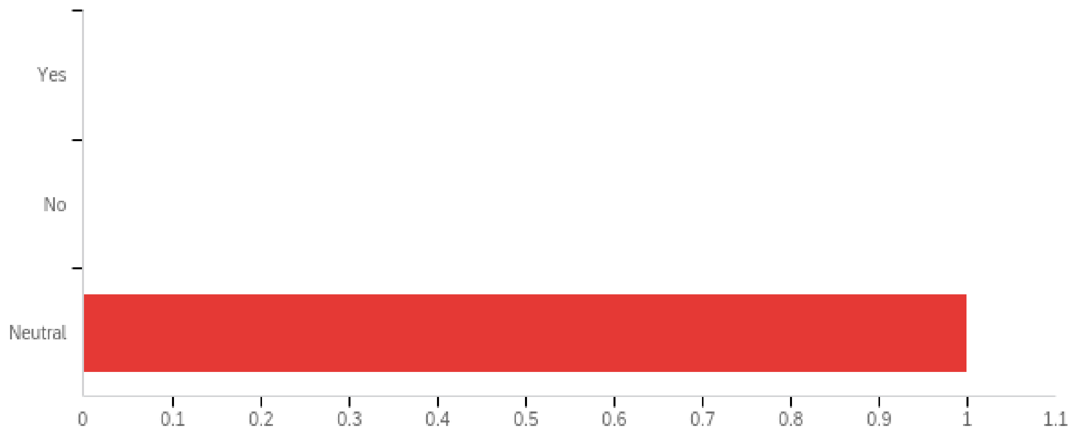
7. For each of the following statements please answer Yes of No: At this point of the study I am knowledgeable in the following:



Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Difference between Comprehensive and Point of Care ultrasound	2.00	2.00	2.00	0.00	0.00	1
Purpose of Point of Care ultrasound	1.00	1.00	1.00	0.00	0.00	1
Applications of Point of Care ultrasound	1.00	1.00	1.00	0.00	0.00	1
Recognition of anatomy in cross-sectional format	2.00	2.00	2.00	0.00	0.00	1
Operator-dependent nature of ultrasound scanning	2.00	2.00	2.00	0.00	0.00	1
Ergonomic impacts of ultrasound scanning	1.00	1.00	1.00	0.00	0.00	1
Definition of the E-FAST* protocol	2.00	2.00	2.00	0.00	0.00	1
What the ultrasound operator is looking for in a E-FAST* exam	1.00	1.00	1.00	0.00	0.00	1
The professional behaviours required in Point of Care ultrasound	2.00	2.00	2.00	0.00	0.00	1
Why standardized patients are used in simulation	1.00	1.00	1.00	0.00	0.00	1
What an Objective Structured Competency Examination is	1.00	1.00	1.00	0.00	0.00	1
How Distance Education can work to learn hands-on skills	1.00	1.00	1.00	0.00	0.00	1

Question	Yes		No		Total
Difference between Comprehensive and Point of Care ultrasound	0.00%	0	100.00%	1	1
Purpose of Point of Care ultrasound	100.00%	1	0.00%	0	1
Applications of Point of Care ultrasound	100.00%	1	0.00%	0	1
Recognition of anatomy in cross-sectional format	0.00%	0	100.00%	1	1
Operator-dependent nature of ultrasound scanning	0.00%	0	100.00%	1	1
Ergonomic impacts of ultrasound scanning	100.00%	1	0.00%	0	1
Definition of the E-FAST* protocol	0.00%	0	100.00%	1	1
What the ultrasound operator is looking for in a E-FAST* exam	100.00%	1	0.00%	0	1
The professional behaviours required in Point of Care ultrasound	0.00%	0	100.00%	1	1
Why standardized patients are used in simulation	100.00%	1	0.00%	0	1
What an Objective Structured Competency Examination is	100.00%	1	0.00%	0	1
How Distance Education can work to learn hands-on skills	100.00%	1	0.00%	0	1

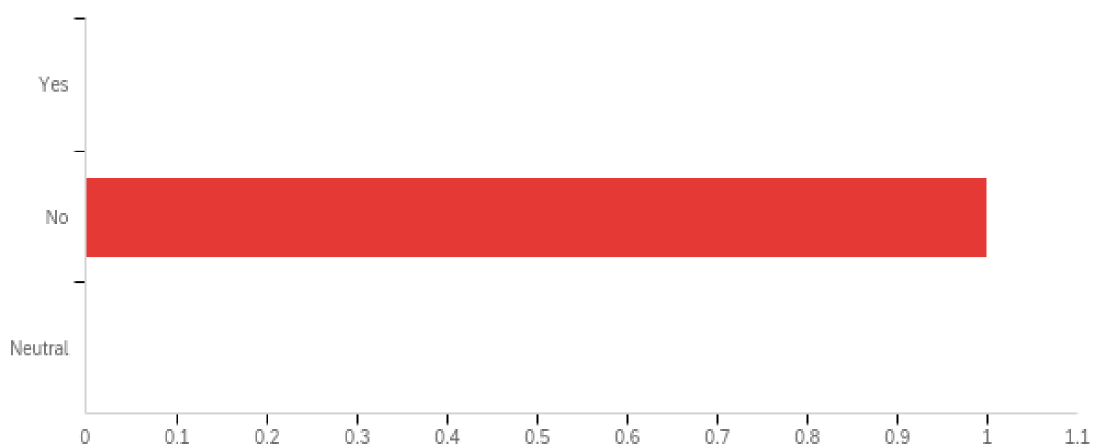
8. Do you believe that hand-on training (psychomotor skills) can be taught entirely via Distance Education? (If No or Neutral please explain in final question/comment section)



Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Do you believe that hand-on training (psychomotor skills) can be taught entirely via Distance Education? (If No or Neutral please explain in final question/comment section)	3.00	3.00	3.00	0.00	0.00	1

Answer	%	Count
Yes	0.00%	0
No	0.00%	0
Neutral	100.00%	1
Total	100%	1

9. Do you believe that attitudes and professional behaviours (affective skills) can be taught entirely via Distance Education? (If No or Neutral please explain in the final question/comment section)



Field	Minimum.	Maximum	Mean	Std Deviation	Variance	Count
Do you believe that attitudes and professional behaviours (affective skills) can be taught entirely via Distance Education? (If No or Neutral please explain in the final question/comment section)	2.00	2.00	2.00	0.00	0.00	1

Answer	%	Count
Yes	0.00%	0
No	100.00%	1
Neutral	0.00%	0
Total	100%	1

10. Do you have any concerns, questions, or comments?

- No responses received.

Appendix M6: Excerpt from Excel file of Learner Participant Data

Learners' data analysis codes were matched with their data collection codes to include profession data, conducted by research administrative assistant, derived from question #2 per each questionnaire: *Which health professional group are you from? (select all that apply)*

Data Analysis Code	Data Collection Code	Reported Profession	
L03MRT	L03	Medical Radiologic Technology	
L18MRD	L18	Magnetic Resonance Imaging, Medical Radiologic Technology	
L13PFT	L13	Other (please specify)	Personal Fitness Trainer
L16ACP	L16	Advanced Care Practitioner (paramedicine)	
L05AHT	L05	Other (please specify)	Veterinarian, previously nursing
L01RET	L01	Respiratory Therapy	
L14RET	L14	Respiratory Therapy	
L06CLX	L06	Combined Laboratory and Xray Technology	
L20CLX	L20	Combined Laboratory and Xray Technology	
L04MRT	L04	Medical Radiologic Technology	
L10BIO	L10	Other (please specify)	Biomedical Engineering Technology
L08ACP	L08	Advanced Care Practitioner (paramedicine)	
L12CLX	L12	Combined Laboratory and Xray Technology	
L15PFT	L15	Other (please specify)	Exercise professional
L17CLX	L17	Combined Laboratory and Xray Technology	
L07CLX	L07	Combined Laboratory and Xray Technology	
L21RET	L21	Respiratory Therapy	
L09RET	L09	Respiratory Therapy	
L19MRT	L19	Medical Radiologic Technology	
L22CLX	L22	Combined Laboratory and Xray Technology	

Appendix N1: OSCE Scores for Sample Group

DATA ANALYSIS CODE					
LEARNER&PROFESSION	OSCE A01	OSCEA02	OSCEA03	OSCE AVERAGE	%
L01RET	31	32	32	32	91.4
L03MRT	26	28	33	29	82.8
L04MRT	29	29	31	30	85.7
L05AHT	20	30	29	26	74.2
L06CLX	32	34	32	33	94.2
L07CLX	31	32	31	31	88.5
L08ACP	24	19	24	22	62.8
L09RET	32	32	34	33	94.2
L10BIO	23	33	25	27	77.1
L12CLX	19	28	27	25	71.4
L13PFT	29	27	32	29	82.8
L14RET	32	29	30	30	85.7
L15PFT	14	28	17	20	57.1
L16ACP	29	32	34	32	91.4
L12CLX	28	35	34	32	91.4
L18MRD	35	34	33	34	97.1
L19MRT	9	17	14	13	37.1
L20CLX	15	24	26	22	62.8
L21RET	28	30	30	29	82.8
L22CLX	24	32	30	29	82.8
AVERAGE	**26**	**29**	**29**	**28**	80

Note: n=20; Group mean is 79.6% and 80% when rounded up; 95%CI (72.6-86.6)

Appendix N2: OSCE Assessment Score Example from Assessor 02 (participant L05AHT)

(To Note: L05AHT was given a participant code of L05 for data collection and recoded by the research assistant to L05AHT for data analysis to ensure anonymity)

Page One of Five

29.5 – 30/35 A2

A02
Jun 18, 2019
station 2
9:00am

OSCE EXAM: VERSION 2 (posted May 17, 2019)

Learner Participant Code: L05 F (AHT) **(participant to write code here BEFORE OSCE starts)**

Maximum of 15 minutes with a 3-minute alert before time is up

Competency area	Competency performance	Check if Completed ✔
Professional Behaviors	Introduces self & explains role to patient RECORD ANSWER	✓
	Explains procedure to patient RECORD ANSWER	✓
	Prepares patient while protecting their modesty	✓
	Applies appropriate amount of gel	✓
Patient Interactions - throughout examination	Responds to patient verbal and non-verbal questions/behaviors with respect RECORD ANSWER	✓

OSCE EXAM: VERSION 2 (posted May 17, 2019)

(5)

Appendix N2 continued: OSCE assessment score example from Assessor 02 (participant L05AHT)

Page Two of Five

Ergonomics	Maintains ergonomic body posture for scanning tasks	✓
	Holds transducer and scanning arm ergonomically	✓
Instrumentation	Uses DEPTH setting correctly	✓
	Uses GAIN correctly	✓
E-FAST Protocol	[illegible]	
Right Liver/Lung	Obtains parasagittal or coronal view	✓
	Freezes image	✓
	ON FROZEN IMAGE ASK PARTICIPANT: Point to location where pleural fluid would be RECORD ANSWER; SAY "THANK YOU, PLEASE MOVE ON"	✓
Right Liver/Kidney	Obtains parasagittal or coronal view	✓
	Freezes image	✓
	ON FROZEN IMAGE ASK PARTICIPANT Point to Morrison's pouch where fluid would be RECORD ANSWER; SAY "THANK YOU, PLEASE MOVE ON"	✓

OSCE EXAM: VERSION 2 (posted May 17, 2019) (10)

Appendix N2 continued: OSCE assessment score example from assessor 02 (participant L05AHT)

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Left Spleen/Lung	Obtains parasagittal or coronal view	✓	
	Freezes image	✓	
	ON FROZEN IMAGE ASK PARTICIPANT Point where pleural fluid would be RECORD ANSWER; SAY "THANK YOU, PLEASE MOVE ON"	✓	
Left Spleen/Kidney	Obtains parasagittal or coronal view	✓	
	Freezes image	✓	
	ON FROZEN IMAGE: ASK PARTICIPANT Point to splenic/kidney space where fluid would be RECORD ANSWER; SAY "THANK YOU, PLEASE MOVE ON"	✓	
Pelvis	Obtains midline sagittal view pointed to bowel	×	24
	Freezes image	×	25
	ON FROZEN IMAGE: ASK PARTICIPANT Point to space where intraperitoneal fluid would be RECORD ANSWER; SAY "THANK YOU, MOVE ON PLEASE"	×	26

OSCE EXAM: VERSION 2 (posted May 17, 2019)

(6)

Appendix N2 continued: OSCE assessment score example from Assessor 02 (participant L05AHT)

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Heart	Obtains sub-xiphoid view of heart to see pericardial echo	✓
	Freezes image	✓
Heart continued	ON FROZEN IMAGE ASK PARTICIPANT Point to area where pericardial fluid would be RECORD ANSWER; SAY "THANK YOU, MOVE ON PLEASE"	✓
Lungs	Obtains right and left sagittal apical views of lungs	✓
	ON LIVE IMAGE ASK PARTICIPANT Point to areas of "sliding" (right and left) RECORD ANSWER; SAY "THANK YOU, MOVE ON PLEASE"	(R) X (L) ✓
	ON M-MODE IMAGE ASK PARTICIPANT to demonstrate areas of "sliding" (right AND/OR left) RECORD ANSWER; SAY "THANK YOU, MOVE ON PLEASE"	X 32
	ON FROZEN OR LIVE IMAGE ASK PARTICIPANT to identify shadowing artifact on the image RECORD ANSW; SAY "THANK YOU, MOVE ON PLEASE"ER	✓

OSCE EXAM: VERSION 2 (posted May 17, 2019)

5½

6

Appendix N2 continued: OSCE assessment score example from Assessor 02 (participant L05AHT)

Page Five of Five

5

	ON FROZEN OR LIVE IMAGE ASK PARTICIPANT to identify reverberation artifact on the image RECORD ANSWER; SAY "THANK YOU, MOVE ON PLEASE"	X
	ON FROZEN OR LIVE IMAGE ASK PARTICIPANT How would you identify a pneumothorax? RECORD ANSWER; SAY "THANK YOU, MOVE ON PLEASE" "there wouldn't be any 'sliding'"	✓
Exam Closure	Wipes gel off patient with care	✓
	Cleans transducer	✓

34

③

Assessor Participant Code: 02 Date: June 18, 2019

OSCE EXAM: VERSION 2 (posted May 17, 2019)

Appendix O1: Instructor Field Notes (I01) Report

Instructor Participant Code: I01

Purpose of the Field Notes:
The purpose of these field notes is to record your instructor experiences in this study to teach ultrasound by distance education methods, and, to glean future recommendations for teaching ultrasound scanning by distance.

Instructions:

1. For each section record your impressions and insights as per the embedded guidelines.
2. You can quote or paraphrase participant questions or comments anonymously.
3. Regular check-ins with the PI are encouraged and important with urgent matters. Do not reveal the identity of any participants when speaking to the PI.
4. At the end of the study submit your completed electronic template to Ruvimbo who will witness your validation by her signature and will immediately store your file anonymously (as per participant code) on a password-protected and encrypted external device for later analysis by the PI.

Section I – Impressions and insights after Topic 1

1. Effectiveness of Moodle course activities and resources.
   As an instructor I did not use the Moodle course too much aside from checking for questions from participants.

2. Technical factors with Moodle as a teaching tool.
   I do think that it provided the necessary resources needed for participants to prepare for the practical component. I did not face any technical factors and the participants did not voice any concerns about this to me.

3. Transfer of knowledge, skills, and professional behaviors in general.
   Average to above average overall.

4. Transfer of knowledge, skills, and professional behaviors for each professional group. Any differences and similarities amongst the different professions?
   I did not notice any significant differences between the professional groups.
   If any differences at all, there may have been some differences in my perception of participants' motivation. Some seemed very invested into learning and a few (small part) seemed somewhat less invested.

5. Interactions with participants via the Moodle Forums (via Forum posts).
   I checked fairly frequently to see if there were posts on the forums and did not see any (therefore I had no Moodle Forum interaction).

6. Fostering a community of learning amongst the participants connected by Moodle.
   Did not notice any at all.

7. Significant questions or comments (based on Forum posts).

No interaction via Forum posts.

8. Other?
Moodle was useful to provide the background knowledge necessary for the practical component (it made it easier to teach the practical part)

Section II – Impressions and insights after Topic 2

9. Effectiveness of Moodle course activities and resources.
Same as topic 1
10. Technical factors with Moodle as a teaching tool.
Same as topic 1
11. Transfer of knowledge, skills, and professional behaviors in general.
Same as topic 1
12. Transfer of knowledge, skills, and professional behaviors for each professional group.
Same as topic I
13. Any differences and similarities amongst the different professions?
Same as topic I
14. Interactions with participants via the Moodle Forums (via Forum posts).
Same as topic 1
15. Fostering a community of learning amongst the participants connected by Moodle.
Same as topic 1
16. Significant questions or comments (based on Forum posts).
Same as topic 1
17. Other?
Same as topic 1

Section III – Impressions and insights after Topic 3

18. Effectiveness of REACTS platform for teaching ultrasound scanning.
It served its purpose well. I would be curious to see how an alternative (free) platform such as Skype would work. I suspect that it would not be too much inferior to REACTS. I did not feel that there was an urgent need to have both, the ultrasound screen as well as the participant's probe position to be displayed simultaneously at all times. As such, if Skype were to be used, I believe that it would be manageable (although it was nice to have the pointer function which Skype would lack).

19. Technical factors with REACTS as a teaching tool.
Internet connection was very frustrating. It cut out without any apparent reason (unpredictably), to make matters worse, it was difficult to tell when the connection cut out fully versus when it was merely weak (there were times when the image was frozen but the voice could still be heard as well as times when the entire Reacts would disconnect). Other issue with reacts was the limitation of when you could use the pointer function (could not use it in the Scene setting).
20. Transfer of knowledge, skills, and professional behaviors in general using REACTS to teach scanning.
Very good – easy to communicate when internet connection was stable.

21. Transfer of knowledge, skills, and professional behaviors with REACTS to teach scanning to each professional group. Any differences and similarities amongst the different professions?
Same as topic 1.

22. Interactions with participants via REACTS.
Very useful when connection was stable.

23. Interactions with participants via Topic 3 Moodle Forum posts.
Same as topic 1. I did not use Moodle to interact with participants. If they had any questions, we addressed them over REACTS.

24. Significant questions or comments during Labs and/or Topic 3 Moodle Forum posts.
One question that came up during labs was what to do if the instructor noticed the appearance of pathology while one participant scanned the other. This created a unique challenge.

25. Other?
Interesting project to participate in.

Section IV - Overall Impressions

26. As a distance educator instructor, using online Moodle activities and REACTS methods, what worked for you and what did not work?
As per above, I was not too impressed with REACTS. It was merely ok, but the freezing made it increasingly frustrating. I believe the study as well as any future teaching could be done using regular ultrasound machines and a tablet with Skype capability.
Moodle was good to provide background theory making it easier to run the labs.
I think it would be better if instructors and assessors were on the same page about what needs to be taught earlier on in the study (it was very helpful to get on the same page eventually).

Section V – Recommendations

27. What recommendations do you have for further distance education instructional design of Point of Care Ultrasound using a pocket ultrasound?
Depending on budgetary considerations, I am not sure if REACTS platform is necessary (? use skype or Messenger).

Stable internet connection is very important.

8-July-2019
(Date)

Appendix O2: Instructor Field Notes (I02) Report

Instructor Participant Code: I02

Purpose of the Field Notes:
The purpose of these field notes is to record your instructor experiences in this study to teach ultrasound by distance education methods, and, to glean future recommendations for teaching ultrasound scanning by distance.

Instructions:

1. For each section record your impressions and insights as per the embedded guidelines.
2. You can quote or paraphrase participant questions or comments anonymously.
3. Regular check-ins with the PI are encouraged and important with urgent matters. Do not reveal the identity of any participants when speaking to the PI.
4. At the end of the study submit your completed electronic template to Ruvimbo who will witness your validation by her signature and will immediately store your file anonymously (as per participant code) on a password-protected and encrypted external device for later analysis by the PI.

Section I - Impressions and insights after Topic 1

1. Effectiveness of Moodle course activities and resources.
   I feel that these resources were a good introduction to the candidates giving them a good idea as to what this research project would be all about. The FAST scan link from Ultrasoundpedia was a great resource as well.

2. Technical factors with Moodle as a teaching tool.
   This biggest thing to get used to when teaching in an online course is to make sure that you long onto the Moodie regularly and keep up with the questions that the students are asking in the forums.

3. Transfer of knowledge, skills, and professional behaviors in general.
   Again, because you are communicating online, you have to ensure that you are keeping up with questions that the candidates might be posting. Because you are not interacting in person, you really have to be able to explain yourself well to relay the information that you are wanting to give.

4. Transfer of knowledge, skills, and professional behaviors for each professional group. Any differences and similarities amongst the different professions?
   N/A.

5. Interactions with participants via the Moodle Forums (via Forum posts).
   There were not any posts in this discussion forum.

6. Fostering a community of learning amongst the participants connected by Moodle.
   Again, there were no questions posed in the Forum and so no interaction with the candidates in this topic.

7. Significant questions or comments (based on Forum posts).

None at this time.

8. Other?

Section II - Impressions and insights after Topic 2

9. Effectiveness of Moodle course activities and resource.
I feel that the power point was well narrated and provided good information on ultrasound in general as well as the steps to performing a FAST scan. The other YouTube videos were also very good supplemental resources as well. I really like the instructional video from Tintinalli that was provided by the paramedic program. The physician gave a great explanation and walk through of the entire EFAST scan.

10. Technical factors with Moodle as a teaching tool.
I guess the biggest thing would be to make sure that the participants have looked at the power point and video links. The other thing to consider with the YouTube links is that they may not stay current as time goes on.

11. Transfer of knowledge, skills, and professional behaviors in general.
I did have several participants approach me saying that the power point was very helpful.

12. Transfer of knowledge, skills, and professional behaviors for each professional group.
Not enough people responded to note any difference.

13. Any differences and similarities amongst the different professions?
Based on the questions and comments there didn't seem to be any significant difference in understanding between the different professions that participated in the study

14. Interactions with participants via the Moodie Forums (via Forum posts).
There were only 2 questions posted in this forum: one regarding setting depth in an ultrasound image and one regarding "comet tail artifact". I was able to address both questions in the forum and there was no further conversation with either one.

The biggest point that required clarification was the appearance of the comet tail artifact when looking at the pleura. I feel that I maybe did not explain this clearly in the power point and after looking into it a bit further, I posted an explanation to the entire group hoping to clarify the question.

15. Fostering a community of learning amongst the participants connected by Moodle.
The Q&A forum was probably the best way to create a sense of community for this topic. The fact that there were questions gave me an opportunity to interact with the candidates and connect with them a bit.

16. Significant questions or comments (based on Forum posts).

Based on how few questions there were, I am guessing that the candidates felt that they had enough background information before participating in the scanning portion of the study.

17. Other?

Section III - Impressions and insights after Topic 3

18. Effectiveness of REACTS platform for teaching ultrasound scanning.
*Overall, I think REACTS is a very effective tool for this type of learning, I like the fact that you are interacting with the participants in real time and are able to observe their scanning as well. I know that there were many features of this platform that I did not utilize such as bringing in images, but I feel that **it** was still very effective and for the most part, easy to use.*

19. Technical factors with REACTS as a teaching tool.
The biggest technical factor when using this platform is the loss of connection while trying to teach. This was frustrating, both for the learner and the instructor as there was verbal communication that was missed and when the ultrasound image had disappeared, I was not able to see what the participant was doing, and it was difficult to guide them. As each participant only had a 30-minute window with me at one time, I tried my best to help them get through the entire scan as best I could, despite the technical issues that we were having. At first, the loss of communication seemed to be related to the room that I was in, but as the week progressed, and I moved to different rooms, the issue still persisted, and Chester was able to figure out that this may have actually been a problem between REACTS and the Lumify system.

20. Transfer of knowledge, skills, and professional behaviors in general using REACTS to teach scanning.
I have to admit that this was very different from any lab instruction that I have ever done. I have only taught students to scan in person standing beside them and giving them verbal guidance as well as having the ability to guide them with my hand if there was something that they were really struggling with.

Right from the beginning, using REACTS to interact with the participants, the biggest thing that I struggled with was being able to describe subtle hand movements in order to optimize images. At first, I tried to describe these hand movements as I was trying to guide the candidates and I found that they were getting confused. After discussing this with my colleague, he suggested, going through and explanation of these hand movements before the actual scanning began and then guide the participants trough the scan. This seemed to be much more effective. I still felt like I was at a loss for not being able to use my hand to guide theirs; Some movements are very subtle and vary slightly from patient to patient and it definitely makes it easier to guide the student's hand with mine in these situations.

The one thing that I found interesting about teaching EFAST to students was what parts of the EFAST scan that the students found easier to pick up and what they struggled with; I found that most of the students had a hard time getting a good view of the Left• Upper Quadrant and guiding them over REACTS was difficult when giving them tips as to how to improve the image. Scanning the subcostal view of the heart went well for the most part, but due to patient anatomy, it did limit the success that some people had in obtaining a good view of this area. The part of the scan that really surprised me, however, was the ease that most candidates had in obtaining a good view of the pleura. This is very different from anything that most sonographers would look for and the motion and artifacts can be very subtle, but most people had no trouble finding and appreciating the sliding of the pleura both using 2D grayscale and M-mode.

21. Transfer of knowledge, skills, and professional behaviors with REACTS to teach scanning to each professional group. Any differences and similarities amongst the different professions?
I guess the participants with an imaging background (X-ray or CLXT), may have been a bit more familiar with cross-sectional anatomy but just like with our ultrasound students, I found that some people seemed to have a natural aptitude for controlling the transducer and being able to manipulate the image and patient to get the images required.

22. Interactions with participants via REACTS.
The biggest challenge was trying to communicate my instructions clearly and, in a way that the participant would know what to do while scanning. As stated, above, the fact that we were having problems with dropping contact during a session made it difficult to teach fluidly and guide them at times.

23. Interactions with participants via Topic 3 Moodie Forum posts.
The only question that was posed in this forum was just clarification of what a reverberation artifact was. The comet tail artifact that is seen on normal sliding pleura and the ring-down artifact seen when encountering a pocket of air as with a pneumothorax, are both examples of ring-down artifact and it was more for clarification that the question was posed.

24. Significant questions or comments during Labs and/or Topic 3 Moodie Forum posts.
The only comment that I have that doesn't really fit anywhere else was the issue of the scanner being set up on the wrong side of the bed with one group. I guess I assumed that whoever was setting up the lab, understood that we typically scan from the right-side of the bed. When I did my first lab with one group, I noticed that there was something that didn't look right when the fust person started scanning, and it wasn't until they were really struggling with something and commented that it was really awkward scanning with the probe in their left hand that I clued into the fact that they were on the wrong side of the bed. I asked the participant to ask Chester to move the machine to the other side of the bed and that it should be like this for all of the participants.

25. Other?

Section IV - Overall Impressions

26. As a distance educator instructor, using online Moodie activities and REACTS methods, what worked for you and what did not work?

What worked:
Being able to interact with the participant via webcam as well as see their ultrasound scan as they were performing it. The fact that the candidates could pose questions on a forum was also a great way to clarify any misunderstandings that may have occurred.

What didn't work:
As stated earlier, the biggest disadvantage for me was not being able to guide a participant with my hand if they were really struggling with something. It's not that they didn't learn from my describing things, but it made it more difficult to explain at times.

The other thing that did not work well for this study was the loss of communication during a session. It was frustrating for both myself and the participants, and I felt that it disrupted the flow of my explanations and I felt that I was always on guard waiting to lose communication and maybe didn't explain myself as well as I could have.

Section V -Recommendations

27. What recommendations do you have for further distance education instructional design of Point of Care Ultrasound using a pocket ultrasound?
I would like to see more labs available to ensure that there is proper understanding of what is required to perform a FAST scan. Maybe, a very first lab that is dedicated to just getting the feel for holding and controlling the transducer and manipulating the controls on the machine before getting into actual scanning and recognizing anatomy and artifacts.

I would like for the learners to have the opportunity to practice in between labs. We give our students this opportunity in the DMS program and I think it really helps to refine their scanning skills.

In a real-life situation, I would like to have the opportunity to guide the student through a FAST scan on a real patient so that they could find real pathology with my guidance and give me an opportunity to clarify how it might be easy to miss things if they were not careful with their scanning or their image optimization.

I understand the communication with the candidates was supposed to be strictly online, but, as the OSCE's were going on, one comment that I was getting from some *of the male candidates is that they had never scanned a female pelvis before doing their OSCE and it left them with a bit of a disadvantage compared to the female candidates who had scanned a female pelvis for all 3 of their labs. My recommendation for this situation would be to give both male and female learners an opportunity to experience scanning people of the opposite sex just to be familiar with the anatomy in both the male and female pelvis. By giving students the opportunity to scan a more varied population of models would give them a better understanding of the variability of the scanning windows when performing a FAST scan.*

July 23, 2019 (Date)

Appendix O3: Comparative Analysis of Instructor Field Notes to Learner Data

Selected Text or Phrase(s) from Instructor Field Notes (n=2)			Learner Data Source	Alignment to Learner Data
Section	Instructor I1	Instructor I2		
Impressions & Insights				
Effectiveness of Moodle course activities and resources	Did not use much, aside from checking forums	Good introduction to project; FAST scan link from Ultrasoundpedia great resource PowerPoint well narrated on steps to perform FAST scan…YouTube videos very good…really liked Tintinalli video	Mid-Study Questionnaire	**Aligned.** Learner feedback indicates effectiveness of multimedia resources (you tube videos, narrated PowerPoint slides).
Technical factors with Moodle as a teaching tool	Provided necessary resources for participants to prepare for practical component Did not face any technical factors and participants did not voice concerns	Make sure you log onto Moodle regularly and keep up with questions in forums Ensure participants have looked at power point and video links; note YouTube links may not stay current	Mid-Study Questionnaire	**Aligned.** Learner feedback indicates no technical issues with Moodle.
Transfer of knowledge, skills, and professional behaviours in general	Average to above average overall	Because you are not interacting in person- have to really explain yourself well to relay information Several participants approached me to say power point very helpful		**Aligned.** Pre and End Study Questionnaires comparing pre and end study knowledge areas indicate positive transfer of learning for most participants.
Transfer of knowledge, skills, and professional behaviours for each professional group. Any differences and similarities amongst the different professions?	Did not notice any significant differences May have been differences in my perception of [their] motivation…some very interested into learning and a few less interested	No significant difference in understanding between the different professions		**Aligned.** Data indicate no significant differences between professional groups.
Interactions with participants via the Moodle Forums (Forum posts)	Checked frequently and did not see any	No posts in Topic 1. only 2 questions in Topic 2 on depth and artifacts – able to address both to entire group as well		**Aligned.** Learner data indicate low use of Moodle forums.
Fostering a community of learning amongst	Did not notice at all	No questions in Topic 1; Q&A forum best way to create sense of community		**Aligned.** Learner data indicate low

the participants connected by Moodle			sense of community.
Significant questions or comments (based on Forum posts)	No interaction via Forum posts	None in Topic 1; few in Topic 2 I am guessing candidates felt they had enough background information before labs	No significant questions reported.
Other?	Moodle useful to provide background knowledge necessary for practical component Made it easier to teach the practical part	[no response]	**Aligned.** Learner feedback that Moodle theory prepared learners for scanning labs?
Effectiveness of REACTS platform for teaching ultrasound scanning	Served purpose well…curious if alternative platform such as Skype would work … [question the] need to have both ultrasound screen as well as the probe position displayed simultaneously at all times…pointer function [of REACTS] nice to have	Very effective tool…like interacting with participants in real time and able to observer their scanning…did not use all the features of the platform…still effective and easy to use	**Aligned.** Learner feedback indicated effectiveness of REACTS platform and 95% would recommend REACTS.
Technical factors with REACTS as a teaching tool	Internet connection very frustrating; unpredictable cut out or weak	Biggest factor was loss of connection while trying to teach…frustrating both for learner and instructor…issues not due to room I was in – a problem between REACTS and Lumify system	**Aligned.** Learner feedback strongly indicated frustration with technical difficulties with REACTS.
Transfer of knowledge, skills, professional behaviours in general using REACTS to teach scanning	Very good – easy to communicate when internet connection was stable	Very different from any lab instruction I have ever done…Struggled to describe subtle hand movements during the scanning…changed to describing movements before actual scanning. Students had hard time with Left Upper Quadrant. anatomy did limit success on the heart for some; I was surprised at the ease that most had to image pleura [lungs]	**Aligned.** Learner data indicate they were able to learn. One learner described communication challenge to describe on how to hold the transducer Aligned. Competency performance data indicate several learners struggled with LUQ.
Transfer of knowledge, skills,	Did not notice any significant differences	Participants with imaging background (X-Ray or	Did imaging

professional behaviours in general using REACTS to each professional group. Any differences and similarities amongst the different professions?	May have been differences in my perception of [their] motivation…some very interested into learning and a few less interested	CLXT) may be more familiar with cross-sectional anatomy but I found that some people seemed to have a natural aptitude for controlling the transducer…to get images required	backgrounds do better? Check if any more professions more motivated?
Interaction with participants via REACTS	Very useful when connection stable	Biggest challenge to communicate my instructions clearly and in a way the participant would know what to do while scanning…fact of problems with dropping contact made it difficult to teach fluidly…	**Aligned.** Learner data found instructor interaction most helpful to learn
Interactions with participants in Moodle Forum posts in Topic 3 [scanning lab week]	Did not use Moodle to interact with participants…questions were addressed during REACTS	Only question was what a reverberation artifact was.	**Aligned.** Learner data indicate low use of Moodle forums.
Significant questions during Labs and/or Moodle Forum posts	Yes: what to do if instructor noticed pathology while one participant scanned the other – this created unique challenge	[comment moved to Other below]	**Aligned** with one learner comment on being surprised to find fluid on their partner.
Other	Interesting project	Scanner set up on wrong side of the bed with one group.	N/A
Instructor Overall Impressions			
Overall Impressions	Not too impressed with REACTS; use of a regular ultrasound machine and tablet with Skype could be done. Moodle was good for theory Instructors and assessors needed to be on same page earlier in the study on what needs to be taught – was helpful to get on same page eventually	What worked: Being able to interact with participant and see their ultrasound scan as they were performing. Also posing a question on a forum. What didn't work: Being able to guide a participant with my hand if they were struggling. Also, loss of communication during a session…I was always on guard…maybe didn't explain myself as well as I could have.	**Not aligned** with majority of learners who were satisfied with their learning via REACTS. **Aligned.** Learner feedback on strength of Real-time interaction between instructor and learner; frustration at technical problems; struggles with some ways to communicate a

			hands-on skill (aligned with comment from L10BIO).
Instructor Recommendations			
Recommendations Stable internet connection no matter what interactive platform used.	Not sure REACTS necessary – use skype or Messenger Stable internet connection is very important	More labs to ensure what is required of a FAST scan, example first lab is getting a feel for holding transducer and manipulating controls; Learners to have practice between labs…to refine scanning skills; Opportunity to guide student on a real patient; Give both male and female learners opportunity to experience scanning people of the opposite sex and giving students opportunity to scan a more varied population of models	**Aligned.** Learners also recommended: More labs, practice labs, opportunity to learn on a variety of patient bodies, and different genders, and real patients. **Not Aligned.** No mention of Ergonomics by Instructors.

Appendix P: Profession Descriptions of Study Participants (ultrasound-naïve learners in alphabetical order)

Advanced Care Paramedic (ACP)
Advanced Care Paramedics (ACPs) deliver the advanced-care skills necessary to treat a variety of medical emergencies. ACPs are already credentialed in the basic healthcare skills as a primary care provider. ACPs are first responders and will diagnose and treat patients in a variety of situations from cardiac care to pediatrics to pharmacology and large-scale trauma. ACPs are on the front line of medical emergencies and are called upon to give treatment to those in critical needs. ACPs are also called upon to assist hospital personnel with medical treatments if necessary; and aid in the triage of emergency patients
https://www.nait.ca/programs/advanced-care-paramedic

ACP Notes:
1. Non-Imaging
2. No formal cross-sectional anatomy education
3. Yes hand-eye coordination

Animal health Technology (AHT)
An animal health technologist is a valuable member of the animal health-care team who performs a large range of tasks, such as nursing, diagnostic procedures and client interactions, to assist veterinarians in the diagnosis, treatment and prevention of disease in animals. Practical skills are employed in both small and large animal practices, including lab work, x-rays and medical and surgical nursing https://www.nait.ca/programs/animal-health-technology

AHT Notes:
1. Non-Imaging
2. No formal cross-sectional anatomy education
3. Yes hand-eye coordination

Biomedical Engineering (BIO)
The healthcare industry continues to see a rapid increase in the usage of advanced medical diagnostic and therapeutic equipment to provide the highest level of patient care possible. As the dependence on high-tech equipment and technical expertise required by medical professionals increases, so have the technology-related risks to patients and clinical staff.
Biomedical engineering technologist careers have evolved to help manage technology-related risks in the health-care industry through the entire lifecycle of medical devices, including specification, inspection, calibration, repair and maintenance, and technical troubleshooting. The Biomedical Engineering Technologist is equipped with the fundamental knowledge and hands-on experience with electronics, microcontroller applications, computer network systems and medical imaging systems; they are also familiar with medical laboratory practices, anatomy, physiology and health technology management https://www.nait.ca/programs/biomedical-engineering-technology

BIO Notes:
1. Somewhat imaging, however, only with phantoms and instruments

2. No formal cross-sectional anatomy education
3. Yes hand-eye coordination

Combined Laboratory and X-Ray Technology (CLX)
Combined Laboratory and X-Ray Technologists (CLXT) are unique in that they are trained in both the medical laboratory and x-ray disciplines, practicing predominantly in rural communities. CLXTs perform general medical laboratory procedures, general diagnostic radiographic procedures, and electrocardiograms and are trained on information systems and technology in the medical laboratory and diagnostic imaging departments. https://www.nait.ca/programs/lab-and-x-ray-

CLX Notes:
1. Yes, Imaging
2. Yes, formal cross-sectional anatomy education
3. Yes hand-eye coordination

Magnetic Resonance Imaging Diploma (MRD)
Magnetic Resonance (MR) technologists operate medical diagnostic equipment that uses magnetic fields and radio waves. Magnetic Resonance technologists work alongside physicians, nurses, and other technologists using their skills in MR to scanning exam and analyze MR images. MR technologists work in a variety of settings from busy trauma centers to outpatient clinics. https://www.nait.ca/programs/magnetic-resonance

MRD Notes:
1. Yes Imaging
2. Yes, formal cross-sectional anatomy education
3. Yes hand-eye coordination

Medical Radiological Technology (MRT)
Medical Radiologic Technology is the art and science of correctly positioning the patient and X-ray equipment to produce and record images for the purpose of visualizing the extent of disease or injury to a patient. Most X-ray examinations are performed in the Diagnostic Imaging Department; however, they are also carried out in the operating room, in the emergency department, on wards and in specialized intensive care units. MRTs also evaluate the diagnostic quality of images quality control of practice. MRTs are also trained in radiation safety and protection practices. Many of the radiographic examinations and procedures involve working alongside physicians, other technologists, nurses and non-medical personnel. https://www.nait.ca/programs/medical-radiologic-technology

MRT Notes:
1. Yes Imaging
2. Yes, formal cross-sectional anatomy education
3. Yes hand-eye coordination

Personal Fitness Trainer (PFT)
Personal Fitness Trainers provide hands-on practice physical training and safe exercise with the knowledge of nutrition and lifestyle counselling. Personal Fitness Trainers incorporates business

management and marketing practices for entrepreneurial endeavours to start their own fitness businesses. https://www.nait.ca/programs/personal-fitness-trainer

PFT Notes:

1. Non-Imaging
2. No formal cross-sectional anatomy education
3. Yes hand-eye coordination

Respiratory Therapy

Respiratory Therapists (RETs) are dedicated to the diagnosis, treatment, rehabilitation and education of patients with heart and lung disorders. RETs work with patients of all ages, from infants and children to adults and geriatrics. The Respiratory Therapist is a crucial life-saving and life-supporting professional, who will work in a wide variety of hospital and health care settings. https://www.nait.ca/programs/respiratory-therapy

RET Notes:

1. Non-Imaging
2. No formal cross-sectional anatomy education
3. Yes hand-eye coordination

Appendix Q: Learner Participant Descriptions of any Training or Experience with Ultrasound Scanning (pre-study questionnaire, questions #3 & #4)

Q3. Have you had any training or experience with ultrasound scanning?

Q4. If yes, please describe the ultrasound scanning experience you had (if no, please type N/A):

L03 N/A
L18 As part of my ESWL training in the past I have used the US transducer built-in our therapy head alongside C-Arm to localize radiolucent renal calculi with small portion of our patients as the majority had radiopaque calculi and normally, we use only the C-Arm for localization
L13 Femoral artery blood velocity and vessel diameter, subject for ventricular filling experiments
L16 N/A
L05 N/A
L01 N/A
L14 N/A
L06 N/A
L20 N/A
L04 N/A
L10 Very basic usage of an ultrasound scanner, and imaging geometric phantoms
L08 n/a
L12 no experience
L15 NA
L17 N/A
L07 N/A
L21 N/A
L09 I answered No
L19 N/A
L22 Modeled as a DMS patient.

Appendix R: Individual Learner Beliefs in Effectiveness of DE for Psychomotor Skills (pre- to end-study)

Learner and profession	Change in belief re psychomotor skills by DE from Pre-Study to End-Study	Direction in belief	Participant Comments	OSCE Score	Comps missed 2 or 3 times
L10BIO	No to Neutral	greater	PS: No comment ES: Yes, but not as efficiently as in-person training. For example, the instructor was limited to a small field of view, and couldn't see my posture	27/35 77%	Pelvis; Heart; Reverberation; Cleans Transducer
L18MRD	Yes, to Yes	same	PS: No comment	34/35 97%	None missed
L05AHT	Yes, to Yes	same	PS: No comment	26/35 74%	Left Spleen/Kidney, Pelvis; Reverberation
L13PFT	Yes, to Yes	same	PS: No comment	29/35 83%	Left Spleen/Lung
LL15PFT	Yes, to Yes	same	PS: No comment	20/35 57%	Right Liver/Lung; Right Liver/Kidney; Left Spleen/Lung; Left Spleen/Kidney; Pelvis; Heart, Pneumothorax
L08ACP	Yes, to Yes	same	PS: No comment	22/35 63%	Depth; Right Liver/Lung; Left Spleen/Lung; Left Spleen/Kidney; Pelvis; Reverberation; Cleans Transducer
L16ACP	Neutral to Yes	greater	PS: I have never delivered or received psychomotor training through distant education, so I have unsure of its effectiveness	32/35 91%	Reverberation
L04MRT	Neutral to Yes	greater	PS: Unsure if all of the skills can be transferred during distance education	30/35 86%	Ergonomics; Left Spleen/Lung; Reverberation
L03MRT	No to Yes	greater	PS: I am not skeptical that psychomotor skills can be taught via distance education. I am curious how	29/35 83%	Ergonomics, Pelvis; Lungs; Reverberation

			these skills would transfer to real patients in a clinical environment. In my experience some level of mentoring and coaching are needed when faced with real patients and all their unique presentations.		
L19MRT	Yes, to Yes	same	PS: No comment	13/35 37%	All areas missed
L01RET	Neutral to Yes	greater	PS: No comment	32/35 91%	Pelvis
L14RET	Yes, to Yes	same	PS: No comment about psychomotor skills	30/35 86%	Pelvis
L09RET	Neutral to Yes	greater	PS: Psychomotor skills: unsure that distance delivery alone would have the same effect as face to face	33/35 94%	Cleans Transducer
L21RET	Yes, to Yes	same	PS: No comment	29/35 83%	Pelvis; Heart
L07CLX	Yes, to Yes	same	PS: No comment	31/35 88%	Pelvis; Reverberation
L17CLX	Neutral to Yes	greater	PS: I'm uncertain about whether these could be taught entirely via distance education.	32/35 91%	Ergonomics
L12CLX	Yes, to Yes	same	PS: No comment	25/35 71%	Depth, Pelvis, Heart, Wipes gel off; Cleans Transducer
L20CLX	No to No	same	PS: No comment ES: Need hands-on learning	22/35 63%	Left Spleen/Kidney; Pelvis; Heart; Lungs; Reverberation; Wipes gel off; Cleans Transducer
L06CLX	Neutral to No	lesser	PS: The success of hands-on training via entirely distance education would, in my opinion, be somewhat dependent on the complexity of the task that is being taught. ES: There's not a way to sufficiently assess ergonomics (which could have a long-term impact on the HCP scanning), nor the patient's reaction to things that the scanner does or says.	33/35 94%	Depth
L22CLX	Neutral to Neutral	same	PS: I am very excited for this research project; I think distance Education will have a great positive impact	29/35 83%	Patient Interactions; Pelvis; Lungs; Reverberation

	for the future of learning. I am hesitant though to see how some skills that require fine detail will be taught from a distance ES: Depends on the type of hands-on skills you are trying to teach	

Appendix S: Individual Learner Beliefs in Effectiveness of DE for Affective Skills (pre- to end-study)

Learner and profession	Change in belief in affective skills by DE from Pre-Study to End-Study	Direction in belief	Participant Comments	OSCE Average	Comps missed on 2 or 3 attempts
L10BIO	Neutral to Yes	greater	PS: No comment	27/35 77%	Pelvis, Heart, Reverberation, Cleans Transducer
L18MRD	Yes, to Neutral	lesser	PS: No comment ES: If combined with prior experience in healthcare, then yes	34/35 97%	None
L05AHT	Yes, to Neutral	lesser	PS: No comment ES: If participants are already professionals, it is easy, however I am not convinced with general public	26/35 74%	Left Spleen/Kidney; Pelvis; Reverberation artifact
L13PFT	Yes, to Yes	same	PS: No comment	29/35 83%	Left Spleen/Lung
LL15PFT	Yes, to Yes	same	PS: No comment	20/35 57%	Right Liver/Lung; Right Liver/Kidney; Left Spleen/Lung; Left Spleen/Kidney; Pelvis, Heart, Pneumothorax
L08ACP	Yes, to Yes	same	PS: No comment	22/35 63%	Depth; Right Liver/Lung; Left Spleen/Lung; Left Spleen/Kidney; Pelvis. Reverberation; Cleans Transducer
L16ACP	Yes, to Yes	same	PS: No comment	32/35 91%	Reverberation
L04MRT	Yes, to Yes	same	PS: No comment	30/35 86%	Ergonomics; Left Spleen/Lung; Reverberation
L03MRT	Yes, to No	lesser	PS: No comment ES: I think this course assumed I had basic professional behaviors, they were not taught	29/35 83%	Ergonomics; Pelvis; Lungs; Reverberation
L19MRT	Yes, to Yes	same	PS: No comment	13/35 37%	All areas missed
L09RET	Yes, to Yes	same	PS: No comment	33/35 94%	Cleans Transducer
L01RET	No to Yes	greater	PS: No comment	32/35 91%	Pelvis

L14RET	Neutral to Neutral	same	PS: I put neutral for the question above as I'm skeptical professional behaviours can be taught at all, whether face to face or distance. I think they are something you have, or you do not, though I do believe an instructor creating a safe environment helps enable learners to have the correct behaviours ES: I think that attitudes and professionalism can only be taught to a limited extent regardless of whether it's in person or by distance. I think they are primarily intrinsic qualities.	30/35 86%	Pelvis
L21RET	Yes, to Yes	same	PS: No comment	29/35 83%	Pelvis; Heart
L07CLX	Yes, to Yes	same		31/35 88%	Pelvis; Reverberation
L17CLX	Neutral to Yes	greater		32/35 91%	Ergonomics
L12CLX	Yes, to Yes	same		25/35 71%	Depth; Pelvis Heart; Wipes gel off; Cleans Transducer
L20CLX	No to No	same	ES: Need hand-on practice	22/35 63%	Left Spleen/Kidney; Pelvis; Heart; Lungs; Reverberation; Wipes gel off; Cleans Transducer
L06CLX	Yes, to Neutral	lesser	ES: If headphones were off and facilitator could hear what the patient was indicating (pain, questions, etc.), then yes	33/35 94%	Depth
L22CLX	Neutral to Neutral	same	ES: Depends on the students you have	29/35 83%	Patient Interactions; Pelvis; Lungs; Reverberation

Appendix T1: Learner Competency Performances for CLX (first 3 learners)

LEARNER (L) NUMBER AND PROFESSION									
A (ASSESSOR) NUMBER									
NUMBER "1" = MISSED ATTEMPT									
	L20CLX			**L17CLX**			**L07CLX**		
COMPETENCY	**A1**	**A2**	**A3**	**A1**	**A2**	**A3**	**A1**	**A2**	**A3**
Introduces self & explains role to patient									
Explains Procedure									
Protects Patient Modesty									
Applies appropriate amount of gel									
Responds to patient									
Maintains ergonomic posture				1				1	
Holds transducer and scanning arm ergonomically				1		1		1	
Uses DEPTH correctly									
Uses GAIN correctly				1			1		
Right Liver/Lung - View	1								
Freeze	1								
Point to location of pleural fluid	1								
Right Liver/Kidney - View	1								
Freeze	1								
Point to Morrison's pouch	1						1		
Left Spleen/Lung - View		1							
Freeze		1							
Point to pleural fluid		1							
Left Spleen/Kidney - View	1	1							
Freeze	1	1							
Point to where fluid would be	1	1							
Pelvis - View		1	1						1
Freeze		1	1						1
Point to posterior cul-de-sac		1	1				1		1
Heart - 4-chamber view	1		1						
Freeze	1		1						
Point to pericardial echo	1		1						
Lungs - apical views	1	1							
Live Image: point to "sliding" right and left	1		1						
M-Mode: demonstrate "sliding" right OR left	1			1					
Frozen or Live Image: identify shadowing artifact	1								
Frozen or Live image: identify reverberation artifact	1	1		1		1	1	1	1
Frozen or live Image: identify potential pneumothorax	1								
Wipes gel off patient with care	1		1	1					
Cleans transducer	1		1	1					
TOTAL	20	11	9	7		2	4	3	4

Appendix T2: Learner Competency Performances CLX (last 3 learners)

LEARNER (L) NUMBER AND PROFESSION									
A (ASSESSOR) NUMBER									
NUMBER "1" = MISSED ATTEMPT									
	L06CLX			L22CLX			L12CLX		
COMPETENCY	A1	A2	A3	A1	A2	A3	A1	A2	A3
Introduces self & explains role to patient									
Explains Procedure	1			1		1			
Protects Patient Modesty									
Applies appropriate amount of gel									
Responds to patient									
Maintains ergonomic posture				1					
Holds transducer and scanning arm ergonomically				1					
Uses DEPTH correctly	1	1	1				1	1	
Uses GAIN correctly				1			1		
Right Liver/Lung - View									
Freeze									
Point to location of pleural fluid						1			
Right Liver/Kidney - View									
Freeze									
Point to Morrison's pouch									
Left Spleen/Lung - View									1
Freeze									1
Point to pleural fluid									1
Left Spleen/Kidney - View									
Freeze									
Point to where fluid would be						1			
Pelvis - View				1			1	1	1
Freeze				1			1	1	1
Point to posterior cul-de-sac				1	1	1	1	1	1
Heart - 4-chamber view							1		
Freeze							1		
Point to pericardial echo							1	1	
Lungs - apical views							1		
Live Image: point to "sliding" right and left				1		1	1		
M-Mode: demonstrate "sliding" right OR left				1	1		1		
Frozen or Live Image: identify shadowing artifact							1		
Frozen or Live image: identify reverberation artifact	1			1	1		1		
Frozen or live Image: identify potential pneumothorax				1			1		
Wipes gel off patient with care			1				1	1	1
Cleans transducer			1				1	1	1
TOTAL	3	1	3	11	3	5	16	7	8

Appendix T3: Learner Competency Performances for RET

LEARNER (L) NUMBER AND PROFESSION												
A (ASSESSOR) NUMBER												
NUMBER "1" = MISSED ATTEMPT												
	L01RET			L09RET			L14RET			L21RET		
COMPETENCY	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3
Introduces self & explains role to patient												
Explains Procedure												
Protects Patient Modesty												
Applies appropriate amount of gel												
Responds to patient	1											
Maintains ergonomic posture								1		1		
Holds transducer and scanning arm ergonomically								1		1		
Uses DEPTH correctly				1	2		1					1
Uses GAIN correctly				1	2		1			1		
Right Liver/Lung - View												
Freeze												
Point to location of pleural fluid											1	
Right Liver/Kidney - View												
Freeze												
Point to Morrison's pouch	1											
Left Spleen/Lung - View												
Freeze												
Point to pleural fluid												
Left Spleen/Kidney - View												
Freeze												
Point to where fluid would be												
Pelvis - View		1	1					1	1			
Freeze		1	1					1	1			
Point to posterior cul-de-sac		1	1				1	1	1		1	1
Heart - 4-chamber view										1	1	1
Freeze											1	1
Point to pericardial echo	1						1			1	1	1
Lungs - apical views								1				
Live Image: point to "sliding" right and left												
M-Mode: demonstrate "sliding" right OR left										1		
Frozen or Live Image: identify shadowing artifact												
Frozen or Live image: identify reverberation artifact	1									1		
Frozen or live Image: identify potential pneumothorax												
Wipes gel off patient with care						1						
Cleans transducer				1	2	1	1					
TOTAL	4	3	3	3	6	2	5	6	3	7	5	5

Appendix T4: Learner Competency Performances for MRT

LEARNER (L) NUMBER AND PROFESSION									
A (ASSESSOR) NUMBER									
NUMBER "1" = MISSED ATTEMPT									
	L19MRT			L03MRT			L04MRT		
COMPETENCY	A1	A2	A3	A1	A2	A3	A1	A2	A3
Introduces self & explains role to patient									
Explains Procedure	1		1						
Protects Patient Modesty									
Applies appropriate amount of gel									
Responds to patient	1								
Maintains ergonomic posture	1			1			1	1	
Holds transducer and scanning arm ergonomically				1	1				
Uses DEPTH correctly	1	1	1		1		1		
Uses GAIN correctly	1			1					
Right Liver/Lung - View	1	1	1					1	
Freeze	1	1	1					1	
Point to location of pleural fluid	1	1	1					1	
Right Liver/Kidney - View	1	1	1						
Freeze	1	1	1						
Point to Morrison's pouch	1	1	1						
Left Spleen/Lung - View	1	1	1				1		
Freeze	1	1	1				1		1
Point to pleural fluid	1	1	1				1	1	1
Left Spleen/Kidney - View		1	1						
Freeze		1	1						
Point to where fluid would be		1	1						
Pelvis - View				1	1				
Freeze				1	1				
Point to posterior cul-de-sac	1			1	1				
Heart - 4-chamber view	1		1						
Freeze	1		1						
Point to pericardial echo	1	1	1						
Lungs - apical views	1	1	1						
Live Image: point to "sliding" right and left	1	1	1	1	1	1			
M-Mode: demonstrate "sliding" right OR left	1	1							
Frozen or Live Image: identify shadowing artifact	1								
Frozen or Live image: identify reverberation artifact	1		1	1	1	1	1	1	1
Frozen or live Image: identify potential pneumothorax	1	1	1						
Wipes gel off patient with care	1								
Cleans transducer	1			1					
TOTAL	26	18	21	9	7	2	6	6	3

Appendix T5: Learner Competency Performances for ACP

LEARNER (L) NUMBER AND PROFESSION						
A (ASSESSOR) NUMBER						
NUMBER "1" = MISSED ATTEMPT						
	L08ACP			L16ACP		
COMPETENCY	A1	A2	A3	A1	A2	A3
Introduces self & explains role to patient						
Explains Procedure						
Protects Patient Modesty	1					
Applies appropriate amount of gel						
Responds to patient						
Maintains ergonomic posture		1			1	
Holds transducer and scanning arm ergonomically					1	
Uses DEPTH correctly	1	1	1			
Uses GAIN correctly						
Right Liver/Lung - View		1	1			
Freeze		1				
Point to location of pleural fluid	1	1	1			
Right Liver/Kidney - View						
Freeze						
Point to Morrison's pouch						
Left Spleen/Lung - View	1	1	1			
Freeze	1	1	1			
Point to pleural fluid	1	1	1			
Left Spleen/Kidney - View		1	1			
Freeze		1	1			
Point to where fluid would be		1	1			
Pelvis - View	1	1				
Freeze	1	1				
Point to posterior cul-de-sac	1	1				
Heart - 4-chamber view						
Freeze						
Point to pericardial echo		1		1		
Lungs - apical views				1		
Live Image: point to "sliding" right and left			1	1		
M-Mode: demonstrate "sliding" right OR left						
Frozen or Live Image: identify shadowing artifact						
Frozen or Live image: identify reverberation artifact	1		1	1	1	1
Frozen or live Image: identify potential pneumothorax						
Wipes gel off patient with care				1		
Cleans transducer	1	1		1		
TOTAL	11	16	11	6	3	1

Appendix T6: Learner Competency Performances for PFT

LEARNER (L) NUMBER AND PROFESSION						
A (ASSESSOR) NUMBER						
NUMBER "1" = MISSED ATTEMPT						
	L13PFT			L15PFT		
COMPETENCY	A1	A2	A3	A1	A2	A3
Introduces self & explains role to patient						
Explains Procedure				1		
Protects Patient Modesty						
Applies appropriate amount of gel						
Responds to patient						
Maintains ergonomic posture		1				
Holds transducer and scanning arm ergonomically						
Uses DEPTH correctly		1				1
Uses GAIN correctly		1				1
Right Liver/Lung - View	1			1		1
Freeze	1			1		1
Point to location of pleural fluid	1			1		1
Right Liver/Kidney - View				1		
Freeze				1		
Point to Morrison's pouch				1	1	1
Left Spleen/Lung - View		1	1			1
Freeze		1	1			1
Point to pleural fluid		1	1	1		1
Left Spleen/Kidney - View	1			1		1
Freeze	1			1		1
Point to where fluid would be	1			1	1	1
Pelvis - View				1	1	1
Freeze				1	1	1
Point to posterior cul-de-sac				1	1	1
Heart - 4-chamber view				1		1
Freeze				1		1
Point to pericardial echo				1	1	1
Lungs - apical views						
Live Image: point to "sliding" right and left		1				
M-Mode: demonstrate "sliding" right OR left						
Frozen or Live Image: identify shadowing artifact						
Frozen or Live image: identify reverberation artifact		1				1
Frozen or live Image: identify potential pneumothorax				1	1	1
Wipes gel off patient with care						
Cleans transducer						1
TOTAL	6	8	3	18	7	21

Appendix T7: Learner Competency Performances for AHT, BIO, MRD

LEARNER (L) NUMBER AND PROFESSION									
A (ASSESSOR) NUMBER									
NUMBER "1" = MISSED ATTEMPT									
	L05AHT			L10BIO			L18MRD		
COMPETENCY	A1	A2	A3	A1	A2	A3	A1	A2	A3
Introduces self & explains role to patient									
Explains Procedure				1					
Protects Patient Modesty									
Applies appropriate amount of gel									
Responds to patient				1					
Maintains ergonomic posture									
Holds transducer and scanning arm ergonomically									
Uses DEPTH correctly	1			1					
Uses GAIN correctly				1					
Right Liver/Lung - View	1								
Freeze	1								
Point to location of pleural fluid	1								
Right Liver/Kidney - View									
Freeze									
Point to Morrison's pouch									
Left Spleen/Lung - View	1					1			
Freeze	1					1			
Point to pleural fluid	1					1			
Left Spleen/Kidney - View	1		1						
Freeze	1		1						
Point to where fluid would be	1		1						
Pelvis - View	1	1		1					
Freeze	1	1	1	1					
Point to posterior cul-de-sac	1	1	1	1	1	1		1	
Heart - 4-chamber view				1		1			
Freeze				1		1			
Point to pericardial echo				1		1			
Lungs - apical views									
Live Image: point to "sliding" right and left									
M-Mode: demonstrate "sliding" right OR left		1							
Frozen or Live Image: identify shadowing artifact									
Frozen or Live image: identify reverberation artifact	1	1		1	1	1			
Frozen or live Image: identify potential pneumothorax									
Wipes gel off patient with care						1			1
Cleans transducer	1			1		1			1
TOTAL	15	5	5	12	2	10		1	2

Appendix U1: OSCE Assessor Comment on Inadequate Bladder Filling (OSCE station A03)

3

Left Spleen/Lung	Obtains parasagittal or coronal view 7	Y
	Freezes image	Y
	ON FROZEN IMAGE ASK PARTICIPANT Point where pleural fluid would be RECORD ANSWER; SAY "THANK YOU, PLEASE MOVE ON"	Y
Left Spleen/Kidney	Obtains parasagittal or coronal view * TOO low on Lt. side	Y
	Freezes image	X
	ON FROZEN IMAGE: ASK PARTICIPANT Point to splenic/kidney space where fluid would be RECORD ANSWER; SAY "THANK YOU, PLEASE MOVE ON"	X
Pelvis	Obtains midline sagittal view	✓
	Freezes image	✓
	ON FROZEN IMAGE: ASK PARTICIPANT Point to space where intraperitoneal fluid would be RECORD ANSWER; SAY "THANK YOU, MOVE ON PLEASE" * pointed posterior to bladder (* UT not well seen due to inadequate bladder fullness)	✓

OSCE EXAM: VERSION 2 (posted May 17, 2019)

(3)

Appendix U2: OSCE Assessor Comment on Lack of Time (OSCE station A01)

5

	ON FROZEN OR LIVE IMAGE ASK PARTICIPANT to identify reverberation artifact on the image RECORD ANSWER; SAY "THANK YOU, MOVE ON PLEASE" Ran out of time	X
	ON FROZEN OR LIVE IMAGE ASK PARTICIPANT How would you identify a pneumothorax? RECORD ANSWER; SAY "THANK YOU, MOVE ON PLEASE" Ran out of time	X
Exam Closure	Wipes gel off patient with care	X
	Cleans transducer	X

0

Assessor Participant Code: A01 **Date: June ~~3~~ 4, 2019**

OSCE EXAM: VERSION 2 (posted May 17, 2019)

Appendix V1: Analysis of Learning Domains and Taxonomical Progressions

Companion documents:
Appendices L (co-coding framework) and V2 - V13 (individual learner narrative analyses)

Group Data Supports:

- Figures reflect highest hierarchy assigned to majority of learners as reflected by individual learner narrative data, and
- Tables include all hierarchies as assigned per individual learner narratives

	Questionnaires	AFFECTIVE	COGNITIVE	PSYCHOMOTOR	Group Data Supports	SHIFTS IN LEARNING DOMAINS
NWKM LEVEL 1 REACTION						
Engagement	Pre-Study	Receiving/	Understanding	Set	Fig. 7	Increase in all domains
Relevance	Pre-Study End-Study	Responding Valuing	Understanding Evaluation	Set Mechanism	Figs 8 and 9	
Satisfaction	End-Study	Valuing	Evaluation	Mechanism	Figs 10 and 11	
NWKM LEVEL 2 LEARNING						
Transfer of Learning	Pre-Study End-Study	Receiving/ Responding Valuing	Understanding Evaluating	Set Mechanism	Fig 12	Increase in all domains
Learner Evaluation of Theory component	Mid-Study	Valuing	Analyzing	Set	Fig 13	Increase in Cognitive and Psychomotor domains from Theory to Practical; Affective remaining the same
Learner Evaluation of Practical Component	Mid-Study	Valuing	Evaluating	Mechanism	Fig 13	
Did theory prepare for labs?	Mid-Study	Valuing	Analyzing	Set	Fig 14	
Are learners prepared for OSCEs?	Mid-Study	Valuing	Evaluating	Mechanism	Fig 15	
Learner beliefs in DE for psychomotor skills?	Pre-Study End-Study	Valuing Organizing	Understanding Evaluating	Set Mechanism	Fig 16	Increase in Affective domain
Learner beliefs in DE for affective skills?	Pre-Study End-Study	Valuing Organizing	Analyzing Evaluating	Set Mechanism	Fig 17	

NWKM LEVEL 3 BEHAVIOURS						
OSCE Scores as a reflection of Learning Domain Hierarchies	Overall Inter-professional Intra-professional	Valuing	Evaluating	Mechanism	Fig 18, 22, 23	Increase in domains for some learners as identified in individual learner data below as validated by higher OSCE scores
Core Skills of performing an EFAST exam	End-Study	Valuing	Evaluating	Mechanism	Fig 24, 25	
Competency Assessments					Figs 19, 20, 21	
HIERARCHIES ASSIGNED TO INDIVIDUAL LEARNER DATA						
Moodle course: Most and least helpful?	Mid Study #6 and #7	Valuing	Analyzing	Set	Table 10	
Scanning labs: Most and least helpful?	Mid-Study #8 and #9	Valuing	Applying and Evaluating	Mechanism	Table 11	
Recommend REACTS?	Mid-Study #10	Valuing	Evaluating	Guided Response and Mechanism	Table 12	
What is your advice?	Mid-Study #11	Valuing	Analyzing and Evaluating	Psychomotor Complex Overt Response	Table 13	
If you could change one thing…?	End-Study #9	Valuing, Organization	Applying, Analyzing, Evaluating	Mechanism and Complex Overt Response	Table 13	
Any surprises? Anything not surprise you?	Mid-Study #12 and #13	Valuing	Analyzing and Evaluating	Guided Response and Mechanism	Table 14	
	Pre-Study #10	Responding	Understanding	Set		
Concerns, Questions, Comments	Mid-Study #14	Valuing	Analyzing and Evaluating	Mechanism and Complex Overt Response	Table 15	
	End-Study #10	Valuing	Analyzing	Guided Response and Mechanism		

Summary of Progressions Learning Domain Analysis

Learning Domain	Hierarchies within the taxonomy reflected in data	At what point in the study did significant hierarchical shifts occur?
Affective	*Receiving to Responding* to *Valuing* to *Organizing*	To *Valuing* at Mid-study-when learning begins To *Organizing* at End-study -with reflection on beliefs
Cognitive	*Understanding* to *Applying* to *Analyzing* to *Evaluating*	To *Applying* at Mid-study – in scanning labs prior To *Analyzing* at Mid-study-with more practice & OSCEs To *Evaluating* at End-Study -in post-study reflections
Psychomotor	*Set* to *Guided Response* to *Mechanism* to *Complex Overt Response*	To *Guided Response* at beginning of scanning labs To *Mechanism*– at the end of scanning labs and in OSCEs To *Complex Overt Response* in OSCEs with higher OSCE scores(>80%)

Appendix V2: Pre-study Narrative Analysis Question 10

Legend: A=Affective; C=Cognitive; P = Psychomotor

Participant Code & Profession	*Selected* Text or Phrase(s) & [primary learning domain – hierarchy] Question: Do you have any concerns, questions, or comments?	Primary NWKM Level	Primary Learning Domain(s)	Emergent Themes 8/20 learners with narratives =40%
L22CLX	**EXCITEMENT** …very excited for this research project [AR]	**Level 1 Reaction**	AR= Affective Receiving/Responding to stimuli; willingness	Pre-study reaction to training is positive and affective learning domain at responding level is engaged
L22CLX L03MRT L17CLX L04MRT L09RET L16ACP	**HESITANCY, CURIOSITY, UNCERTAINTY, SKEPTICISM** …hesitant... to see how some skills that require fine detail will be taught from a distance [AR, PS] …not skeptical [AV, PS] that psychomotor skills can be taught at a distance education. I am curious [AR, PS] how these skills would be transferred to real patients in a clinical environment. In my experience some level of mentoring and coaching are needed when faced with real patients and all their unique presentations [AV,PS] …uncertain whether these could be taught entirely via distance education [AR,PS] Unsure if all of the skills can be transferred during distance education [AR,PS] Psychomotor skills unsure that distance delivery alone would have same effect as face to face [AR, PS] I have never delivered or received psychomotor training [PS] through distance education so…unsure [AV] of its effectiveness	**Level 1 Reaction**	AR= Affective Responding AV= Affective Valuing PS=Psychomotor Set	Pre-study reaction to training invokes feelings of hesitancy and questioning of own experience, knowledge, and beliefs with 1) affective learning domain involved up to valuing level of taxonomy and 2) psychomotor – Set hierarchy triggered – a mental readiness for hands-on skills training in the study
L22CLX	**BELIEFS, OPINIONS** I think distance Education will have a great positive impact for the future of learning [AV]	**Level 1 Reaction**	AV=Affective Valuing PS=Psychomotor Set	Pre-study reaction to training invokes own skepticism and/or beliefs of the value of distance education for hands-on skills and/or professional

		behaviors
L06CLX	Success of hands-on training via entirely distance education would, in my opinion [AV], be somewhat dependent [PS] on the complexity of the task being taught	Pre-study learning domains & highest taxonomy levels are: Affective - Valuing Psychomotor – Set No Cognitive domains co-codes on narrative analysis
L14RET	I am skeptical professional behaviours [A-VALUING] can be taught at all, whether face to face or distance. I think they are something that you have, or you do not, though I do believe [AV] an instructor creating a safe environment helps enable [AV] learners to have correct behaviours [PS]	
	NO AS RESPONSE OR	
L21RET	**BLANK**	
L01RET	No	
L12CLX	Blank	
L08ACP	No	
L20CLX	n/a	
L07CLX	blank	
L13PFT	blank	
LL15PFT	blank	
L18MRD	blank	
L05AHT	blank	
L10BIO	blank	
L19MRT	blank	
	blank	

Appendix V3: Mid-study Narrative Analysis Question 6

Participant Code & Profession	*Selected* Text or Phrase(s): What was MOST helpful for your learning experience in the Moodle course site?	Learning Domain & Hierarchy and NWKM Level(s)
	POWERPOINT SLIDES	
L14RET	*narrated* PowerPoint	PsychomotorSet
L22CLX	PowerPoints	
L20CLX	*voice over* on PowerPoints	Level 2 - Learning
L08ACP	*guided* PPTs	Level 4 - Results
L19MRT	PowerPoints and *images*	
L03MRT	*narrated* PowerPoint…great *explanations and tips*	
L04MRT	all *images* in PowerPoint presentations	
	VIDEOS (YouTubes)	As above
L05AHT	*audio within* the video	
L07CLX	YouTube	
L01RET	Supplemental YouTube videos *showing the whole scan*	
L09RET	…US *image and hand/probe placement at same time*	
LL15PFT	YouTube videos	
L13PFT	videos of *EFAST scan being done*	
	BOTH POWERPOINTS AND VIDEOS	As above
L17CLX	PowerPoint and 2 videos in particular…*shorter* ones	
L12CLX	*narrated* PPTs and videos	
L06CLX	…*recommend students watch those* [YouTube videos] *first before* [PowerPoints] to *provide visual clarity* to content	
L18MRD	PPTs with *voice over* and videos	
L16ACP	*narrated* PowerPoints *combined* with video *demonstrations*	
L10BIO	*narrated* PowerPoint slides…*multiple examples of good/bad pathology*…YouTube *videos great supplements*	
L21RET	*both* PPT and videos	

Appendix V4: Mid-study Narrative Analysis Question 7

Participant Code & Profession	*Selected* Text or Phrase(s): What was LEAST helpful for your learning experience in the Moodle course site?	Learning Domain(s) & Hierarchy and NWKM Level(s)
	FORUMS	CAN=Cognitive
L07CLX	forums	Analyzing
L17CLX	*didn't use* the forums…they *would have been helpful* if I had	
L20CLX	forums – *didn't get used*	Level 2 - Learning
L06CLX	forums *not used* by students…*more questions* would have been of use…we all worked through material and *didn't need* the forums	Level 4 - Results
L01RET	forums	
L14RET	*didn't use* forums or *[didn't] watch most* of the videos	
L18MRD	forums	
L13PFT	forums	
L03MRT	forums *not used by group* very much…*didn't find instructor answers helpful…*	
	[Data analysis instructional design questions. How were forums positioned to the learners? What were the instructions on purpose, use, etc. Were the forums monitored, how often? Who created the PPTs? What model was used? Not a cognitive load issue. Who created the glossary? Intent? Accessible? How were the videos selected? Is the COI worth considering here? Did responses surprise?]	
	MULTIMEDIA	
FIPFT	*narrated* slides	CAN=Cognitive
L04MRT	some *talking slides repeated* word content…would like *talking only when it adds to visual content*	Analyzing
L19MRT	*[not enough] images with markers* identifying what I'm looking for	
L16ACP	couple *variances in technique* on videos confusing…rectified in labs	
	RESOURCES	As above
L12CLX	Did not use Glossary	
	ALL WAS HELPFUL [ALL AV?]	AV= Affective Valuing
L05AHT	none	CAN=Cognitive
L22CLX	nothing; everything was helpful [AV]	Analyzing
L10BIO	no negative experiences in Moodle [AV]	
L08ACP	n/a	Level 1 – Reaction –
L09RET	nothing comes to mind	Satisfaction with
L21RET	nothing	training

Appendix V5: Mid-study Narrative Analysis Question 8

Participant Code & Profession	*Selected* Text or Phrase(s): What was MOST helpful for your learning experience in the scanning labs?	Learning Domain(s) & Hierarchy and NWKM Level(s)
	INSTRUCTOR CHARACTERISTICS/COMPETENCY	AV= Affective Valuing
L20CLX	awesome instructors [AV]	
L19MRT	very *patient and helpful* remote instructors [AV]	Level 2 - Learning
L03MRT	remote instructors very *helpful and knowledgeable* [AV]	Level 4 - Results
	INSTRUCTOR NUMBER	AV=Affective Valuing
L17CLX	liked more than one instructor[AV]…helped to learn more than one approach [CAP,PM]	CAP=Cognitive Applying
L10BIO	two instructors beneficial[AV]– they each stressed different points [CAP, PM]	PM=Psychomotor Mechanism
		Level 2 – Learning Level 4 - Results
	INSTRUCTORINTERACTION (RELATEDTOINTERACTIVE TECHNOLOGY)	CAP=Cognitive Applying CE=Cognitive Evaluating
L07CLX	instructor real time…able to see my pointer [PM]	
L22CLX	Instructorto help with scans…teach usproperanatomy [PM]	PGR= PsychomotorGuided Response
L05AHT	interaction with instructor[CE,PGR]	
L01RET	video chat with instructor [CE, PGR]	PM=Psychomotor Mechanism
L18MRD	screen-sharingwith instructor[CEPM]	
L13PFT	instructor guidance [CAP, PGR] instructoras expert	
L08ACP	realtime instructorfeedback [CAP,PM]; to improve processingor psychomotor? Was there a change in attitude?	Level 2 – Learning Level 4 - Results
L16ACP	real time instructor feedback [CA, PM] Pratt – Teacheras Expert	
	INTERACTIVE TECHNOLOGY	CAP=Cognitive Apply
L07CLX	…beingable to see mypointer[PM]	
L12CLX	instructorguidanceto position probe,adjustgain anddepth,point out anatomy [PM]*	PM=Psychomotor Mechanism
L14RET	havinginstructor confirm what I'm seeing…able to see instructor demonstrate how to manipulate probe to get a better image [PM]	Level 2 – Learning Level 4 - Results
L09RET	Beingable to see whatimageswere produced basedon myhand/probe placement[PM]	
L04MRT	Wonderfulto have remote instructorand thatthey can see your monitor…able to turncamera so theycan seeyourtransducerposition [PM]	
L16ACP	hands-on labs [CAP, PM]	
	COURSE DESIGN	CE= Cognitive Evaluating
L16ACP	hands-onlabs[PM]*Teacheras Expert– PrattTPI	
L21RET	beingable to scan [PM]	PM=Psychomotor Mechanism
LL15PFT	hands on instruction and one on one instruction [PM]	
L06CLX	back-to-back labsforfirsttwo sessions...gavemea breaktodigest feedbackandthentry againwhen information stillfresh [CE]	Level 2- Learning Level 4 - Results

Appendix V6: Mid-study Narrative Analysis Question 9

Participant Code & Profession	*Selected* Text or Phrase(s): What was LEAST helpful for your learning experience in the scanning labs?	Learning Domain(s) & Hierarchy and NWKM Level(s)
	TECHNICAL – CONNECTIVITY ISSUES	Cognitive – Evaluation of Learning Level 2 - Learning Level 4 - Results
L07CLX	poor connection and one lab had loose iPad stand	
L12CLX	video call kept freezing…difficult to hear instructor…information lost	
L14RET	software had some technical issues	
L18MRD	Reacts losing voice and call dropping	
BIOM5	video stream of instructor would frequently freeze…problematic for demonstration how I should adjust probe position, experienced dropped calls	
LL15PFT	when the computer would freeze	
L03MRT	technical difficulties with REACTS software	
	TECHNICAL – DESIGN	Cognitive – Evaluation of Learning Level2 – Learning Level 4 - Results
L06CLX	no way for instructor to properly assess my ergonomics while scanning – was constantly readjusting when I'd feel any pain in my shoulder	
L13PFT	trying to position camera on tablet for instructor to see, and maintain ergonomic position	
L08ACP	screens were small…hard to see screen and scan at same time	
L21RET	not being able to learn from partner when scanning me – couldn't hear discussion due to headphones	
	ALL WAS HELPFUL OR NO RESPONSE TO QUESTION	Cognitive – Evaluation of Learning Level 1 – Reaction – Satisfaction with training Level 2 – Learning Level 4 - Results
L22CLX	everything was helpful [AV]	
L20CLX	nothing [AV]	
L05AHT	none [AV]	
L01RET	[no response]	
L16ACP	Unsure [AV]	
	COURSE DESIGN	CE=Cognitive Evaluating Level 2- Learning Level 4 - Results
L17CLX	only had female patients [scanning partners & models] so not confident scanning male pelvis	
L09RET	3rd lab…would have liked it…more self-directed [CE]	
L19MRT	would have like more time [CE]	
L04MRT	…difficult to know what was meant by some verbal directions…not used to terminology [CE]	

Appendix V7: Mid-study Narrative Analysis Question 10

Participant Code & Profession	*Selected* Text or Phrase(s): You learned how to scan using REACTS as a distance education method. Would you recommend this method for learning pocket ultrasound? If yes, why? If not, why not? If unsure, please expand.	Learning Domain(s) & Hierarchy and NWKM Level(s)
	YES – EASE OF USE	Av=Affective
L07CLX	user-friendly…clean design [CE]	Valuing
L12CLX	easy to use when working well [CE]	
L03MRT	REACTS software easy to use, the access to mentor easy as well which is crucial. I would not feel comfortable scanning without a mentor without more experience [AV,PGR]	CE – Cognitive Evaluation
L05AHT	easy and at your own pace [CE]	Psychomotor Guided Response
		Level 2 - Learning Level 4 - Results
	YES – EFFECTIVENESS – ABILITY TO LEARN	AV=Affective
L08ACP	I believe it was a good tool to learn with…but we'll see how I perform in my OSCE! [AV, CE,PGR]	Valuing
L13PFT	Seemed effective, and I feel I grasped the main concepts with understanding that mastery may take more time [CE,PM]	CE= Cognitive Evaluating
L10BIO	It wouldn't be my preferred choice, but I was able to adequately learn how to scan [CE,PGR]	PGR=Psychomotor Guided Response
L04MRT	would need more practice, I think to try it on an injured person…I expected my lab partner NOT to have fluid where it was not supposed to be! [CE,PM]	
L17CLX	more effective than I anticipated [CE,PGR]	PM=Psychomotor Mechanism
L21RET	I was able to learn via this method [CE, PGR]	
		Level 1 – Satisfaction with training Level 2 – Learning Level 4 - Results
	YES – EFFECTIVENESS – REACTS TECHNOLOGY FOR LEARNING	Av=Affective
L01RET	allowed instructor to see what you were doing and redirect [PGR]	Valuing
L09RET	Worked well for me; variety of teaching modalities [CE]	
L16ACP	seemed to work well [AV]	CE – Cognitive Evaluation
L18MRD	effectiveness with no geographic limitation [CE]	
L06CLX	can work in certain contexts (ex. physicians in remote rural sites) [CE,PGR]	
L22CLX	great way to learn basics of ultrasound [CE,PGR]	PGR - Psychomotor Guided Response
		Level 1 – Reaction – Satisfaction with training Level 2 – Learning Level 4 - Results

	YES - COURSE DESIGN	CE – Cognitive Evaluation
L12CLX	I found the system easy to use and when it was working well it was effective. I would recommend having a back-up communication for when the video call is having connectivity issues [CE]	
L20CLX	It was awesome! I was nervous… but with other medical knowledge it was not bad [CE, PGR]	PGR – Psychomotor Guided Response
L06CLX	I would say that this can definitely work in certain contexts (ex. physicians in remote rural sites). However, there needs to be parameters worked out (such as ergonomics) and consistent labs to ensure regular evaluation and competency at the end [AV, CE, PGR]	PM - Psychomotor Mechanism
L03MRT	I think the course is very well set up, easy to access and thorough [CE, PGR]	Level 2 - Learning
L04MRT	I expected my lab partner NOT to have fluid where it was not supposed to be! [CE, PM]	Level 4 - Results
L19MRT	It would be a valuable tool to assess trauma [CE]	
LL15PFT	…very practical way to learn and one on one was great [CE, PM]	
	NO – TECHNICAL ISSUES	
L14RET	I didn't have a single lab where there wasn't a connection problem…even with IT support right there it was frustrating…when it was working well the tool was great and I learned, but the technical issues were a barrier [CE, PM]	

Appendix V8: Mid-study Narrative Analysis Question 11

Participant Code & Profession	*Selected* Text or Phrase(s): What is your advice for future distance educational instructional design for remote skill acquisition?	Learning Domain(s) & Hierarchy and NWKM Level(s)
	INTERACTIVE TECHNOLOGY (REACTS)	
L07CLX	Ensure good connection for the REACTS labs [Can]	CAN=Cognitive
L12CLX	Concept of sharing the scanning image with the instructor and the camera so they can see how you are positioning the probe to be very helpful [CE.PCOR]	Analyzing CE=Cognitive Evaluating
L14RET	Ensure perfect connectivity [CAN]	
L21RET	Reacts software requires some improvement in connectivity [CE]	PCOR=Psychomotor Complex Overt
L18MRD	Add option to be able to call instructor using regular phone call if Reacts failed [CE]	Response
L16ACP	Using a camera focused on technique separate from device displaying US image; aiming camera at scanning hand (to assist instructor see technique issues) – ergonomic issues [CE, PCOR]	Level 2 - Learning
L13PFT	Better video capture devices [CAN]	Level 4 - Results
	INSTRUCTIONAL RESOURCES	CAN=Cognitive
L12CLX	Material was engaging; variety of learning tools is beneficial [CE]	Analyzing CE=Cognitive
L22CLX	Review PowerPoints before the labs [CAN]	Evaluating
L20CLX	Practice quizzes [CAN]	
L09RET	Long PowerPoints (90 mins) difficult to sit through [CAN]	Level 1 – Satisfaction with training
LL15PFT	More videos showing examples – shorter videos [CAN]	Level 2 – Learning Level 4 - Results
	SCANNING LABS	CE=
L17CLX	One more lab (4 instead of 3 and for the fourth mimic OSCE scanning patient in a 15-minute timeframe twice) [PCOR]	PCOR=
L20CLX	More hands-on learning of equipment and settings [CE]	Level 1 – Reaction –
L19MRT	More practice scanning labs [CE]	Satisfaction with training
L05AHT	Be aware of timelines and it is very easy [assumption this comment is related to scanning labs] [CE]	Level 2 – Learning Level 4 - Results
L04MRT	Suggest more practice time and more exam practice time [CE]	
L03MRT	Longer lab sessions…increase to 45 min per session…gain a better sense of how my movements with the transducer changes the anatomy appearance [PCOR]	

	REMOTE INSTRUCTION	
L06CLX	I do think there is a need for it. I think this form of remote skill education should be focused in environments where appropriate (such as northern rural hospitals) [AV]	AV=Affective Valuing
L04MRT	Seems an efficient and good way to learn skills required [AV]	
L10BIO	Trying to communicate how one should hold a probe is difficult at a distance. Future studies need to look how to break down barriers that result from instructor not being able to physically interact with the student [AV]	
	NO RESPONSE	
L01RET	[no response]	
L08ACP	n/a	

Appendix V9: Mid-study Narrative Analysis Question 12

Participant Code & Profession	*Selected* Text or Phrase(s): Were there any surprises in your learning experience in this research project?	Learning Domain(s) & Hierarchy and NWKM Level(s)
	YES	AR=Affective
L07CLX	How quickly I could learn this skill in 3 short labs [CAN, PGR]	Responding
L17CLX	How effective the remote system was for learning [CAN, PGR] (I began as a bit of a skeptic) [AR]	CAN=Cognitive
L12CLX	That someone without sonography experience could learn the E-FAST scan so quickly [AR, CAN, PGR]	Analyzing CE=Cognitive
L18MRD	How easy was the very first lab [AR, CAN, PGR]	Evaluating
L10BIO	That I'm able to complete an E-FAST scan after only an hour…of instruction [AR, CA, PM]	PS=Psychomotor
L06CLX	How thorough content was before labs began…expected to feel more blind heading into them…eased the nerves [AR, CAN]	Set PGR =
L09RET	Having to be a patient also [CE, PGR]	Psychomotor
L21RET	How easy it actually was with the right instruction [AR, CAN, PGR]	Guided Response
L03MRT	How easy it was to find the correct anatomy [CAN, PGR]	PM=Psychomotor
L04MRT	How quickly I became familiar with the anatomy in the US image [CAN, PGR]	Mechanism
L19MRT	Seeing live images was amazing [AR, CAN, PS]	
LL15PFT	How fun it was [AR, CAN]	Level 2 - Learning
L13PFT	Amount of videos to see technique [CAN, PS]	Level 4 - Results
	NO, UNSURE, OR [NO RESPONSE]	
L05AHT	No	
L01RET	[no response]	
L14RET	No	
L22CLX	None	
L12CLX	No	
L16ACP	Not sure	
L08ACP	No	

Appendix V10: Mid-study Narrative Analysis Question 13

Participant Code & Profession	*Selected* Text or Phrase(s): Did anything NOT surprise you in your learning experience?	Learning Domain(s) & Hierarchy and NWKM Level(s)
	NOT SURPRISED THAT:	Can=Cognitive
L17CLX	Some of the routine patient care principles are quite standardized [CAN, PGR]	Analyzing
L12CLX	That I could learn the theory component of E-FAST through Moodle – distance delivery [CE, PM]	CE=Cognitive Evaluating
L06CLX	Quality of instruction…message consistent [CE, PM]	
L18MRD	Instructors ability to coach and teach along [CAN, PGR]	PGR=Psychomotor
L16ACP	Learning could be effective if technology used effectively (and if there were no technical issues) [CE, PM]	Guide Response PM=Psychomotor
L10BIO	Technical difficulties (dropped calls, etc.) [CAN, PGR]	Mechanism
LL15PFT	How great instructors were in labs [CAN, PGR]	
L19MRT	At my clumsy handling of the transducer Mechanism? [CAN, PGR]	Level 2 - Learning
L03MRT	NAIT mentors would be amazing [CAN, PGR]	Level 4 - Results
L04MRT	I am not perfect at EFAST, but getting pretty good [CE, PM]	
	NO, UNSURE, OR [NO RESPONSE]	
L05AHT	No	
L01RET	[no response]	
L14RET	No	
L09RET	No	
L21RET	No	
L07CLX	No	
L22CLX	Nothing surprised me,	
L20CLX	No	
L08ACP	No	
L13PFT	Unsure	

Appendix V11: Mid-study Narrative Analysis Question 14

Participant Code & Profession	*Selected* Text or Phrase(s): Do you have any other comments to share?	Learning Domain(s) & Hierarchy and NWKM Level(s)
	SATISFACTION	AV=Affective
L22CLX	Great experience, learned a lot, I am happy to have taken part in this research project [AV, CAN, PM]	Valuing
L12CLX	Really enjoyed participating in the study and learning the E-FAST scan (AV, CE, PM)	CAN= Cognitive Analyzing
L08ACP	Interesting study, glad to be a participant [AV,CAN]	
L16ACP	Enjoyed the experience [AV,CA]	CE=Cognitive
L18MRD	Thanks:) [AV]	Evaluating
L10BIO	That was fun! [AV, CAN]	
LL15PFT	Fun experience [AV,CAN]	PM - Psychomotor
L19MRT	Great experience to participate in [AV, CAN]	Mechanism
L04MRT	Very interesting to be a participant. My EFAST training works well with the uninjured patient, but may be quite different, and more difficult with patients who may be in pain, etc., and potentially have injuries and fluid [(CE, PCOR COR]	PCOR= Psychomotor Complex Overt Response Level 2 - Learning Level 4 - Results
	NO COMMENT, UNSURE, OR [NO RESPONSE]	
L07CLX	[no response]	
L17CLX	[no response]	
L20CLX	No	
L06CLX	[no response]	
L14RET	No	
L21RET	[no response]	
L09RET	No	
L05AHT	No	
L03MRT	No	
L13PFT	[no response]	
	COURSE DESIGN	
L01RET	Embed narration and slide timing into slides…consider saving as PowerPoint show file…having to click on each individual sound file took me out of the flow of learning the material [CE,PM]	CE=Cognitive Evaluating PM=Psychomotor Mechanism Levels 2 and 4

Appendix V12: End-study Narrative Analysis Question 9

Participant Code & Profession	*Selected* Text or Phrase(s): If you could change one thing in your learning experience what would it be?	Learning Domain(s) & Hierarchy and NWKM Level(s)
	VARIETY IN BODY HABITUS FOR HANDS-ON LEARNING	CAP=Cognitive
L12CLX	I would have liked to scan 3 different patients during practice labs to get experience with various body habitus. During the OSCE I was confused when I could not find required anatomy-questioning whether it was due to probe placement or incorrect gain and/or depth. Different body habitus during labs would have helped me understand gain/depth a bit better [CAP, PM]	Applying CAN=Cognitive Analyzing CE – Cognitive Evaluating PM=Psychomotor
L07CLX	More than 1-2 patient body habitus [CE, PM]	Mechanism
L13PFT	Variety of partners to scan on, prior to OSCE [CE, PM]	
L16ACP	Practical labs with different partners for each lab [CAN. PM]	
L04MRT	I would have different partners for the lab component…would see more than one person's anatomy in the practice sessions [CE,PM]	Level 2 - Learning Level 4 - Results
	BOTH GENDERS FOR HANDS-ON LEARNING & OSCE PREPARATION	CAP=Cognitive Applying
L10BIO	During training I was scanning on male patients; however, in the exam, all SPs were female. Landmarking was different enough that I wish I had been able to practice on both patients of both genders [CAP. PCOR]	CE=Cognitive Evaluating PM=Psychomotor
L16ACP	Practical labs…with both males and females [CE, PM]	Mechanism
L01RET	Use patient models [OSCE ultrasound models?] in at least one of the practice sessions…during my practice sessions I was only paired with males…in comparison during the OSCE I only had female patients…proved challenging especially during bladder scanning…and other surrounding structures [CE,PM]	PCOR= Psychomotor Complex Overt Response Level 1 – Satisfaction with training Level 2 – Learning Level 4 - Results
	MORE TIME HANDS-ON PRACTICE IN SCANNING LABS (TO IMPROVE)	AV=Affective Valuing
L06CLX	One more lab to practice [PM] …OSCE went just fine… [AV, CE] …would like more exposure to really feel competent [AV,CE,PM]	CAP=Cognitive Applying CAN – Cognitive
L05AHT	More time in the hands-on labs [CAN,PM]	Analyzing
L03MRT	Longer lab time with instructor [CAN,PM]. I don't feel confident I could trouble shoot how to find the anatomy with a different patient [CE,PM]	CE – Cognitive Evaluating
LL15PFT	…a little more lab time [CAN, PM]	
F6 CLX	…like to have a mock OSCE during the last lab…Ex. 15-minute OSCE, remainder is going over what could be improved etc. [CAP,PM]	PM – Psychomotor Mechanism PCOR - Psychomotor COMPLEX OVERT RESPONSE Level 2 – Learning Level 4 - Results
	INSTRUCTIONAL DESIGN	AV= Affective
L09RET	less outright direction in labs 2 and 3 …let me make my mistakes and correct me as I go [CAP,PM]	Valuing
L18MRD	an additional OSCE station using a phantom or mannequin that simulate certain pathology [CE,PM]	CAP=Cognitive Applying
L20CLX	More time to learn material on Moodle [CE, PM]	CAN=Cognitive

L20CLX	last lab completely participant led with feedback from instructor[CE, PM]	Analyzing
L19MRT	I would be more attentive in how to use the transducer[CE, PM]. I was lost without the voice in my ear[AV]	CE – Cognitive Evaluating PM – Psychomotor Mechanism
	TECHNOLOGY	CAN – Cognitive Analyzing
L14RET	Less glitchy technology [CAN PM]	
L21RET	No headphones- then I could hear learnt from my partner as well…couldn't hear what instructor was saying to her [CE, PM]	CE – Cognitive Evaluating PM – Psychomotor Mechanism
	NOTHING TO CHANGE	
L22CLX	Nothing	
L08ACP	n/a	

Appendix V13: End-study Narrative Analysis Question 10

Participant Code & Profession	*Selected* Text or Phrase(s): Do you have any concerns, questions, or comments? If none, enter "not applicable"	Dominant Learning Domain(s) & Hierarchy and NWKM Level(s)	Notes and Themes
	COURSE DESIGN	AV=Affective Valuing CAN=Cognitive Analyzing PM=Psychomotor Mechanism Level 2 - Learning Level 4 - Results	Note #1: L07CLX – missed reverberation on all 3 attempts; OSCE score was 31/35 = 88.5% Future design: Ensure Moodle content transferred to lab instruction, e.g. reverberation artifact Themes: More realistic practice
L07CLX	Did not learn artifacts in the lab and could not locate artifacts on the OSCE (never heard of the term reverb). After OSCE I review[ed] Moodle PowerPoint and could not locate the term reverb. After seeing my results, I feel this affected my OSCE score as I was asked to show reverb. [AV, CAN] See Note #1		
L04MRT	During practice labs did NOT expect to find fluid, on my healthy partner, so things maybe different and more difficult if the patient MAY have blood or free fluid… [CAN, PM]		
L03MRT	I would like to see inclusion of more robust image critique. I believe I could find most structures, but I am not confident I was imaging them in the most accurate way to make diagnosis [CAN, PM]		
	SATISFACTION STATUS	AV=Affective Valuing CAN=Cognitive Analyzing PGR=Psychomotor Guided Response Level 2 – Learning Level 4 - Results	Themes: General Satisfaction with training Note #2: refers to time for completion of online questionnaires - note to future researchers
L06CLX	Nothing beyond what I state earlier. Thank you for the fun and informative opportunity [AV, CAN, PGR]		
L12CLX	I truly enjoyed the experience [AV, CAN, PGR]		
L17CLX	It was a pleasure to be a part of this research project [AV, CAN, PGR]		
L09RET	Make the timer on these surveys longer [CAN] See Note #2		
	NO CONCERNS, QUESTIONS, OR COMMENTS = n/a		Themes: Assuming general satisfaction with training
13/20 participants	L01RET, L14RET, L21RET LL15PFT, L13PFT L16ACP, L08ACP L22CLX, L20CLX, L19MRT, L18MRD, L10BIO, L05AHT		