A SIMULATION-BASED TEACHING STRATEGY TO ACHIEVE COMPETENCE IN LEARNERS

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Approval of the Dissertation

This Dissertation, by James R. Gerace, MS, PA-C has been approved by the committee members below, who recommend it be accepted by the University of Bridgeport, College of Health Sciences in partial fulfillment of the requirements for the degree of Doctor of Health Sciences (D.H.Sc.)

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Abstract

Background: Simulation-based education has become the mainstay of clinical education in health sciences and medical education. A simulation-based education is a result of work hour restriction placed on graduate learners, increased number of students requiring clinical experience, decreased number of clinical sites and lack of the availability to perform certain procedures by learners. Research has demonstrated that integration of a simulation-based educational teaching strategy in a curriculum and throughout continued learning achieves competence in learners.

Methods: The review of the literature highlighted the following topics: (a) history of medical simulation, (b) fidelity used in simulation training, devices and equipment, (c) learning theories associated with simulation-based education, (d) role of simulation training in medical and health sciences education, e) advantages and disadvantages of simulation training, f) competence in simulation-based education, g) debriefing/reflection in simulation.

Results: An extensive review of the literature supports the use of a simulation-based teaching strategy in health sciences and medical education. Learning theories associated with simulation-based education allow educators to provide teaching strategies that align with learner's ability to achieve competence in learning clinical and procedural skills required for their profession.

Conclusion: A simulation-based education integrated in all stages of learner education that provides deliberate/repetitive practice and feedback achieves competence in learners throughout a life-time of learning.

Keywords: Simulation, Simulation-Based Medical Education, fidelity, curriculum, deliberate practice, repetitive practice, debriefing, reflection

To my parents for their continued love and support.

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Chapter 1

Introduction and Background

History of Medical Simulation

A model in the form of a human developed by Greek physician Galen in 200 A.D. is one of the first documented recordings that suggests models were used as educational devices to teach the anatomy of the human body. Models were also built out of clay and stone to demonstrate the manifestations of diseases clinically and physically in humans (Jones, Passos-Neto, & Brghiroli, 2015). Model Simulators were used across varying cultures, allowing male physicians the ability to diagnosis and treat women when societal norms did not allow women the right to expose their body parts for educational purpose (Jones et al., 2015). In the 18th century, Grégoire father and son developed an obstetrical mannequin, "The Phantom," made of a human pelvis and a dead baby, this provided obstetricians the ability to teach delivery techniques allowing for a reduction in maternal and neonatal mortality rates (Jones et al., 2015).

The practice of mouth-to-mouth resuscitation, a concept introduced by Peter Safar in the 1960's is one of the earliest documented simulation techniques; he and a toy maker by the name of Ausmund Laerdal designed the first human-like mannequin simulator which was used to teach and practice mouth-to-mouth ventilation (Jones et al., 2015). This mannequin allowed physicians the opportunity to practice advanced life-saving resuscitation techniques such as the head tilt chin lift and jaw thrust for the use in a trauma patient to properly achieve an open airway in the unresponsive patient. Laerdal modified the original design after receiving recommendations from Safar to incorporate a spring mechanism in the chest cavity of the mannequin to allow recoil and simulation of cardiac compressions used in cardiopulmonary resuscitation. This mannequin

known as Resusci-Anne is still in use today. Educators and facilitators teach the proper techniques required to perform cardiopulmonary resuscitation utilizing Resusci-Anne to lay individuals and medical providers around the world (Jones et al., 2015).

The use of a standardized patient was introduced into the concept of medical education in the 1960's. Standardized patients are medical actors who portray patients and have knowledge of the underlying disease or illness which they are portraying. Standardized patients allow the learners the opportunity to improve interviewing techniques, history taking skills for a patient's chief complaint, physical examination techniques and clinical thinking skills, while an educator assesses the skills of these learners providing feedback on the interactions throughout the examination prior to patient interactions (Jones et al., 2015).

Dr. Michael Gordon a physician and educator from the University of Miami Medical School introduced the Harvey mannequin in the late 1960's. The technology utilized in this mannequin was the first simulator to achieve and replicate the functions of the cardiac system (Kunkler, 2006). The Harvey mannequin allows the learner the opportunity to perform examinations such as obtaining a blood pressure, the proper fundamentals of cardiac assessment including; palpation of the point of maximal intensity, auscultation of heart sounds for murmurs, rubs or gallops and to perform an electrocardiography (Kunkler, 2006).

The advancement of software technology and computers in the early 1990's enabled a physician researcher and medical educator at Stanford University Dr. Gaba to develop a new simulation device. Dr. Gaba combined a low-fidelity mannequin with the technology of the Harvey mannequin to produce a new training mannequin. The enhanced or high-fidelity mannequin allows for physiologic response and feedback with waveform generators to simulate patient response to treatment and interventions while undergoing anesthesia called the

Comprehensive Anesthesia Simulation Environment (CASE). The CASE simulator was modeled after the aviation technology training format for new and experienced pilots (Jones et al., 2015). CASE simulation provides a realistic learning environment that allows learners the ability to achieve proficiency in the skills required for anesthesia and an improvement in teamwork learning scenario's (Jones et al., 2015). The CASE model successfully trained and improved provider's skills in anesthesia and team-based communication allowing Gaba to introduce simulation-based medical education (SBME) into the anesthesia curriculum at Stanford University (Jones et al, 2015).

The use of virtual reality simulation produces a realistic learning environment allowing health science education students the opportunity to use internet-based systems to practice history taking and clinical examination skills presently. The most recent advancement in medical and dental education is the introduction of Anatomage. The Anatomage table is to date the most technology advanced anatomy visualization tool for anatomy education. The system allows learners the capability of viewing anatomical structures as if they were participating in a fresh cadaver gross anatomy lab. The system is fully integrated 3D modality, which allows for reconstruction of human anatomy and rotation on different planes enabling life-like visualization of structures. The newest version, "Table 7," enhanced features include a physiology content which is designed for medical education allowing learners the ability to understand both structures and function of the human body (https://www.anatomage.com/table/, 2018, p.1). The interactive program provides detailed physiologic representation of nerve innervation and function on cardiac muscle throughout the cardiac cycle as one example. Table 7 also provides simulation learning activities which include, physiological pathways, and catheter simulation

tools which is aimed to improve learner competence, improve patient safety and efficiency (https://www.anatomage.com/table/, 2018).

Fidelity used in Simulation

The term fidelity is how real or life-like the simulator or simulation learning activity is portrayed for an individual learner or learners experience (Lopreiato, 2016). In the development and production of a simulator, the developers consider aspects of the learning activity or task which mimics the real experience to achieve learning outcomes and competence. Teams develop simulation experiences to produce real life-like scenarios to enhance the simulator and simulation learning activity. The Society for Simulation in Healthcare describe fidelity as, "the physical, semantic, emotional, and experiential accuracy that allows learners to experience a simulation as if they were operating in an actual activity (https://www.ssih.org/About-SSH/About-Simulation, 2019, p.1). The literature describes five dimensions of fidelity, the *physical* which comprises the environment for the simulation experience (classroom, lab, operating room suite, etc.) and the equipment required to perform the simulation or task. The *psychological* which is the emotions and beliefs surrounding the simulation activity with the self-awareness by the participants engaging in the learning activity. The *social* which is the motivation for learning the skill or procedure to achieve a goal. The *culture* of the learners (medical, military, aeronautical) and the ability to work as a team in a *trusting* environment. The fidelity level should be appropriate for the task and training stage of a learner in order to achieve appropriate learner outcomes (Munshi, Lababidi, & Alyousef, 2015).

A novice learner can achieve similar or even higher skills transfer of theoretical knowledge with a simulator/simulation experience of simple design (Munshi et al., 2015). A

clinical vignette provided as a pre-learning activity followed by integrated simulation training such, as a task trainer, will aid in the novice learner's understanding of how to proceed in a simulation environment. As learners progress and build upon their basic medical knowledge, the level of fidelity should support higher levels of learning to incorporate speed and practice of a task to achieve proficiency and competence. A simulator is best utilized if used in parallel with curriculum goals, educational level and/or post-graduate training (Munshi et al., 2015).

Mannequin simulators have become an integral part of simulation-based training and education in healthcare. Mannequins are used to train the psychomotor and cognitive domains of learning for the clinical skills required to perform tasks and procedures when treating patients (Vincent-Lambert & Bogossian, 2017). Mannequins have become technologically advanced since the early models in the 1960's which were used to teach mouth-to-mouth ventilation like Resusci-Anne to now a computer-based and controlled mannequin simulator. This technological advancement has provided learners a more realistic and life-like learning experience enhancing learner outcomes. There are two types of mannequins commonly used in education and training, operator driven and autonomous (Vincent-Lambert & Bogossian, 2017). Operator driven mannequins are controlled by an educator or simulation technician conducting the activity. There may be limited feedback from the mannequin making the simulation activity seem less real. However, these mannequins are simple to use, and the expense associated with the use of this type of mannequin is considerably less making the activity more cost effective (Vincent-Lambert & Bogossian, 2017). Autonomous mannequins are technologically advanced, utilizing electronics and detailed mathematical algorithms to provide physiological responses to interventions applied during the simulation training (Vincent-Lambert & Bogossian, 2017). For example, when administering intravenous fluid to a mannequin programmed to simulate

physiologic shock, the response will be an increase in blood pressure and a reduction in heart rate. However, these technologically advanced mannequins require training for proper instruction and use, require preventative maintenance, and can be expensive (Vincent-Lambert & Bogossian, 2017).

Mannequin trainers can be used by an individual learner or may be used in conjunction with a team of learners to build effective communication skill and improve outcomes required when using a team-based approach in healthcare. This simulation activity may incorporate low fidelity or highly advanced simulation modalities to achieve learning outcomes. Use of the mannequin can either focus on a specific task (e.g. lumbar puncture) or the entire body depending on the learning outcome. High-fidelity mannequins have the capability of blinking and moving eyes, tearing, crying, breathing, portraying different levels of cyanosis, learners have the capability of listening for a heartbeat and palpating a pulse, they allow for external monitoring and the application of various medical equipment which can be used to provide feedback via a computer application, and they have the ability to respond to learners' interventions/treatments (Lopreiato, 2016). The ability to receive real-time response and feedback from the simulator, learners and the educator, provides the learner with an opportunity to improve teamwork communication skills and refine task or procedures being learned through the simulation experience.

Low-Fidelity

A low-fidelity simulation does not require the mannequin to be programmed or controlled by an instructor for use or for learner to participate (Lopreiato, 2016). A low-fidelity mannequin,

such as a task trainer, is used for specific skills or procedures for learners requiring competency. Examples of low-fidelity simulator include:

- an arm used for practicing injections or intravenous catheter placement
- a pig's foot used for practicing suturing and wound closure techniques
- a chicken to practice chest tube placement
- a mannequin used for practicing CPR
- a lower back for practicing lumbar puncture or epidural placement.

Other forms of low-fidelity simulation include, case studies, and role playing with standardized patients (Lopreiato, 2016). A low to medium-fidelity mannequin is a full-body simulator with specific computer components, like the Harvey mannequin, which allows the learner to assess and interpret heart sounds as a component of the simulation without being interactive (McDougall, 2015).

High-Fidelity

High-fidelity simulation refers to the use of full-body mannequins that have the capability of providing a realistic physiologic response mimicking real patients, cadavers, interactive standardized patients and virtual reality (Lopreiato, 2016). A high-fidelity mannequin incorporates a technologically advanced computer, which is commonly wireless, which can be programmed to provide a realistic patient physiological response dependent upon the learners' treatment or interventions (McDougall, 2015). High-fidelity mannequins are used in a variety of clinically difficult and stressful learning scenarios, such as a mock code (SimMan 3G simulator), a postpartum hemorrhage (NOELLE S550 simulator), or a mass-casualty incident requiring team-based interaction. A low-fidelity simulation typically requires instructor or mentor

oversight, compared to multiplex and computerized high-fidelity simulators that can incorporate a virtual instructor (McDougall, 2015).

Task Trainers

Partial-task trainers are used to simulate a portion of a complete system or to learn and practice a specific skill required by the learner. Partial-task trainers are potentially lower in cost, depending on the type of fidelity, but they can also be used for highly complex task with higher fidelity which require specialized training (Curtis, DiazGranados, & Feldman, 2012). Partial-task trainers are classified based on the type of procedures or skill for which they are intended and have been designed for specific training requirements such as: airway management (nasal intubation, oral endotracheal intubation, laryngeal mask intubation, cricothyrotomy), lumbar puncture and epidural placement trainers, orthopedic joint injections, anesthetic blocks, suturing and surgical knot tying, chest tube placement, breast exams, nasogastric tube placement, tracheostomy care, bladder tap, and surgical simulators (Vincent-Lambert & Bogossian, 2017). Training techniques may also include complex procedural skills such as endovascular surgery for vein harvesting (Kunkler, 2006). Partial-task trainers may use interfaces, electronic or mechanical, to teach and provide feedback to learners for skills being taught in a simulation activity such as simulation utilizing an ultrasound for placement of a central venous catheter (Lopreiato, 2016).

Task trainer simulation allows the learner to perform basic skills repeatedly without harm to real patients ensuring proficiency resulting in improved patient safety, and comfort on behalf of the learner performing the procedure/skill. Task training improves critical thinking capabilities, and allows for tactile and visual learning (Kunkler, 2006).

Standardized Patient

A standardized patient is a person/actor who has been coached and provided a script to simulate an actual patient. While performing the simulation, the standardized patient presents the history and symptoms of the patients' illness/complaint in conjunction with the appropriate body language, physical findings, and the emotional and personality characteristics as well to achieve a realistic patient and provider interaction (Barrows, 1993). A standardized patient is used for the purpose of practicing and learning communication skills, performing patient assessments, and to establish an understanding of different patient and provider interactions. Standardized patients/medical models are routinely used for training providers the proper techniques to perform female breast and pelvic examinations, and male genitourinary and testicular examinations. Standardized patients particularly in this clinical area can provide an immediate formative assessment of the learners and suggest corrected examination techniques. The standardized patient also provides an experiential learning experience allowing the learner to practice different interviewing techniques, breaking difficult news, and interacting with the difficult patient.

The use of standard patients has routinely been accomplished in a live interactive face to face setting within the skills laboratory. The Yale School of Medicine Physician Assistant online program has introduced the concept of utilizing the standardized patient in the virtual reality arena recently in 2019. Students connect with live patients virtually through the secure video application ZOOM and are able to conduct patient interviews, limited physical examinations, and provide counseling. The ability to participate and interact with standardized patients in this format also provides students with a learning experience associated with the increased and

emerging use of telemedicine by patients. Bridging two simulation educational activities enhances learner's competence in preparation for future practice.

Virtual simulation

Jaron Lanier, a computer scientist coined the term virtual reality in 1987 (Vincent-Lambert & Bogossian, 2017). Virtual reality allows individuals the capability of interacting with computer generated objects and environments in a realistic 3D experience. Virtual reality allows for real time responses through learner interactions. Virtual reality has the technology and the capability to interact with both human perception and cognition (Vincent-Lambert & Bogossian, 2017). This is accomplished through learners using headsets or glasses to stimulate senses and create the illusion of reality. Glove-based devices and wireless hand held controllers allow for simulating minimally invasive surgical instruments (Vincent-Lambert & Bogossian, 2017). Virtual reality headsets can allow interaction with a virtual patient in different environments alone or in a team as previously mentioned.

Virtual reality simulation is a highly sophisticated trainer that allows the learner to train using procedural techniques with life-like tactile simulation and sensation during the learning activity. Virtual reality allows for procedural training with robotics in areas such as laparoscopic procedures, colonoscopy, endoscopy, arthroscopy, spinal surgery, catheterizations, and airway management (Kunkler, 2006). The use of these simulators provides healthcare professions with cutting edge tools to train and become proficient in less invasive techniques and improve patient outcomes (Kunkler, 2006).

One of the drawbacks of virtual reality is motion sickness related to the design of the program or ergonomics, which may cause dizziness, nausea, and learner disorientation during the

simulation experience (Vincent-Lambert & Bogossian, 2017). In addition, development of virtual reality simulation is time consuming, and costly which can cause difficulty integrating sophisticated virtual reality such as robotic simulation into health sciences education (Vincent-Lambert & Bogossian, 2017).

Simulation in Education

Training competent health care professionals is a multifaceted process. Healthcare professional educators should be familiar with the different learning theories and teaching strategies to achieve learning based on the educational setting, the context being taught, the learners' (undergraduate, graduate, or professional), the purpose of the educational instruction, potential for learners' use, and integration of existing resources and knowledge and the learner (Mukhalalati & Taylor, 2019). Simulation education must address learning objectives in the following domains: cognitive, affective and psychomotor (McDougall, 2015). Simulation-based education has the ability to provide clinical and procedural experiences with varying degrees of difficulty required by learners rather than learning through clinical experiences which may not be suitable for learners (Weller, Nestel, Marshall, Brooks, & Conn, 2012). Simulation learning activities are scheduled, observed by expert instructors, and can be repeated to allow for proper remediation and learning. Simulation-based education allows learners the ability to transfer and apply theoretical knowledge to clinical experiences in the simulation environment (Weller et al., 2012). Simulation allows for a learner-centered approach to education for a trainee when learning complex procedural skills or tasks without the stress or fear of causing harm to a patient. Simulation-based education provides a learning opportunity which is clinically pertinent allowing for competent practice daily in the health care professionals career. Simulation-based training is the quintessential educational program for the adult learner because it provides the

learner the ability to build upon and strengthen previously learned knowledge (McDougall, 2015).

Research Rationale

Simulation has become a mandatory component of health sciences education including undergraduate, graduate, and professional practice continuing education. The reasons leading to the incorporation of a simulation-based education include, a decrease in the number of clinical site for learners, mandatory work hour restrictions, need for deliberate practice and critical clinical experiences and the need to improve patient outcomes.

Health care delivery is changing throughout the United States and other countries which has created challenges in providing learners the opportunity to obtain clinical experiences required to perform their duties as competent providers (Weller et al., 2012). The major struggles in health sciences education are the availability of clinical training sites, an increased number of learners requiring clinical experiences, and the increased number of programs being established creating a competition among learner's access to procedures and tasks required for their profession (Guinane & Molloy, 2013). These factors decrease the learner's ability to partake in clinical experiences and do not allow for an environment suitable for learners.

The Accreditation Council for Graduate Medical Education (ACGME) mandatory change in resident work hours have decreased clinical experiences and learning opportunities for resident physicians and fellows (Lewiss, Hoffman, Beaulieu, & Phelan, 2014). Residents nationwide were graduating with poor self-perceived competency following the ACGME mandate, and simulation-education provided during residency training has been shown to be a safe and effective way to teach procedures and improve competency in learners (Meerkov, Fischer, & Saba, 2019). Simulation-based education has the ability to provide scheduled,

observed, and repeated learning allowing learners the opportunity to achieve clinical experiences and procedures without limiting experiences secondary to limitations in work duty hours (Weller et al., 2012).

The increased focus on patient safety and outcomes has limited a learner's hands-on training experience with real patients (Lewiss et al., 2014). Adverse events and harm to patients are most typically a result of miscommunication among team members or a provider inexperience (Weller et al., 2012). Simulation-based education provides learners the opportunity to focus on team-based interaction and procedural skills in a risk-free environment allowing for improved patient safety and healthcare patient outcomes.

Purpose of the Research

This research intends to demonstrate the use of a simulation-based teaching strategy as a powerful tool in educating health science students, medical students, residents, practicing clinicians/practitioners and to present the current literature which supports the use of simulation in education and training. The various fidelities used in simulation-based education provide the learner acquisition of knowledge by building on previously learned information to transition from novice to expert in clinical skills. The research will demonstrate the educational theories used in a simulation-based teaching strategy provide a foundational backbone for learners and is demonstrated by the transfer of theoretical knowledge learned to its application in clinical practice.

The various learning strategies associated with a simulation-based teaching strategy allow learners to utilize a multimodal approach to learning providing them the tools required to achieve competence in learning. The research will also show the advantages associated with a simulation-based teaching strategy for learner competence and the disadvantages requiring the

health science educator the task and creativity in designing a curriculum to incorporate simulation-based education allowing the learner to achieve competence in learning. Lastly, the research will show the reflective learning process in simulation-based education enhances learner's confidence and competency. Healthcare professionals are life-long learners and the use of simulation will continue throughout their professional career and the integration and application of reflective learning in practice will strengthen their ability to treat patients competently.

Chapter 2

Review of the Literature

Adult Learner (Andragogy)

Adult learning theory describes ways in which adults comprehend knowledge, skills and their attitude toward learning. Andragogy assumes that adults have the capability to learn independently and have a self-directed motivation toward learning, with different degrees of experience to build upon, and are more interested in immediate problem centered approaches of learning (Albela, 2009). Adult learning theory is based upon the principle that learners will retain and recall information which is learned when it is associated with meaning (Bradshaw & Hultquist, 2017).

According to Knowles (1988) the motivation of adults to learn is different than children in six respects:

1. *The need to know* - Why do I need to learn this? (Taylor & Hamdy, 2013). The adult learner needs to know how the learning will be instructed, what will be learned and does the learning have application to their needs (Palis & Quiros, 2014). This is especially true for simulation education. The learner wants to be certain that the learning activity associated with simulation will provide them with the skills required to perform their job effectively and with competence.

2. *The learners' self-concept* – The learner is responsible for their own decisions (Taylor & Hamdy, 2013). The adult learners' have a responsibility to make their own decision about self-directed learning (Palis & Quiros, 2014), and as educators in simulation we need to encourage active learning and self-direction by allowing repeated and deliberate practice in simulation learning activities.

3. *The role of the learners' experiences* – the learner has experiences and knowledge which they value, and they should be respected (Taylor & Hamdy, 2013). Adult learners' have different and varied experiences associated with learning particularly different learning styles, needs, motivation, requirements and goals (Palis & Quiros, 2014). In simulation

education educators need to connect previously learned knowledge to new concepts and ideas through different teaching strategies to engage all learners.

4. *Readiness to learn* – the learner needs to learn because their needs are changing and require additional knowledge (Taylor & Hamdy, 2013). The adult learner is prepared to learn in order to gain needed information to accomplish goals in the real world (Palis & Quiros, 2014). The simulation activity should focus specifically on the content required (i.e. a skill required to perform individual duties in a profession).

5. *Orientation to learning* - Learning will allow the learner to deal with the situation in which they find themselves (Taylor & Hamdy, 2013). Adult learners are more apt to learning when they view the information being learned will benefit their professional tasks and allow them to improve problem-solving and critical thinking skills They will learn more effectively when learning is associated with real-life requirements (Palis & Quiros, 2014). This concept implies that when simulation-based education is being used as a teaching strategy it should provide the learner with the necessary skills and tasks to perform their duties in and effective manner in which they will learn from the experience and gain competency in the skills required.

6. *Motivation* – the learner learns because they want to (Taylor & Handy, 2013). Adult learners desire knowledge to improve career goals, increase job satisfaction, and they search for new knowledge to build upon experiences (Palis & Quiros, 2014). Educators need to present simulation-based learning in a manner which will motivate learners to achieve new goals.

Experiential Learning

The Association for Experiential Education, describes experiential learning as "a philosophy that informs many methodologies which educators purposefully engage with learners in direct experience and focused reflection in order to increase knowledge, develop skills, clarify values, and develop people's capacity to contribute to their communities" (https://www.aee.org/what-is-ee, n.d., p.1). According to Svinicki and McKeachie, (2014), the following pieces are incorporated into almost all experiential learning methods:

- The learning uses real-world scenarios, problems, equipment, or actions like simulation to mimic real-life experiences.
- The scenarios involve complex, problem-solving situations that require critical thinking skills to answer or resolve.
- The scenarios allow the learners to participate and solve a problem which reflects experiences or problems they would encounter in the real-world setting utilizing skills and tools to achieve learning.
- The instructor is a resource for learners, to guide and assist in the learning activity.
- Learners reflect on the simulation experience and are able to debrief the learning activity to gain knowledge and receive feed-back based on what they learned and how they performed.

A simulation-based teaching strategy allows the learner to be an active participant rather than a passive observer. Learners must critically think, solve problems, and respond to the results of their decisions/interventions (Svinicki & McKeachie, 2014). Experiential learning is focused on the development of competencies and skills in a specific context (Palis & Quiros, 2014).

Kolb's (1984) describes experiential learning as the learner having a situational learning experience, and then reflecting on the completion of the learning activity. Reflection allows the learners the opportunity formulate concepts about the educational activity, and gain knowledge based on the activity and input from others. Learners are then allowed to apply this knowledge by participating in situations or learning activities which are new. This then provides the learner different experiences to learn from, and the cycle repeats (Taylor & Hamdy, 2013). Learners

with different learning styles will have strengths in different quadrants of Kolb's cycle as seen in Figure 1.

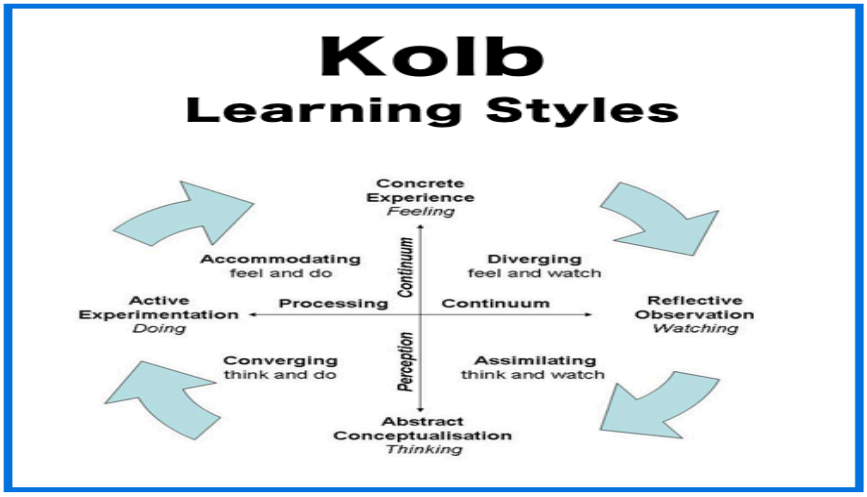

Figure 2.1. Kolb Learning Styles. Reprinted from *Simply Psychology,* by McLeod, S, 2017. Retrieved from https://www.simplypsychology.org/learning-kolb.html

Kolb's (1984), considers the process of learning as a "cycle", consisting of 4 steps:

1. The learner participates in a concrete experience (feeling).
2. The learner observes and reflects on the experience from alternative perspectives (watching).
3. The learner makes abstract concepts and generalizations (thinking).
4. The learner processes the new material learned, participates in active experimentation (doing).

This learning model allows for the inclusion of a variety of strategies during simulation-based education, such as scenarios/cases, standardized patients, simulations, and virtual reality. The healthcare educator can utilize these strategies to help the learner through the different steps of learning from the experience provided in the simulation activity (Palis & Quiros, 2014).

Miller's Pyramid and Scaffolding

Miller's (1990) pyramid of learning is represented in a hierarchical model divided in four stages with progression of learning building upon the previous to reach clinical competence. On

the bottom level of the pyramid is **knowledge or knows**, which learners are tested on by written examinations and multiple-choice questions (MCQs). The next level on the pyramid progressing in an upward fashion is the application of **knowledge or knows how**, which can be assessed by problem-based solving exercises and advanced MCQs. The third level of the pyramid represents clinical skills competency or **shows**, assessed by using standardized patient, simulations and objective standardized clinical examinations. The peak or top level of the pyramid is the learner performing clinically or **does**, which is assessed by observation in clinical settings with patients or by using simulation task trainers, low- and high-fidelity, and virtual reality (Witheridge, Ferns, & Scott-Smith, 2019). The lower level provides the learner the cognitive components of competence and involve classroom-based assessments with written testing, and the two higher levels of the pyramid account for the behavioral components of clinical competence, which involve assessment in simulated and clinical settings (Witheridge et al., 2019). Miller's model suggests that simulated practice provides a learning experience equal to how learners would perform in the real-world clinical setting. In health sciences education, Miller's pyramid can be used as a guide for planning and assessing within a curriculum using simulation-based education. The pyramid is important, because in training learners for the healthcare professions it is essential to remember that the competency of training learners is required as they transition to professionals caring for patients and knowledge is the foundation of the pyramid used as a building block but not the pyramid itself (Taylor & Hamdy, 2013). Scaffolding refers to the teaching strategies that educators use to enhance the learner's ability to learn new material. These strategies provide the necessary tools for learners to build upon knowledge already understood (Taylor & Hamdy, 2013). Learner competence is not a fixed entity and may be enhanced with educational scaffolding.

Sawyer et al. (2015) describes an evidence-based pedagogical framework for teaching procedural skills in health sciences education. The researchers developed a proposed framework of - **learn**, **see**, **practice**, **prove**, **do**, and **maintain** as seen in Figure 2. This is based on a review and critical synthesis of the literature in which their team conducted. The proposed framework includes simulation as a key educational modality and incorporates proven instructional design features, such as deliberate practice and mastery learning, as critical components of student learning. The framework addresses the development, assessment, and maintenance of procedural skills required for healthcare professionals. The foundation of the framework is rooted in adult learning theory which uses a modification of Miller's (1990) pyramid and scaffolding to provide competency in learning.

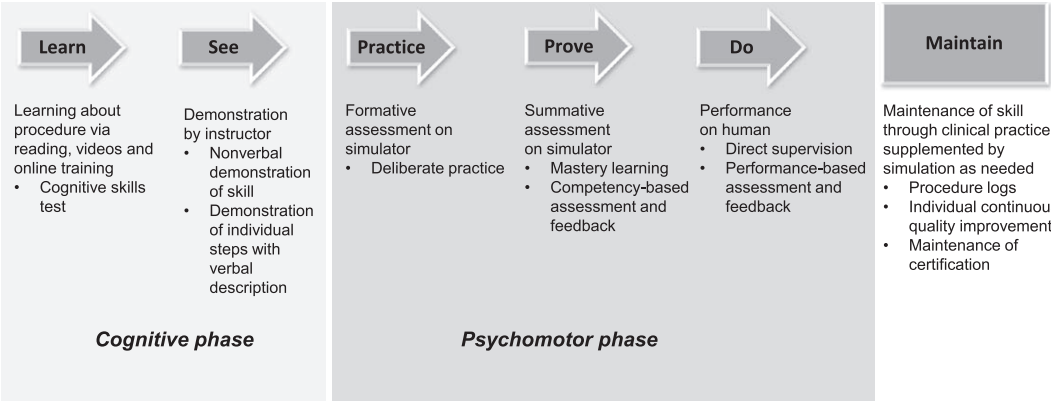

Figure 2.2. Pedagogical framework for teaching procedural skills in health sciences education. Sawyer[2], et al., 2015, (reprinted with permission)

The cognitive learning phase is focused on mental and psychological processes, understanding and processing of information, and not in the behavioral processes. The cognitive phases are made up of two subphrases: conceptualization and visualization. The **Learn** step focuses on conceptualization. Instructional techniques involved in this phase could include learning strategies such as assigned reading, internet instruction via flipped classroom, formal didactic sessions, and problem-based learning sessions with case scenarios. The benefits of

providing a cognitive portion prior to any hands-on training provides the learner with the fundamental knowledge required to perform in simulation. This step can be completed individually, or in a group environment, and by asynchronous or synchronous instruction. The **See** step focuses on the concept of visualization. The educator demonstrates the procedure or skill which the learners will perform in simulation. The demonstration of a skill or procedure is accomplished by including both nonverbal and verbal instruction to the learner.

The psychomotor phase of procedure or skills training is practicing the procedure with correction and reinforcement, as well as completing the procedure on a patient in the clinical setting. Sawyer et al., (2015) proposes practicing the procedure (**Practice**) and proving competency through simulation-based education and assessment (**Prove**) prior to performing the procedure on a patient (**Do**). The **Practice** step is improved by using deliberate practice, which has been shown to provide clinical competence in the literature. A safe learning environment for the **Practice** step, such as a simulation center utilizing partial-task trainers, mannequins, high-fidelity simulators or virtual reality, provides the learner with the opportunity to perform deliberate practice without risk or harm to a patient. In the **Prove** step, the authors proposed framework, has the learner complete objective skills assessment in a simulation environment, to make certain that procedural competence has been achieved, prior to the learning performing the procedure on a real patient. The **Prove** step uses simulation-based mastery learning (SBML).

The teaching of procedural skills must eventually move from the simulation learning environment to the clinical arena. In Miller's (1990) pyramid the assessment begins with "knows," then moves up to "knows how," "shows," and finishes with "does" when the learner has completed the skills training. In the authors proposal assessment of procedural skills using a

simulator aligns with "shows how," and assessment of procedural skills on a real patient aligns with "does" in Miller's pyramid (Sawyer et al., 2015). In the authors pedagogical proposed framework, upon completion of the cognitive knowledge of the procedure has been accomplished (**Learn**), the procedure has been demonstrated (**See**), with repeated practice utilizing simulation (**Practice**), and validation of procedural skill competency on a simulator has been shown and accomplished (**Prove**), the learner is then allowed to perform the procedure on a patient (**Do**). The **maintain** step is accomplished in both clinical practice and simulation. Simulation training is used for training when a certain procedure is real performed or as refresher course (Sawyer et al., 2015).

Cook et al. (2013) conducted a study to evaluate the effectiveness of educational instructional design comparing simulation-based educational interventions. Simulations allow educators the ability to create learner experiences which allow for non-judgmental learning in a practicing environment. Simulation-based education provides learners the opportunity to be assessed and receive formative feedback in real time allowing for corrective action and intervention in learning experiences.

The authors completed a systematic review of the literature using multiple databases. There was no specified start date and the last date for the review of the search was May 11, 2011. Specific search criteria was used to include articles reviewed in this study. A total of 10,297 articles were identified and screened for use and after exclusion criteria was completed a $n = 289$ was used to complete this review. Results of the review for skills outcomes favoring instructional design for multiple learning strategies was 0.62 (70 studies; $p < 0.001$) for mastery learning 0.45 (3 studies, $p = 0.57$) and for feedback 0.44 (80 studies; $p < 0.001$).

The authors' findings suggest that greater emphasis should be placed on instructional design of programs utilizing simulation-based education to include outcomes related to mastery learning and feedback. Mastery learning, as part of Miller's pyramid, allows learners the ability to demonstrate skills learned through performance, knowledge of information and integration into practice. Feedback from the educational design provides the learner the ability to refine and improve skills in a timely fashion. Educational design has a profound impact on learner outcomes. Properly designed curricula in simulation-based education need to encompass specified outcomes in order to achieve competence in learning.

Assessment of learning is standard throughout a healthcare professional's education and continues during their professional career. Healthcare professionals are exposed to a variety of assessments depending upon their individual specialty or role. An evaluation of their knowledge, clinical skills, and team/interprofessional interactions have become an important part of the learner's curriculum. Simulations are routinely used in the health professions to assess the learner's aspects of clinical competence (Munshi, Lababidi, & Alyousef, 2015).

The ability to assess clinical competence is an important factor in evaluating the outcomes of the learner (Munshi et al., 2015). Miller (1954), explained that training consists of acquiring a set of skills and using equipment in an environment which mimics reality. Miller also provided an important distinction in simulation learning which identified the engineering aspect or physical fidelity and the psychological or functional fidelity. The engineering fidelity as he described is the manner in which the simulation activity replicates the physical aspects (i.e. the environment) of the actual activity. The psychological fidelity is the extent to which the skills of the task are learned by the simulated activity.

Fleming's Visual, Auditory, Read/Write, Kinesthetic, (VARK) learning styles

Simulation education used as a modality to enhance learning and assessment of learners must take into account the different learning styles and experiences each learner brings to the simulation environment or activity. All learners participating in a simulation, group activity, individual skills station, task trainer, or virtual reality environment present with their individual learning styles. Learning style is the manner in which learners gather, absorb, interpret/process, organize, comprehend and retain information for further use (Vanderbilt University, 2020). The four most common learning styles described by Fleming (1987) are: visual (V), auditory (A), read/write (R), and kinesthetic (K). Learners may also use a combination of these learning styles (multimodal/mixture learners) to comprehend the information being learned. Simulation-based education provides learners an environment that incorporates these individual learning styles in a manner which allows students the ability to comprehend and achieve competence in learning new and difficult tasks. Table 1 highlights the characteristics associated with each of these learning styles as described by Wilson and Wittman-Price (2015).

Table 1

Learner characteristics associated with VARK learning styles

Visual (V) or Spatial Learner	Aural or Auditory (A) Learner	Reading (R) or Writing Learner	Kinesthetic (K) or Active Learner	Multimodal/Mixture Learners
Learn best by what they see	Prefer learning through what is heard or spoken	Prefer to have information presented in the written form	Learn by using touch when participating in a physical learning activity	Utilize two or more learning styles to achieve comprehension
Learn through pictures, flow charts, concept maps, diagrams, timelines, demonstrations	Learn best by attending lectures, listening to audio tapes, group discussions, web chats, phone conversations	Learn through a text-based activities such as PowerPoints, lists, flash cards	Process information pertaining to the learning activity while exercising	Learner wants information to be pertinent to needs and content specific allowing for a style of learning which is appropriate to the situation
Use computers and graphics to augment learning	Understand and learn information by talking through concepts and new ideas out loud	These learners will require written instruction when participating in simulation-based educational model prior to the task or activity	Learn by playing games, role-play, and using models	Uses each style of learning to broaden understanding
These learners do not particularly like to learn by watching movies, videos or PowerPoint presentations	Auditory skills allow these learners to process information and recall what was taught		Learn best when demonstrations are provided, through simulation, case studies, virtual reality	These learners can also be classified as tactile learners and linguistic learners
			Active learning environment	

Papanagnou et al. (2016), conducted a randomized controlled study to assess if medical students self-perceived learning style influenced individual performance when learning placement of an intravenous catheter. The authors of the study used the domains of the VARK model to determine if there is a specific teaching strategy that addresses learning styles when being taught procedural skill that influenced student performance. A total of 162 third-year medical students were enrolled in the study. Student received two instructional training sessions prior to catheter placement, a didactic session and a hands-on simulation session. The didactic session consisted of a 30-minute lecture on proper placement and need for intravenous catheterization. The didactic lecture was completed using a PowerPoint presentation with slides consisting of a mixture of written text which was verbally read by the instructor, images and video clips. Also, students were provided an intravenous catheter to handle and inspect during the lecture. The simulation session consisted of three treatment arms which were designed based on the VARK domains. Students were randomly assigned to one of the three groups which included, "V," "A" and "K" learning-styles. The authors chose to not form a treatment arm for the "R" learning-style. Secondary to the skill being assessed was a procedure. Successful placement of the intravenous (IV) for all groups was defined as return of blood into the IV chamber after insertion of the IV into the skin and threading of the IV through any of the task trainer's veins. Placement of the IV after only one attempt was considered successful.

The self-perceived learning style of students included Kinesthetic 48 %; visual 43 %; auditory 5 %; and only a few students reported multi-model at 4 %. Percentages of each respective learning style were similar across all assigned treatment arms. The percent of self-reported visual and kinesthetic learners was the highest; with visual ranging from 40–48 % and kinesthetic ranging from 44–52 %. Self-reported auditory learning and multiple learning were

the least common, ranging from 4–6 % and 2–8 %, respectively. The differences in self-reported learning styles among treatment arms were not statistically significant. The overall average number of attempts for intravenous placement was 1.62. There was no statistical significance in the number of IV attempts or successful IV placement between assigned groups. Also, success was examined across self-perceived learning in learners, and there was no statistical difference in the average number of attempts for IV placement.

This study demonstrates that regardless of the students' self-perceived learning style, the IV catheter placement was the same. The use of a simulation based-teaching strategy is acceptable to produce competence in IV skills despite individual learning styles. Individual learning styles can benefit students as this will allow them to formulate the appropriate learning strategies and enhance their learning when participating in a simulation-based education.

Lipps, Bhandary, and Meyers (2017), synopsis of the literature (original and reviews) related to simulation-based medical education (SBE) as a component of undergraduate curriculum over the last 20 years has been an increasingly vital component of undergraduate medical and health sciences education.

Simulation-based educational opportunities within a curriculum allows educators the opportunity to create an immersive learning experience for students as opposed to the traditional didactic lectures (Lipps, Bhandary, & Meyers, 2017). SBE allows the educator the ability to deliver informational knowledge in a manner designed for different learning styles (Lipps et al., 2017). Learning styles associated with simulation-based education include visual, auditory, and kinesthetic. Simulation allows the learner to be an active participant, which is essential for kinesthetic learners. Educators using simulation also have the ability to demonstrate skills/procedures while instructing learners providing an auditory and visual component to the

simulation activity enhancing this learning style. Simulation-based education utilizes the principals of andragogy. In adult learning theory, learners need to know why they're learning, be an active participant in their learning process, have motivation to solve problems, build upon previous learning experiences and provide diversity amongst learners. Simulation provides a safe environment for students to learn the practical applications of the basic concepts learned and practice critical and procedural skills. A hybrid simulation and lecture model has the ability to engage students through the demonstration of basic concepts, while applying them to the clinical application (Lipps et al., 2017).

Simulation allows the learner the ability to connect basic theoretical knowledge to the practical application an essential component related to the adult learning theory (Lipps et al., 2017). Learning theories related to simulation-based education provide an opportunity to appeal to different learning styles and support a learners cognitive and psychomotor advancements (Lipps et al., 2017). SBE introduced early in a curriculum for learners provides the foundational support which they can apply to new knowledge and practical experiences throughout careers and a lifetime of learning.

Advantages and Disadvantages of Simulation-Based Medical Education

Simulation-based education is used to develop health professionals' knowledge, skills, and attitudes, while protecting patients from risk or harm (Lateef, 2010). A simulation-based medical education can be used for learning to eliminate the ethical concerns of training on human patients (Lateef, 2010). Simulation-based education can be applied in designing structured learning experiences, as well as be used as an assessment tool for teamwork competencies and learning objectives. Simulation-based learning itself is not new, it has been used in aviation, anesthesiology, as well as in the military. Simulation sessions allow the learner

to see their self at work, review different actions and outcomes using the same scenario's and be able to repeat and practice uncommon procedures or situations (Carron, Trueb, & Yersin, 2011). Simulation-based education helps to eliminate errors and maintain safety, especially in industries where there is no tolerance for any deviation from set standards resulting in harm of loss of life (Lateef, 2010).

Simulation education enhances technical and procedural training, improves problem-solving and decision-making skills and enhances interpersonal and communication skills or team-based competencies (Lateef, 2010). Simulation-education can be tailored to a learner's fundamental knowledge base. Simulations can be repeatedly practiced, and learners do not need to wait for a procedure to arise to learn a skill. Simulation allows for improvement in teamwork-oriented scenario's (Eppich, Howard, Vozenilek, & Curran, 2011). Simulation education enhances a learner's outcomes by providing immediate or reflective feedback, deliberate/repetitive practice, curriculum integration, in a non-judgmental environment (Lateef, 2010). The educational benefits of simulation include exposure to uncommon procedures, skills or patient interactions, a reproducible learning experience, and an opportunity to assess of learners without the risk to patients (Lateef, 2010) as seen in Table 2.

Table 2

Advantages of a simulation-based education

- Learners are able to engage in high-risk learning scenario's
- Safe learning environment
- Reduced risk to patients and learners
- Improves technical procedural skills
- Allows opportunity to correct errors without harm to patients
- Effective teaching strategy for undergraduate, post-graduate and faculty development
- Allows for hands on interaction
- Use medical equipment
- Improves critical thinking skills
- Effectively assess and evaluates clinical skills of learners

Konia and Yao (2013) highlights the advantages associated with simulation education and the learning theories which support learners using simulation education. Advantages associated with simulation education include: acquiring of basic knowledge prior to treating patients, practice/learning sessions to avoid mistakes, practicing in a safe environment, being able to learn to respond to adverse events or complications, practices skills, improve communication skills and working with a team. A simulation-based education with defined curriculum goals will also allow for a comparison between different training programs and countries. The author's share similar findings which align with Motola et al., (2013), specifically regarding the importance feedback, deliberate practice and the integration of simulation in a curriculum. Simulation allows the learner to be an active participant through the utilization of critical thinking skills, decision-making and clinical judgement based upon the simulation scenario/skill. Simulation provides the adult learner with experiential learning and fulfills the why, problem-solving and being able to build upon previously learned knowledge. Simulation allows the learner to demonstrate skills achieved by a progression from the novice to master and knows how to perform (does) competently.

Simulation education provides training for various high-risk industries effectively and is becoming a standard within the field of health sciences education and medicine. Multiple studies have supporting evidence providing improved knowledge and skills of learners who participate in a simulation-based educational activity. This perspective again highlights the adaptive use of simulation to train professionals effectively in a safe and controlled environment when high stakes or risks are associated with the duty or profession individual's practice. Educators must fully understand the benefits and advantages of simulation-based education over other teaching

strategies and use the most appropriate method to produce competent healthcare professionals (McDougall, 2015).

Disadvantages of simulation include an increased cost associated with learning new simulation equipment and providing education to trainers (Eppich et al., 2011). The skills and competency of procedures learned are based on the training provided. A simulation laboratory is costly to maintain as is the equipment (Al-Elq, 2010). A high-fidelity mannequin with monitoring and supportive equipment may cost close to $250,000, also needed are the synthetic body fluids, replacement skins, and other supplies which are necessary to simulate the experience of treating real patients (Al-Elq, 2010). Simulation also does not allow for real life experience and interactions with patients (Eppich et al., 2011). Simulation can only imitate, not replicate reality (Al-Elq, 2010). Table 3, displays the disadvantages (cons) of medical simulation as described in a review by Krishnan, Vasu Keloth, and Ubedulla, (2017).

Table 3

Disadvantages (Cons) of medical simulation

Disadvantage (Con)	
Incomplete mimicking of human systems	The complexity of human physiology is not always accurately achieved. Loss of human interaction and feedback.
Defective learning	Poorly designed simulation activities may result in negative or improper learning. May create rehearsed rather than genuine communication skills.
Attitude of learners	Hypervigilant learner causing excessive concern over the learning activity. Cavalier behavior during the learning activity because it is perceived as not “real” without human interaction.
Cost	Affordability may be less possible for small teaching programs. Initial cost is expensive as well as maintaining equipment.

Time	Multiple teaching sessions required in order to provide learning activities especially learning a specific skill.
Infrastructure	Dedicated space required. Simulation educators and techs required for learning activity.
Technical restraints	A physiologic responses is not capable with all simulators. Physical examination findings are not always life-like.
Programming difficulties	Required responses to the simulation activities need to be programmed and maintained for accuracy by simulation techs.

Debriefing and Reflective Learning

Debriefing is essential to simulation-education (Bradshaw & Hultquist, 2017). Debriefing allows the learners the opportunity to reflect on the scenario, team interaction, medical decision making, interventions, process and outcomes (Bradshaw & Hultquist, 2017).

Post-simulation debriefing is one of the most effective elements of simulation-based education (Abulebda, Auerbach, & Limaiem, 2019). Debriefing sessions provide a period of reflection allowing learners the opportunity to assess the components of the simulation experience and critically think about the educational experience. Debriefing is a facilitated discussion in which learners use the experiential learning component of reflection to identify weakness in skills and knowledge to achieve learner competence (Eppich & Cheng, 2015). Educators or simulation facilitators (experts) role in the debriefing process is to guide the learner by having the learner consider what they were thinking during the simulation, how they felt, what they did, and how they can use the skills learned within the simulation to care for patients (Bradshaw & Hultquist, 2017).

Debriefing can occur at two different times, within-event or post-event. Within-event debriefing is conducted by the facilitator alone when a corrective action is required during a

procedural skill to ensure competent learning of the procedure or skill; and during the simulation activity when a group of learners requires redirection in the simulation scenario to guide learning (Sawyer, Eppich, Brett-Fleeger, Grant, & Cheng, 2016). Post-event debriefing is conducted at the completion of the simulation-educational activity and can be either facilitator-directed or learner/self-directed. The facilitator-directed post-event debriefing is the most common method of debriefing reported in the literature (Sawyer[1] et al., 2016). Facilitators in this group serve as experts in the simulation activity and are able to provide feedback to the learner in the debriefing based on experience and training (Sawyer[1] et al., 2016). The facilitator follows the essential elements of debriefing as seen in Table 4 to guide the conversation during the debriefing learning component of the simulation.

Table 4

Debriefing essential elements

Elements of Debriefing	**Characteristics**
Psychosocial safety	Provide a supportive climate for learners. Provide pre-simulation instruction and post-simulation debriefing. Learners participate without fear of negative consequences to self-ideals, social blame, or career.
Debriefing stance	All learners participating are doing so to increase knowledge, gain and improve skills, and become competent practitioners.
Debriefing rules	Standard rules for the debriefing process. Confidential discussion. Group participation.
Shared mental model	Review of the simulation activity by learners and facilitator.
Key learning objectives	Restate learning objectives and analyze outcomes pertaining to the learning objectives.
Asking open-ended questions	Avoid yes or no questions. Foster reflection and reflective questioning.

Silent period	Period of silence after a posed question promoting reflective learning, internal processing, and formulation of thoughts and analysis of the learner's mental frames

In a facilitator-directed debrief, Sawyer[1] et al., (2016) describe educational strategies and conversational techniques which are utilized to enhance the discussion including directive feedback, circular question, advocacy inquiry, guided team self-correction, and learner self-assessment as seen in Table 5. Learner (self)-directed debriefing is having the learners conduct the debrief portion individually or with-in the team using cognitive aids to ensure that the learning objectives are addressed during the debriefing. Debriefing should be conducted immediately following the simulation-based educational activity to capture the immediate reactions of the learners (Bradshaw & Hultquist, 2017).

Table 5

Facilitator-directed debriefing

Educational strategies and conversational techniques	
Directive feedback	Focuses on a specific area of performance. Facilitator provides an explanation to the learner correcting the technique or behavior to ensure proper learning.
Circular question	A third person describes the relationship between the other two. Asks the learner to "circle back" and comment from an outside perspective on the simulation activity the participated. Allows teams to: • Track behavior patterns • Generate new information • Foster perspective taking in the debriefing
Advocacy inquiry	Gains insight into another person's frame of mind in relationship to the learning activity.

	Facilitator first advocates their observations of a skill or performance and then asks about the learner's frame of mind in relation to the action.
Guided team self-correction	Allows simulation learners to correct their own actions. Learners compare their performance against the standard both positive and negative. Facilitator guides the conversation on specific components of the simulation activity.
Learner self-assessment	Learners assess their individual performance. Uses the plus/delta(Δ) method; What went well (plus) and What could you change (delta)?

The role of debriefing is essential in the experiential learning process and needs to be mastered by educators (Eppich & Cheng, 2015) although, simulation educators may struggle with the process of debriefing a simulation educational training activity. Simulation educators have a tendency to draw from different educational strategies during debriefing sessions based on the content of the simulation activity rather than focusing on one particular strategy. Eppich and Cheng (2015) developed a script based on 4 important phases of debriefing (Figure 3). The Promoting Excellence and Reflective Learning in Simulation (PEARLS) debriefing tool combines strategies during the debriefing session and provides a guideline for educators to follow based on the simulation activity/task (Eppich & Cheng, 2015). The guideline helps support the debriefing session allowing for a reflective experiential learning strategy and either a learner or educator guided debrief.

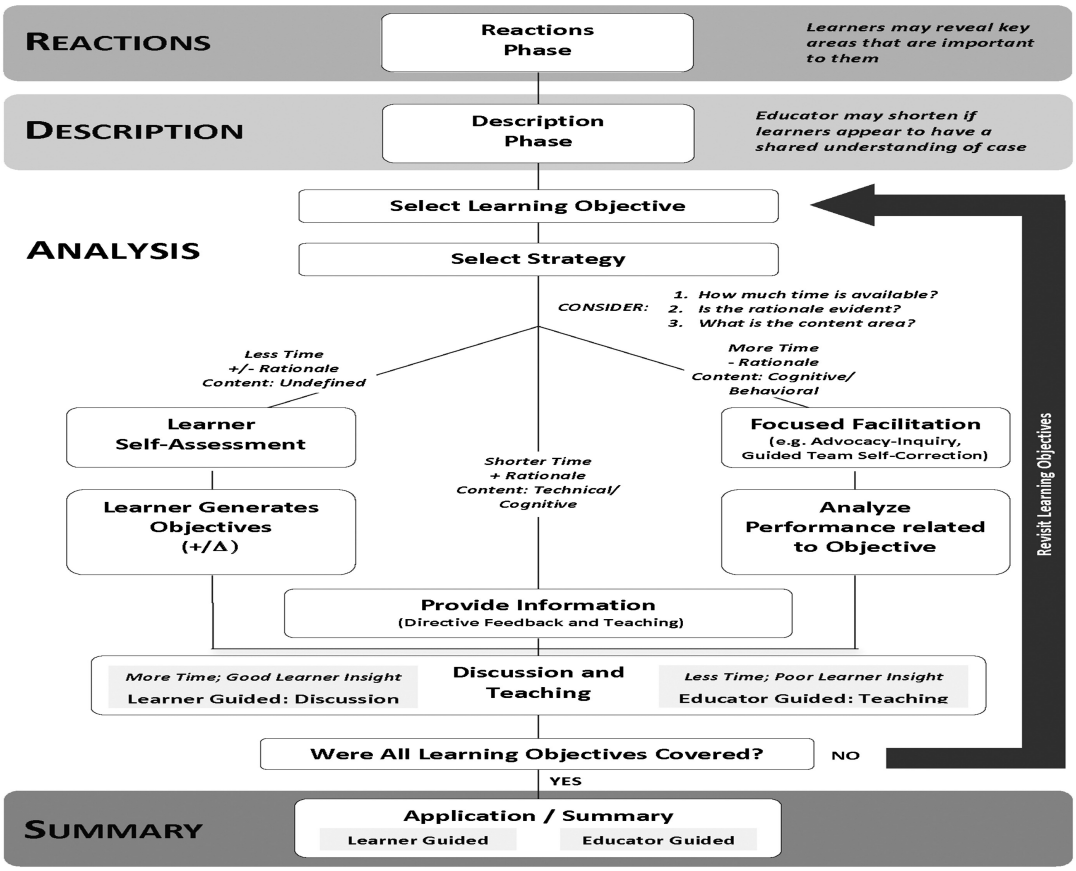

Figure 3. PEARLS debriefing framework. Reprinted from Eppich & Cheng, 2015. Retrieved from https://journals.lww.com/simulationinhealthcare/Fulltext/2015/04000/Promoting_Excellence_and_Reflective_Learning_in.7.aspx

Reflective learning in simulation allows the learner the opportunity to derive meaning from the experience so learned experiences and practices can be applied to future clinical practice. The debriefing guides available to educators allow for a continuation of learning associated with a simulation-based educational activity, however a group of simulation activities may require additional strategies to enhance learning. Grant et al. (2018) reviewed the different types of difficult debriefing situations and provide simulation educators with strategies to help guide these situations in order to achieve the learning objectives of the simulation.

The *quiet learner* varies, depending on the situation, and includes individuals who: a) are cognitively engaged but do not participate in conversation, b) shy or lack confidence, c) prefer a formal didactic lesson, d) have difficulty understanding the language. Also, situation-specific may change including: a) culture, b) tired, hungry, c) activity was too demanding or difficult.

The *disinterested learner* are those who are distracted for various reasons including: a) previous bad experience in a simulation activity, b) language barrier, and c) personal issues. Situation-specific distractions include: a) simulation is not realistic, b) lack of relevance to learning. The learner who *dominates* the learning experience with either poor insight or good insight in the simulation experience who hinder others learning by manipulating the activity. There are learners who have *emotional reactions* to the simulation from previous similar experiences, which may impact individual and others learning experience. These learners may be withdrawn, frustrated, or sad. The *defensive learner* may include those who receive poor feedback; or have personality issues with the instructor causing contention between the two.

Strategies for responding to difficult debriefing situations are divided into proactive and reactive. Proactive strategies include: a) pre-simulation briefing - provides the expectations of the simulation experience, limitations of equipment and physical space and mutual respect for educator and learners, b) debriefing environment – should be a place where individuals are able to sit comfortably which maintains confidentiality for the learner receiving feedback, c) body language – educators should be cognizant in the manner in which they are sitting by having an inviting posture which is engaging to the student and not crossing arms or leaning back, d) eye contact – should be maintained when being spoke to and conversely should be broken intermittently when providing feedback. Reactive strategies include: a) body language – educator needs to be aware of the individual receiving feedback if the learner is shy then the body language needs to be open and if the learner has a tendency to react poorly the educator should adapt body language in accordance to the mood, b) eye contact – deliberate eye contact can be used in response to lack of discussion/communication with the individual receiving feedback, and with a defensive learner eye contact can be used to de-escalate a situation by redirecting the

discussion, c) silence – may allow learners an opportunity to generate questions or reflect on what was learned prior to engaging in a discussion or if silence is prolonged the question maybe misunderstood and should be re-worded, d) directive questioning – choosing a specific learner to engage especially when a dominate learner maybe monopolizing the question and answer period a learner is seemingly disengaged, e) specific questions – allows for experiences related to the simulation activity as a whole, (i.e. what did you like best/least about the simulation activity), f) validation – recognize the learners behavior, emotion/feelings of the simulation experience good or bad, g) follow-up – allows for a period of time when individuals can return and discuss aspects of learning which were not fully understood, it allows time for the argumentative or defensive learner to relax and resolve conflict.

Establishing a simulation-based educational activity which provides all learners the opportunity to succeed is a priority. Grant et al. (2018) provides techniques for engaging learners and redirecting the learning activity to achieve goals and objectives of the simulation-based education activity. The authors provide the educator the tools necessary to ensure that the learner will be competent in the simulation activity.

Chapter 3

Methods

A comprehensive review of the literature on simulation-based education was conducted, in order to provide evidence supporting a simulation-based teaching strategy achieves learner competence.

Procedures

Search Procedure. A careful review of the literature related to simulation-based education in healthcare was conducted. The review highlighted the following topics: (a) history of medical simulation, (b) fidelity used in simulation training, devices and equipment, (c) learning theories associated with simulation-based education, (d) role of simulation training in medical and health sciences education, e) advantages and disadvantages of simulation training, f) competence in simulation-based education, g) debriefing in simulation.

Libraries used. There were two libraries used for the search of the sources for this research project. The Health Professions Division Library at University of Bridgeport Whalstrom Library and the University of Connecticut Health Center Lyman Maynard Stowe Library.

Search engines and databases used. The following databases were used to search for the sources for this project. Electronic databases included articles from Medline, Scopus, Pubmed, EBSCOhost, Science Direct Journal, BMJ Open Access and free journals, Ovid, and Citations and Abstracts for Literature of Nursing and Allied Health (CINAHL). Google Scholar was also utilized as a resource to identify pertinent articles and references to obtain current published literature on simulation-based education.

Search terms. Several search terms were used to identify sources for this project. The search terms included (a) simulation technology, (b) medical simulation education, (c) health

science simulation education, (d) fidelity in medical simulation, (e) learning theories in simulation education (f) advantages and disadvantages of simulation education, g) simulation education debriefing .

Boolean strings. Boolean strings were considered for this literature search. Boolean strings used: simulation AND medical education, simulation AND health science education, medical simulation AND advantages AND disadvantages, medical simulation AND learning, medical simulation AND fidelity, debriefing AND simulation education, competence AND simulation-based education.

Age of the sources. The significant literature was reviewed. Sources from the last 12 years were considered for the inclusion in the review of literature. Pertinent historical or seminal articles were also considered for historical purposes.

Inclusion criteria. There were four inclusion criteria. Inclusion criteria included (a) literature published sense 2008, except historical sources; (b) English-language text; (c) website relating to healthcare simulation technology; and (d) peer-reviewed articles.

Exclusion criteria. There were four exclusion criteria. The exclusion criteria included (a) literature published before 2005, except historical sources; (b) text not published in English; (c) articles not peer-reviewed; and (d) websites not relating to simulation technology and education in health sciences and medicine.

Chapter 4

Results and Findings

Simulation-based education has increased in use over the last three decades and has become a major teaching strategy in educating health science and medical professionals. The following literature is presented to support the use of a simulation-based teaching strategy to provide confidence and competence in learners. The literature review has provided evidence that simulation using various forms of fidelity improves learner competence when compared to non-simulation strategies in a structured educational setting.

Pre/Post-test study design supporting SBME and competency

It has been the practice of health sciences and medical education to provide a basic foundation of medical knowledge prior to the clinical interaction/experience with patients (Morgan, Cleave-Hogg, Desousa, & Lam-Mcculloch, 2006). Simulation-based education allows for the integration of practice and theory in a curriculum (Morgan et al., 2006), and the use of high-fidelity simulation provides learners the opportunity to practice clinical scenarios and skills without the risk to patients. Morgan, Cleave-Hogg, Desousa, and Lam-Mcculloch (2006), conducted a study to assess if experiential learning utilizing high-fidelity simulation, improved undergraduate scores on simulation-based and written examinations based on four different scenarios.

This study was a pre- and post-test using both a performance checklist for the scenarios which was shown to have internal consistency per the authors with a Cronbach's alpha > or equal to 0.6 and < or equal to 0.9, and a pre- and post-pharmacology multiple choice test. Two hundred and ninety-nine students participated in the study. Study results reported no statistically

significant differences in pharmacology pre-test scores between academic years with a $p = 0.565$ and a significant improvement in between students pre-and post-test pharmacology answers with a $p < 0.0001$. Significant improvement was also seen in team performance scores pre- and post-test simulator with a $p < 0.001$.

This study suggest that a curriculum designed to incorporate simulation-based education which provides a hands-on experiential learning allows students to achieve competency by doing. Applying basic theories learned and incorporating theory into practice utilizing simulation improves overall communication skills and teamwork in undergraduate education. This study provides supporting evidence for the use of simulation in health sciences education at improve outcomes related to learner knowledge for competency of the subject.

As simulation-based education has become integrated in the curriculum of health sciences education at both the graduate and undergraduate levels the acquired basic understanding of theoretical knowledge learned by students has not been applied clinically (Adams et al., 2015). Adams et al., (2015) study was to examine if novice learners had the ability to learn aspects of Advanced Cardiac Life Support (ACLS) in training conditions that did not incorporate simulation in comparison to training session which contained low- and high-fidelity simulation.

The authors conducted a pre- and post-test design to determine competency using simulation-based education training. Participants enrolled $n = 39$ consisting of medical students and physician assistant students. Learners were randomly assigned to 4 training conditions, a control group which was lecture only, a video-based didactic instruction, and low- and high-fidelity simulation. Learners were assessed by completing a written pretest of ACLS knowledge. All learners then received a lecture describing the science behind ACLS and the use of the

designed algorithm. Participants were then taught specific aspects (bradyarrhythmia, tachyarrhythmia, pulseless electrical activity and asystole), of ACLS according to their assigned condition in the scenario. During post-training, each learner was assessed via a Megacode performance examination and a written posttest. All groups performed significantly better on the written posttest compared with the pretest with a $p < 0.001$. There were no groups that outperformed any other groups. On the Megacode performance test, the video-based, low-, and high-fidelity groups performed significantly better than the control group $p = 0.028$, $p < 0.001$, $p = 0.019$. Testing revealed that the high-fidelity simulation condition was statistically equivalent to the video-based and low-fidelity simulation conditions.

The results of this study suggest that the use of simulation improves learner knowledge when using simulation in conjunction with didactic lectures. Novice learners were able to build upon previously learned knowledge and apply it to the task at hand when performing in a simulation-based learning activity. Simulation also allows the learners the ability to practice and reflect on the learning both during and after the completion of training.

Donkers, Bednarek, Downey, and Ennulat (2015) conducted a study to introduce high-fidelity simulation experiences in the didactic component of physician assistant physical diagnosis classes I and II and assess the learner's confidence and interest in acute care medicine before and after the simulation experience. A pre- and post-course self-assessment questionnaire was given to students, of which thirty-nine students completed the pre-course assessment questionnaire and thirty-six completed the post-course questionnaire. Three students did not complete the course work. A 5-point Likert scale was developed asking students to rate their confidence level for the following questions, a) safely evaluating and treating a patient in an acute care setting, b) identifying medical equipment used in the simulation, c) interpreting

physiologic information and making a clinical decision, d) responding to changes in a patient's status , e) interest in practicing in an acute care setting. Respondents were greater than somewhat confident pre- and post-coarse respectively for the questions as follows a) 6% and 45%, b) 5% and 55%, c) 3% and 39%, d) 3% and 34%, e) 56% and 69%.

The results of the study suggest that learner confidence levels increased post simulation activity to identify medical equipment and manage patients in the acute care setting. The role of simulation introduced in the introductory phase of the physical diagnosis class allows for improved confidence in learners when combined with didactic lessons. Learner's ability to connect previously learned knowledge from didactic sessions was strengthened when combined with a simulation-based educational session.

Li and Lopes (2016) conducted a similar study to evaluate the use of simulation-based education using high-fidelity simulation mannequins in the physiology course curriculum for physician assistant (PA) students. Simulation provides an active learning strategy similar to student's clinical experiences in a safe environment (Li & Lopes, 2016). Simulation can be used to provide a learning experience bridging theoretical knowledge and practice between the preclinical and clinical years of education in order to increase confidence prior to managing patients (Li & Lopes, 2016). In the Li and Lopes (2016) study a didactic component was given prior to the simulation activity on the principles of the Frank-Starling curve.

This study was a pre- and post-test study designed to assess the value of integrating simulation into the physiology curriculum. Seventy-five students participated in the study, 34 in the simulation group and 41 in the control group which was a traditional didactic course without simulation. Student's confidence was assessed using self-scored evaluation pre- and post-simulation experience with respect to understanding the concept of the Frank-Starling curve in

the normally functioning heart and congestive heart failure. Pre-simulation was low at 3.03 +/- 0.85 out of 5 for normally functioning heart and lower for congestive heart failure at 2.36 +/- 0.96 out of 5. Post-simulation confidence increased to 3.8 +/- 0.76 and self-reported confidence increased from 11.7% to 79.4 in understanding the Frank-Starling curve for congestive heart failure.

This study results suggest that a curriculum which integrates simulation allows for an increased understanding of physiological effects of certain conditions when used in conjunction with the didactic component. Student understanding of physiology is improved with scenario's allowing for higher-order thinking improving cognition. Simulation provides improved learning outcomes to novice learners.

The physician assistant (PA) curriculum must be inclusive of an educational framework that comprises medical care for all age groups including; the emergency and acute care needs of prenatal, pediatric and adult patients according to The Standards of the Accreditation Review Commission on Education for the Physician Assistant (Donkers, Truscott, Garrubba, & DeLong, 2016). Opportunities to engage in learning assessments skills that are required to care for the neonate and obstetric patients are limited before clinical rotations in the second year (clinical component) of PA education. Use of simulators and simulation strategies to learn these skills prior to clinical experience will improve comfort levels of students providing care (Donkers et al., 2016). The purpose of this study was to evaluate the use of simulation to assess students comfort level in providing care to the obstetric patient and assigning an Apgar to the neonatal patient.

This study was a pre- and post-test study questionnaire designed to assess student comfort level in being able to estimate cervical dilation; and deliver a neonate and assign

appropriate Apgar scores. Seventy-five PA students completed a 5-point Likert scale to assess comfort level prior to and post-simulation experience. Pre-simulation comfort level in assessing cervical dilation was 2.36 and post simulation activity was 3.65. Pre-simulation comfort level in delivering a newborn was 2.23 and post simulation was 3.42. Pre-simulation comfort level of assigning an Apgar score to a neonate was 2.99 and post simulation activity was 4.11.

The results of the study suggest that students comfort level increased for each skill/assessment post simulation activity. Thus, simulation allows for improved confidence in a student's ability to be able to recognize and estimate proper cervical dilation, assist in delivery of a newborn, and appropriately assign Apgar score to a neonate. Simulation education provides a safe and effective environment to allow students to practice skills which may be limited in clinical experience prior to engaging in the management and care of patients.

Studies using simulation-based education have shown that students trained utilizing this method have shown a significant increase in their clinical ability (Multak et al., 2015). Miller's framework of competence presents that learners first acquire their fundamental knowledge in the novice form and written examinations confirm learned knowledge and concepts while demonstrated skills can further assess the competency of student based on performance in a simulation setting (Multak et al., 2015). In the study, Multak et al. (2015) evaluated the effectiveness of a curriculum incorporating simulation with deliberate practice in teaching physician assistant (PA) student's physical exam techniques of cardiopulmonary assessment.

This was a controlled intervention study using a pre- and post-test design for both cognitive and skills domain. This was a multi-institutional study conducted at four different PA programs. Participants in the study were students in good academic standing, with geographic diversity and they all had completed a course in physical examination skills prior to the study. A

total of 56 PA students (12-17 from each program) enrolled in the study. Technique scores for cardiac examination increased by 8.7% from a pre-test mean of 83.5 to a post-test mean of 92.2 indicating significant improvement of student exam techniques with $p < .001$. The students' ability to identify abnormal cardiac exam findings improved by 19.1% with a pre-test score of 53.7 and a post-test score of 72.8. Student ability to perform and identify auscultatory findings showed a gain of 42.5% in a pre-test score of 41.7 and a post-test score of 84.2. Knowledge and cognitive abilities of the PA students improved post intervention with a pre-test score of 57.4 and a post-test score of 77.4. Self-confidence also increased from 2.79 to 4.04 on a 5-point Likert scale. Cognitive abilities increased by 20% with a free test average approximately 57% and a posttest of 77%.

The study results suggest that integrating a simulation-based education in a PA curriculum to teach and assess student knowledge and skills provide a valid and reliable method to teach cardiac examination techniques. The ability to provide a standard and reliable teaching method using simulation for students to learn normal and abnormal cardiac examination findings allows for an accurate assessment and learning competency.

There has been increased difficulty in establishing clinical experiences in the field of health sciences secondary to the increased number of learners and programs attempting to secure positions for these learners (Bai et al., 2012). Simulations can be used to validate the competency of health care professionals in place of actual patent exposure for procedures or skills (Bai et al., 2012). Simulation allows for repeated practice and remediation and the use of debriefing for reflective learning (Bai et al., 2012). Competence for learners occurs with repeated exposure, and when critical thinking skills are gained through exposure to differing situations during a

simulation (Bai et al., 2012). Bai, et al. (2012) developed a collaborative faculty initiative of a virtual learning prototype by utilizing a 3D virtual platform for simulation.

This was a pre- and post-test study design with an addition of a Likert-scale survey to assess student's attitudes toward the different formats of learning. Thirty-three students participated in a one-day workshop. The number of positive responses (LPOS) was statistically greater than the number of negative responses (LNEG) for Survey 1, $p < 0.0001$ and Survey 2, $p < 0.0001$. The statistically greater number of positive responses was maintained within each group for Survey 1 for control, $p < 0.0001$ and experimental, $p < 0.0001$) and Survey 2 for control, $p < 0.0001$ and experimental, $p < 0.0001$). Students enjoyed their experience of the case studies and the presentation of the interactive 3D simulation regardless of whether they received the initial case study via written text or 3D virtual simulation. However, no data was presented on pre-post-test learning experience.

This use of virtual reality has been shown to be a modality used for simulation experiences especially for surgical procedures. The study here suggests that integrating VR as part of the learning platform is liked by students. Further research needs to be completed to assess the validity of the results in order to integrate a VR platform into a curriculum to achieve competence in learners when clinical experiences for procedures are limited or not accessible to the learner.

Comparative Studies

The use of High-Fidelity (HF) simulators have become more common in residency training programs in order to achieve procedural and skills assessment for learners (Girzadas et al., 2007). The use of HF simulation to evaluate resident performance in the general competencies is required to ensure proper learner outcomes (Girzadas et al., 2007). The purpose

of this study was to determine if HF simulation-based evaluation using time measurement alone and identification of observable actions differentiate between novice and experienced residents in an emergency residency training program.

This was a prospective, comparative trial assessing resident performance in the competency of patient care. A simulated case of anaphylactic shock with upper airway obstruction was used and the simulator had standardized vital signs, trends, and programmed responses to therapeutic interventions of the learner (Girzadas et al., 2007). Only time measurements (stopwatch) and facilitator observable, objective events were assessed. The study sample was divided into two groups based on clinical experience, the novice group $n = 22$ included orientees and first year emergency residents. Residents had just completed medical school or had at least 9 months of emergency medicine training prior to the simulation experience. The experienced group $n = 22$ included second- and third-year emergency medicine residents. Each resident in the experienced group had successfully completed 1 or 2 Trauma rotation, ICU rotations, thoracic surgery rotation, and surgical airway training on at least one or more animal models. The novice residents took significantly longer 621 seconds than the experienced residents 512 seconds to achieve completion of surgical airway a $p = 0.028$. The novice residents also took significantly longer 534 seconds versus the experienced residents 442 seconds to achieve the secondary outcome which was time to start a surgical airway a $p = 0.043$.

The study results suggest that HF simulation-based assessment produces different time for completion between the novice and experienced residents in the competency of patient care. This is likely secondary to learner's experience level as demonstrated by Miller's pyramid. The experienced learners had more patient care experiences when compared to the novice learner

which resulted in a quicker reaction time to identify life-threatening medical decision-making assessment and skills completion.

Ahmed et al. (2019) completed a study to evaluate a newly designed boot camp curriculum to evaluate the use of simulation education for advanced practice providers (APPs) with minimal or no critical care experiences. The boot camp was designed to provide these APPs the opportunity to perform essential critical care procedures effectively and competently (Ahmed et al., 2019). The program was setup by three different instruction strategies, asynchronous learning completed by the student in a didactic format (required passing a multiple-choice test with score of 80% to proceed), formal hands-on instruction and simulation with evaluator feedback.

This was an educational quality assurance study with an $n = 9$ participants with varying levels of patient care experience and no critical care experience with the exception of ACLS training which is required for all providers. Pre-boot camp, a knowledge assessment, was completed in a written test for procedure prior to simulation with an average score of 84%. Average test scores post simulation for procedures was 88%. Pre-boot-camp self-efficacy assessment from learners was 50 and post was 62 with a mean increase of 0.8 for all procedures.

This small however educational experience demonstrated to be a valuable learning experience for the learners. The learner's post-simulation and boot-camp experience felt adequately trained to perform the tasks required in critical care units. Learners demonstrated competence by successfully completing tasks and procedures required to perform their clinical responsibilities for standard patient care within the critical care setting.

A study conducted by Littlewood et al. (2013) evaluated learner outcomes and understanding of shock between two groups, a case-based group and a simulation-based group.

Both groups were provided cases which were evenly distributed for evaluation. The case-based groups received a case presentation which was followed by the group developing a differential diagnosis for the case, patient assessment and diagnostic work-up and immediate and intermediate intervention plans. The simulation group was provided a brief patient history, followed by a patient evaluation with pertinent signs/symptoms supplied by the patient's nurse, followed by a deterioration in the condition of the patient requiring an intervention and stabilization, then a review of the differential diagnosis, diagnostic work-up, management and finally debriefing of the case.

This comparative study occurred over several months with an $n = 85$. A graph representation of all learners participating in the study comparing simulation to case-based discussion indicated superior performance in scenarios following simulation. In the two scenarios the simulation group demonstrated statistically significant improvement in performance in a post-test (Littlewood et al., 2013). The data was represented using paired differences with a 95% CI of the difference. Simulation SD for cardiac and sepsis was - 0.0014 and 0.0014 respectively and case based was 0.1531.

The data presented by the authors was difficult to interpret however the data provided does support the use of simulation to improve learner comprehension. Simulation augments learning by allowing the student to use previously learned knowledge and apply it to a scenario with critical thinking to work through the problem. This higher order thinking aligns with Miller's pyramid of progression from novice to expert.

Systematic Reviews

A systematic review of the literature conducted by Issenberg et al. (2005) from 1969 through 2003 resulted in the review of 109 articles relating to a simulation-based education using

high-fidelity medical simulation after selection of set inclusion and exclusion criteria was met. The purpose of this review was to examine the literature and ascertain the features which correlated with effective learning when utilizing high-fidelity simulation.

The authors identified 10 repeated characteristics throughout the literature using simulation-based education and high-fidelity simulation as educational interventions that positively influenced effective learning. These characteristics included a) *feedback* - 47% of the articles reported that feedback (during simulation, in real-time, or after/debriefing) as a principal feature related to learning; b) *repetitive (deliberate) practice* – 39% of the articles identified learners engaging in repetitive practice, focusing on skill acquisition that increased when procedures or skills were performed allowing learners the opportunity to correct errors or improve skills; c) *curriculum integration* – 25% of the articles detailed the need to have simulation as a standard component of the educational experience within the curriculum to achieve learning. The deliberate practice of using simulation throughout a curriculum allows learner engagement and improved learner outcomes; d) *range of difficulty* – 14% of the articles address utilizing a wide range of simulation activities from basic (early in education) to expert to achieve effective learning as an important variable in effective learning; e) *multiple learning strategies* – 10% of the articles addressed different learning strategies associated with simulation including, large groups, small groups, or independent. The educational objectives must meet the specific learning associated with the simulation and learners involved in the activity for effective learning; f) *capture clinical variation* – 10% of the articles addressed using simulation to represent a variety of scenarios; g) *controlled environment* – 9% of the articles addressed the learning environment as a feature which influenced effective learning. Allowing instructors and learners to focus on learning the skill or procedure without distraction or harm provides an

advantage in learning opportunities; h) *individualized learning* – 9% addressed active participation, learners taking an active role in their progress and being able to focus on components of the activity in order to achieve mastery in the skill;) *defined outcomes or benchmarks* – 6% of the articles addressed goals and assessment of skill or procedures for learner outcomes based on their level of training. A defined outcome for the high-fidelity simulation activity improved learning; j) *simulator validity* – 3% of the articles addressed how real the simulation activity needs to be in order to achieve the outcomes related to the learning activity.

Weaver et al. (2010) addressed the concept of teamwork as an essential component within the healthcare system to provide safe care especially in the critical care. Simulation training provides a venue for teams to practice in a safe environment to develop, practice and adjust competencies for effective team performance including communication, awareness, behaviors, closed-loop communication and interdisciplinary communication (Weaver et al., 2010). Simulation provides an effective learning environment by actively engaging the learner through deliberate repetitive practice, which allows the learner the ability to critically think, as well as perform procedures and receive feedback (Weaver et al., 20101). Simulation scenarios allow for a transfer of appropriate processing which is a manner of cognitive processing that is required to perform task or procedures in a safe environment. Weaver et al. (2010) conducted a qualitative analysis of existing peer-reviewed literature of simulation-based team training.

A systematic review resulted in 27 peer-reviewed articles meeting specific inclusion criteria for simulation-based team training. In the review, an analysis of the articles revealed that 15% (n = 4) indicated some need for training development, 85% (n = 23) no information, and

22% (*n* = 6) assessed baseline levels of teamwork experience or skills for learners. Competency training associated with simulation revealed 78% (*n* = 21) targeted teamwork communication, 48% (*n* = 13) situational awareness, 40% (*n* = 11) leadership, and 33% (*n* = 9) team member role clarification. However, 70% (*n* = 19) focused on teamwork skills.

The study results suggest that competency for effective and safe care requiring a team-based approach can be accomplished through simulation-based training. The use of this multidisciplinary approach targeting all team members allows for a training modality which is critical in providing safe care. Assessment of team-based skills has been used successfully by the American Heart Association to evaluate competency in learners.

The assessment of students and health professionals engaging in simulation-based education and training and the overall effectiveness of determining competency is difficult to achieve (Ryall, Judd, & Gordon, 2016). A systematic review of the literature was conducted between 2000 and 2015 to evaluate the current literature related to the use of simulation as a form of assessment for technical skills in health sciences education.

. Ryall, Judd, and Gordan (2016) identified 1,190 articles with an additional 33 by reference searches for an *n* = 1,223. Duplicate articles were discarded. With inclusion and exclusion criteria applied, 21 articles were used for the systematic review. Studies were separated by simulation theme, 40% used high-fidelity, 27% used standardized patients, 14% used virtual reality, 9% used manikins ranging from low to high-fidelity, 5% used medium-fidelity, 5% used part-task trainer and 2 studies compared standardized patients or low to high-fidelity patient simulators. High-fidelity simulation in general was found to have high reliability and validity of assessment, however the generalizability coefficients were less than what is

acceptable for a summative assessments with a G coefficient < 0.8. A formative assessment was found to be very reliable for low risk examinations. The majority of the standardized patient simulations used checklists to assess skills with varying degrees of clinical standards based on specialty. Checklist assessments varied as to whether or not standardized patient examinations were able to determine the level of experience, however they were reliable in assessing readiness to treat patients by the learner. Standardized patient examinations revealed low correlation with curriculum and were not useful as a primary source to determine clinical competence. Virtual reality simulation was found to be a valid assessment in distinguishing between novice and expert and is a useful modality for training prior to treating real patients. Mixed fidelity patient simulators revealed mixed benefits with high interrater reliability however written assessments and clinical simulation of assessments differed in a practical setting among raters. Mix fidelity allowed for immediate remediation of skills when they were not performed appropriately depending upon the learners needs in order to achieve competence.

The authors provide evidence suggesting that a combination of simulation techniques be utilized to assess clinical competence in learners. Competence for task related skills is most appropriately established when utilizing a specific task trainer. The use of standardized patient in conjunction with high-fidelity simulation allows for interrater reliability and assessment of learner competence, based on the clinical expertise of the evaluator. A combination of mixed-fidelity simulation allows for re-education and practice of individual learner's skill sets to achieve competence in tasks required to perform clinically.

McKinney, Cooke, Wood, and Hatala (2013) reviewed simulation-based medical education as an effective modality in training healthcare professionals in cardiac physical

examination techniques and to assess the instructional designs for teaching cardiac auscultation using simulation-based medical education.

Meta-analysis of the studies were grouped into two categories, one assessing knowledge outcomes, 343 learners and the other assessed skills outcomes,1074 learners. Simulation-based cardiac auscultation instruction pooled effect size was 1.10 (95% CI 0.49 – 1.72) for knowledge and was 0.87 (95% CI 0.52 – 1.22) for skills. These results suggest the simulation-based instruction has a positive effect on learner outcomes when learning cardiac auscultation.

Airway management and stabilization is often a life-saving skill performed by providers and required for critically ill patients. Experiences to practice establishing an airway for patients is difficult for providers to achieve secondary to the increased number of learners required to learn the skill or the inopportunity to perform the task. Thus, experiences are needed for providers to become and remain competent experts in airway management. Sun, Pan, Li, and Gan (2017) performed a systematic review to evaluate evidence in the literature comparing simulation-based training and non-simulation-based training (NSBT) in the effectiveness of airway management education.

The authors identified 9,086 articles for screening, and after specified inclusion and exclusion criteria this systematic review and meta-analysis consisted of 17 articles. The median sample size for the studies reviewed was 60. The majority of the studies were randomized controlled (13), and four studies were non-randomized two-group studies. The studies evaluated used virtual reality and high-fidelity simulators (7), partial-task simulators (7) and unspecified (3). Meta-analysis included learning outcomes such as time to complete the skill, behavior performance and learner knowledge. Findings of the study include: simulation-based training

having favorable effects for behavior of learners in comparison to NSBT with a pooled fixed-effects standard mean difference of 0.30 (95% CI). Also, simulation-based training has a favorable effect on learners' confidence compared to NSBT with confidence scores of 21 in the simulation-based training groups compared to NSBT groups.

The authors of this study provide supporting evidence for the use of simulation-based training for procedural competence in learners. The authors findings allows further review of simulation-based training on the behaviors and required skill acquisition for medical professionals to perform procedural tasks competently. Simulation-based training when compared to non-simulation-based training provides learners with greater confidence and ability to practice individual procedures to become and remain competent.

Simulation-based learning is increasing in medical education and in particular in the realm of surgical education (Theodoulou et al., 2018). It has been shown that simulation-based education provides the necessary skills and confidence required to perform a skill or task. Surgical education experiences for learners have decrease secondary to the work hour restrictions placed on learners (Theodoulou et al., 2018). A systematic review was completed by Theodoulou et al. (2018) as to how basic surgical training is evolving, to assess simulation-based education as a tool in education and to review the assessment methods and outcomes used by simulation-based learning studies.

Initially 2,371 potentially eligible titles and abstracts were found and after screening and using PICO data extraction, 40 articles were reviewed for this qualitative synthesis. Medical students participating in any form of simulation training, which included, any wet or dry laboratory learning, gross anatomy/cadaveric lab, and high or low fidelity simulation. Nineteen studies in the review assessed the effectiveness of simulation-based learning comparing students'

improvement pre and post learning activity. There were 16 studies that assessed the students' perspectives using a simulation-based training activity and 1 study was used to assess a new tool for surgical use and assessment. The 40 studies reviewed consisted of 12 using dry laboratory, 7 wet, 12 mixed (dry and wet), 9 gross anatomy and a comparison between the learning modality/intervention revealed a positive result of 75%, 57%, 92%, and 100% respectively.

A positive learning outcome for each intervention was found for each simulation activity. Results of this study suggest that there was no specific gold standard for surgical training and the use of simulation using any modality is proven beneficial for learning outcomes of learners. An improved acquisition of learners' skills, knowledge and confidence utilizing simulation-based learning improves competence.

Review of the literature/Perspective

Changes in healthcare delivery has decreased the ability of new learners to have the opportunity to experience certain procedures/interactions/skills secondary to limited patient availability, and training centers available to learners, along with the goal of reducing medical errors and improving patient safety (Scalese, Obeso, & Issenberg, 2008). Simulation allows for the practice of required skills, interactions, and procedures for assessment and demonstration of competence (Scalese et al., 2008). The purpose of the article by Scalese et al. (2008) was to demonstrate the increased use of simulation-based education and provide a general overview of the strategies used for training/education and assessment.

Training and assessment using simulators can focus on individual skills of learners and the effectiveness of teamwork (Scalese et al., 2008). Simulation allows the learner to respond and interact with the given scenario and team members as if it were a real-life experience (Scalese et al., 2008). The reduction of patient availability and learning opportunities require the

use of simulation as a means of educating learners effectively (Scalese et al., 2008). Simulators can be readily available for learners and they can be programmed to mimic a variety of clinical situations providing a standardized experience for all learners. A simulation-based education enhances the development skills required and also effectively builds team-based interactions in a safe environment (Scalese et al., 2008). Simulation also allows the learner to recognize mistakes and correct errors without harm to a patient or fear of performing the skill or procedure incorrectly. This experience allows a learner-centered approach to education (Scalese et al., 2008). Competency of learner's using a simulation-based education can be assessed by four different levels based on Miller's pyramid. The four levels include:

1) Knows – The learner is able to recall the basic principles, facts, and theories
2) Knows how – ability to apply the know or knowledge, able to solve problems, make decisions, and describe procedures
3) Shows how – the learner is able to perform, and demonstrate skills acquired
4) Does – or acts, behavior in real situations or practice

The learner's competency is evaluated by an educator in a simulation environment assessing, the learners critical thinking process, knowledge and the capability of applying skills or procedures learned in a controlled manner free from variability as the clinical encounter will be the same for all learners (Scalese et al., 2008).

The approach described by the authors can be used for various types of simulation education. The competency of the learner can be evaluated in a manner which allows for reflection by the learner once the assessment is provided by the examiner to the individual increasing individual reliability. Competency is further validated through the learner's ability to perform the task in an environment which is established and can be replicated.

The increasing use of simulation in medical education continues to expand across all education levels and specialties (Curtis, DiazGranados, & Feldman, 2012). The design of

simulation education/training is tailored to replicate real-world scenarios, specific skills using simulators and create conditions in which cognitive skills are required to achieve the outcomes designed for the simulation (Curtis et al., 2012). A review was completed to summarize the simulation literature and the level of fidelity required to achieve a balance of practicing skills and/or tasks to effectively train learners.

Curtis, DiazGranados, and Feldman (2012) identified three primary dimensions of fidelity to achieve learning appropriate for needs: physical, functional, and psychological. Physical fidelity incorporates the environment in which the simulation activity is replicated. This re-creation of the physical environment allows for sensory characteristics to be achieved such as personnel, support equipment, and arena allowing for a more realistic work environment. The use of low physical fidelity is useful in training new tasks as the focus is on developing basic foundational skills which then can be applied to a more complex environment for mastery learning. Functional fidelity incorporates using an interactive and active learning environment with the resources to enhance the overall learning experience. Psychological fidelity involves creating an experience which is as realistic to the real-world environment allowing for cognitive task analysis to perform required skills within the simulation scenario.

Educational goals utilizing simulation are impacted by the fidelity of simulation used and learning objectives should encompass these goals to achieve learner success. Activities should be learner specific allowing for the greatest benefit of the educational experience. The dimension discussed in this review will allow for a simulation education experience which incorporates the needs of the learner while addressing the skills needed to become competent in the task or skill.

Simulation training has been used in the military and aviation sector which are both high-stakes professions with improved learning by participants and improved safety outcomes

(Lawson, Reid, Morrow, & Gardiner, 2018). In healthcare education, simulation-based education positively influences learner outcomes and patient safety/outcomes. In a perspective article by Lawson, Reid, Morrow, and Gardiner (2018) an overview of simulation-based education and human factors is provided.

Human factors and the manner in which individuals respond are influenced by the situation and the environment (Lawson et al., 2018). Training associated with improving human factors can be accomplished through the use of simulation (Lawson et al., 2018). The World Health Organization has identified human factors which directly correlate to patient safety/outcomes in the clinical arena: safety culture, managerial leadership, communication, teamwork, situational awareness, decision-making stress, fatigue, and the work environment (Lawson et al., 2018). An in-situ simulation area (on the unit) or designated simulation center allows for replication of the work environment healthcare professionals are accustomed to working (operating room, emergency department, radiology suite, intensive care setting, etc.) while providing the learners with a life-like learning experience to perform deliberate practice, communication, procedural skills and team work in a safe and effective environment to reduce the human factors associated with a stressful environment (Lawson et al., 2018).

Providing a training environment which mimics the real-world allows for a simulation activity that improves learner competence, communication, and teamwork in a manner which reduces or eliminates adverse patient events. Simulation experiences provide the learner a safe place to practice, debrief and learn from others improving the human factors associated with outcomes related to patients. The idea of providing an in-situ simulation space allows the simulation experience to occur at any time reaching as many learners as possible.

Quantitative Meta-analysis

A study by McGaghie et al. (2011) compared traditional clinical education versus simulation-based medical education (SBME) with deliberate practice (DP) in order to compare skill acquisition. A traditional method of clinical education consists of the learner observing a skill, performing a skill and then teaching a skill also known as "see one, do one, teach one" (McGaghie et al., 2011). SBME allows the learner to participate in clinical/procedural experiences with simple task trainers, high-fidelity mannequins and virtual reality used to simulate clinical situations. Deliberate practice allows for processing of previous learned information and behaviors to improve skills and maintain skills (McGaghie et al., 2011). DP has defined learning objectives and tasks, and is used for highly motivated learners, with a rigorous, and focused repetitive practice which yields skill acquisition, allowing for informative feedback and correction by the learner to achieve mastery McGaghie et al., 2011).

This study is a quantitative meta-analysis of the literature between the years of 1990 to 2010. A total of 3,742 articles were reviewed and 14 research reports are used to complete the quantitative meta-analysis after completing specific inclusion and exclusion criteria. A total of 633 learners participated, 389 residents from surgical, medical and emergency residencies, 226 medical students, and 18 internal medicine fellows. SBME studies addressed a large number of competencies throughout specialties. Result of the meta-analysis comparing SMBE with DP and traditional clinical education suggest that SMBE with DP patient centered outcomes exceed that of traditional clinical education within 95% confidence intervals for each individual study reviewed.

SBME, when compared to traditional clinical medical education allows for improved clinical skills acquisition. Evidence supporting SBME is seen with improved patient outcomes,

and cost-effectiveness in health professional's education. SMBE with deliberate practice provides competence in learners.

Qualitative Synthesis

McGaghie, Issenberg, Bursuk and Wayne, (2014) conducted a review of simulation-based learning to assess two objectives. First, the authors evaluated the implementation of simulation-based learning along with immediate results in conjunction with the implementation, and transitional outcomes such as improvement in patient care/outcomes, and learning. Second, they addressed the use of simulation-based learning in medical education and healthcare. Simulation-based education (SBE) allows learners the ability to practice clinical skills in a safe and controlled environment. SBE allows learners to receive a formative assessment of skills and procedures, with feedback allowing the learner to achieve and maintain clinical competence (McGaghie, Issenberg, Bursuk, & Wayne, 2014).

This study was a qualitative synthesis of mastery learning. The authors searched multiple databases yielding 3514 articles between 1968 and 2013. Specific exclusion criteria established by the authors yielded a final $n = 23$ for review with publication dates were from 2006 to 2013. Mastery learning model has been used to assess skills of learners in medical education in numerous studies. Clinical skills evaluated in mastery learning included: interpersonal skills, technical skills and procedural skills (management of patients in an intensive care setting, thoracentesis, lumbar puncture, cardiac auscultation, advanced cardiac life support, central venous line placement, paracentesis, and laparoscopic surgery) these accounting for a major portion of learner outcomes.

The authors present findings from a study comparing training methods and outcomes between internal medicine interns (using simulator) and neurology residents (mastery learning) ability to perform a lumbar puncture (LP). Internal medicine interns demonstrated a wide range of skills at base-line in performing a LP using a simulator. Post a three-hour education session with deliberate practice and review, the interns in internal medicine achieved or out-performed the mastery standard of the neurology residents in performing LP's from clinical experience.

The critical review of the literature shows that simulation-based medical learning is an important educational practice which improves clinical skills in learners. Medical education research specific to simulation-based learning provides strong evidence that a curriculum which integrates simulation, deliberate practice, formative assessment, and debriefing/feedback has a substantial effect on the learners' knowledge and skills acquisition.

Mixed Methods Study

In order to promote learning, task complexity should be customized to the learners' level of knowledge as to provide new knowledge in which the learner can build upon and increase their proficiency (Trembley et al., 2019). Cognitive load theory describes the complexity of a task by the manner in which the elements interact (Trembley et al., 2019). Intrinsic cognitive load is the processing of new knowledge in the context of which it is taught (Trembley et al., 2019). Extraneous cognitive load is the use of the learners working memory of unrelated information which may result in a distraction in learning new information (Trembley et al., 2019). The educator should decrease the extraneous cognitive load from learners in order to promote learning associated with the intrinsic cognitive load (Trembley et al., 2019). Simulation education allows for learning opportunities associated with new information and the

development of procedural and cognitive skills (Trembley et al., 2019). The purpose of this study was to determine the effects of simple and complex tasks in simulation education in terms of cognitive load, individual learning and performance.

A mixed methods study conducted by Trembley et al. (2019) enrolled 167 second-year pharmacy students who were randomly assigned to participate in one simple and one complex learning task in a simulation educational activity. Results of the study found that students with previous work experience in a pharmacy showed a small correlation for intrinsic cognitive load for complex and simple task with a confidence interval of 95%. Also, significant differences were seen in intrinsic (1.72-2.23, CI 95%) and extrinsic (0.95-1.62, CI 95%) cognitive load and self-perceived learning (0.54-1.17, CI 95%) between complex and simple tasks. Simple task performance was appropriate 95.8% compared to complex task which was appropriate 85.5% of the time.

The results of this study suggest that an increase in the complexity of the task affects the problem-solving process producing a higher cognitive load. A simulation learning activity allows the learner the opportunity to process and manage scenarios which influence cognitive load in a safe environment. Activities which require higher order thinking allow the learner to become confident with practice which leads to learner competence for the task.

Observational Study

van Vught, van den Brink, Hilkens, and van Oers, (2018) conducted a study to investigate the role of the Physician Assistant (PA) as a provider in an intensive care setting as an alternative to medical residents (MR). The study was conducted to evaluate if the PA's ability to perform is at the same quality and clinical skill set of the resident. Increasing demands for staffing and continuity of care is required in the intensive care (ICU) setting and PA's have been

identified as a substitute for the shortage of medical doctors in this discipline (vanVught, van den Brink, Hilkens, & van Oers, 2018).

An observational study was completed to assess the clinical skills of PA's versus MR's utilizing human patient simulators (HPS) required to work in the ICU. Eleven PA's and 10 MR's participated in the study. PA's participating in the study had an average of 46 ± 17 months experience and the MR's had 12 ± 4 months experience. The total mean score of PA's found was 66% ± 13% compared to MR's 68% ± 9% for level of clinical skills. Individual scores for the 2 case scenarios were 70% ± 19% and 61% ± 11% for PA's and 76% ± 7% and 61% ± 16% for MR's. There were no differences between the two groups on total score $p = .66$.

The authors' findings show no significant difference in the skills required to staff an ICU in a simulation environment between PA's and MR's. There was no difference noted in clinical competency between the two groups. The benefit of having competent providers with equal skill sets established in the ICU setting allows for a continuity of patient care and also allows for training of new providers in the ICU.

Chapter 5

Discussion

Discussion

Similarities exist between the role of an educator and that of a coach in conjunction with the use of a simulation-based education model. Janes, Silvey and Dubrowski, 2016, state "teachers who use simulation as their teaching and learning technology function as coaches and not educators as they are currently labeled (p.1)." An educator's goal is to present information and knowledge to learners via a set curriculum and then test the learned information or knowledge utilizing both formative and summative assessments to ensure learner comprehension. A coach's goal is to emphasize individual skills and encourage team interaction to produce a specified result (Janes et al., 2016).

I would disagree with Janes et al. as they are completely misunderstanding the significant role and impact simulation-based education has on a learner's ability to build upon foundational learning. Educators use simulation as a bridge to apply theory into practice. Didactic sessions are lectures which rely on an educator's ability to deliver information to learners through a passive means, with the goal of knowledge acquisition. Simulation as an active learning strategy improves knowledge retention and creates an understanding of learned information. Educators are able to use formative assessment with immediate feedback to enhance learning in simulation. Learners are also able to reflect on the situation or scenario used in the simulation activity to reinforce the learning activity. Simulation educators are not coaches. They provide a specific learning experience which fosters a learners' success.

Health science and medical educators have an incredible responsibility of making sure the numerous procedures required for health science and medical professionals to perform

competently are attained above the minimum standard by all learners (Kovacs, Levitan, & Sandeski, 2018). Procedural and skills training is dependent upon how accurate and life-like the simulation experience is used to train learners to achieve a level of expert which is validated by the instructor or educator (Kovacs et al., 2018). This can only be accomplished when the advances in simulation-based education are utilized to their fullest potential as a component of clinical learning (Kovacs et al., 2018). An increase in a simulation-based educational approach is secondary to the advances in technology and the ability to provide real-word clinical experiences furthering a learner's opportunity for experiential learning (Curtis et al., 2012). Advances in technology have also provided educators the ability to augment instruction in traditional basic science content in undergraduate and post-graduate health science curriculums (Lipps et al., 2017). Simulation-based education with enhanced technological features allows for the blending of principles learners acquire in the basic sciences with its practical application (Lipps et al., 2017). These advances have allowed for the possibility of providing an immersive and realistic educational experience for all participants in an environment which replicates the clinical arena (Curtis et al., 2012). Educators are not merely coaches but an integral part of the simulation-based teaching strategy which provides the learner the expertise to practice competently in their profession.

Simulation is a teaching strategy available to educators as a component which complements an existing curriculum in health sciences and medical education (Motola et al., 2013). A simulation-based education can be incorporated into any level of education and throughout the entire curriculum requiring an evaluation of learner knowledge and competence. A diverse range of simulation-based educational scenario's, tasks, and skills can promote learning and learner performance in multiple areas of health science and medical education

(Scalese et al., 2008). Simulation-based education provides health science educators the ability to design a curriculum and learning environment suitable for learners to enhance the educational experience bridging theoretical knowledge for use in clinical and diagnostic skills while decreasing risk to patients with clinical on the job-training (Curtis et al., 2012). Simulation provides an environment in which cognitive skills associated with performing complex tasks can be practiced safely and effectively to become competent providers (Curtis et al., 2012). Simulation experiences produce an environment which accurately reproduces clinical work conditions through the integration of visual, auditory and kinesthetic domains of teaching and learning (Carron et al., 2011).

Deliberate or repetitive practice during a simulation is performing a skill or procedure repeatedly to ensure a cognitive or psychomotor understanding of the educational framework associated with the simulation activity (Motola et al., 2013). Deliberate practice used as a method to provide instruction to learners using simulation is regarded as the foundation for skill acquisition (Petrosoniak et al., 2019). Learners are able to receive informative feedback which allows for improved skill performance in a safe in controlled learning environment. Deliberate practice provides learners the opportunity to use simulation in training allowing the learner time to process learned information and strengthen skills (Motola et al., 2013). Deliberate practice benefits novice learners as well as experienced learners who require simulation learning to maintain clinical competence for procedures not used regularly in daily practice. Deliberate practice enhances the learner's ability to process information and improve upon the skill each time it is performed allowing for the transition from novice to expert (Motola et al., 2013). Deliberate practice has also been shown to be a strong predictor of professional achievement than clinical experience or educational performance (McGaghie et al., 2011).

Mastery learning used in conjunction with deliberate practice allows the educator the capability of providing task-oriented feedback to the learner during the simulation activity (Petrosoniak et al., 2019). Mastery learning provides clear learning objectives, educational activities (task-trainers, skills, and procedural tasks), formative assessment, and continued practice until mastery is achieved (Motola et al., 2013). Learning objectives and outcomes serve as benchmarks for learners to achieve in a simulation activity as well as across the board in a health science curriculum (Motola et al., 2013). Deliberate practice in conjunction with mastery learning, divides learner tasks into a group of smaller tasks (individual task-trainers) and then increases the complexity of the task (simulation, and team-based interactions) to ensure learner competence (Petrosoniak et al., 2019). Learner outcomes provide a clear understanding for the faculty serving as a guide to provide learner specific content, educational instruction and feedback (Motola et al., 2013). The learning objectives and outcomes, along with the learning environment, greatly influence knowledge and skill acquisition by the learner (Motola et al., 2013). Learners' progress through each simulation by applying previously learned skills they have acquired in the previous task (Petrosoniak et al., 2019). Mastery learning with deliberate practice require standards to determine when the learner has achieved the level of expert (Motola et al., 2013). The goal of mastery learning with deliberate practice is to make certain that learners achieve the objective and outcomes at a higher-level of competence (Motola et al., 2013). Simulation-based mastery learning has been shown to improve skills for learner's and provide retention of the learned skill or task (Motola et al., 2013). Deliberate practice with masterly learning has been shown to improve learner performance across different disciplines including sports and music and increasing evidence based on the literature supports its use in medical education as an effective modality to achieve learner competence (Petrosoniak et al., 2019).

Learner feedback is a critical component to ensure effective learning in simulation-based education (Motola et al., 2013). Learner feedback and debriefing is a process of reflective observation, abstract conceptualization and active participation in the learning cycle by learners and directed by educators who guide learners in the understanding of the simulation scenario, allowing reflection of their simulation experience to improve future performance (Burns, 2015). Instructor or educator feedback during the simulation can be provided at any time throughout the learning activity allowing for corrective actions during procedural skills training or at the end of a session when a complex scenario is being performed. Feedback makes certain that learners have a clear understanding of the learning outcomes expected and allows the learner the opportunity to bridge previously learned information to current simulation activity and what may be required in future practice (Swanwick, 2010, p.171). Debriefing and learner feedback after a simulation learning activity was found to be the most important aspect of the educational experience associated with simulation (Motola et al., 2013). Feedback provides the learner with positive reinforcement and strengthens technical and procedural skills (Swanwick 2010, p.171). Feedback is a reflective conversation between an educator and learner which focuses on and reviews the learners' performance during the simulation activity and what the actual performance should have been to achieve the learning outcomes (Center for Medical Simulation, 2020). Debriefing allows the learner the opportunity to reflect upon the simulation experience and subsequently analyze the learning activity with other learners in their experience. Feedback guarantees that learning objectives are met and discussed upon completion. Feedback should be conducted throughout and at the completion of a simulation activity to complement the learning process and promote reflective learning thereby producing providers who are competent in their profession (Swanwick, 2010, p.171).

Conclusion

The outcomes of this research present strong evidence supporting a simulation-based teaching strategy. The research focused on selected literature which supports a simulation-based education to achieve competence in learners. The literature review specifically focused on: (a) history of medical simulation, (b) fidelity used in simulation training, devices and equipment, (c) learning theories associated with simulation-based education, (d) role of deliberate practice in simulation training in medical and health sciences education, e) advantages and disadvantages of simulation training, f) competence in simulation-based education, g) debriefing and feedback in simulation.

Research conducted over the last three decades provides evidence that a simulation-based educational teaching strategy composed of a curriculum which integrates simulation early in learning providing deliberate practice, assessment of learning, debriefing and feedback, instructor and faculty preparedness with organizational support and an environment dedicated to simulation provides knowledge retention and skills acquisition and maintenance among health science and medical learners (McGaghie et al., 2014). Simulation alone does not achieve or guarantee learning, but when simulation is designed and incorporated into an educational curriculum it provides a learning environment which enhances the adult learning theory and achieves competence in learners (Jones et al., 2015). Simulation-based education integrates the principles of the adult learning theory building upon previously learned knowledge and experiences (Lipps et al., 2017). A simulation-based teaching strategy can be designed to accommodate the various learning styles of participants in a lesson/session being taught allowing all learners the ability to learn and retain the information (Lipps et al., 2017).

Simulation-based education provides learners an experiential learning experience which is effective and demanding in comparison to achieving learning opportunities which may not be acquired through clinical experiences (Weller et al., 2012). Simulation replicates real-world experiences and patient interactions increasing learner memory retention when used along with the didactic component of the curriculum (Lipps et al., 2017). Clinical interactions with a patient provides learners a foundation to improve clinical decision-making prowess however instructional designs supporting the different domains of medical education are supported and augmented by a simulation-based education (Weller et al., 2012).

A simulation-based education provides effective training for the development of skills and improves team-based communication and collaboration with a goal of producing a safety-oriented healthcare culture (Scalese et al., 2008). A learner-centered educational experience evolves when participating in simulations activities especially when performing and learning complicated procedures without causing harm to patients (Scalese et al., 2008). Designing a curriculum to foster the learning experience for all participants will produce competent health science professionals (Motola et al., 2013). Simulation-based education can be used throughout a lifetime of learning. A simulation-based teaching strategy provides competence in learners and has excellent potential for use throughout healthcare education from undergraduate to continuing medical education.

Recommendations

Instructor Training

Health science educators require a distinctive and specific pedagogical skill set to provide an effective teaching strategy to promote learning in simulation (Nestel et al., 2016). Australia

developed task force of individuals to design a program to "train-the-trainer" specifically in simulation-based education. The task force resulted in the development of the Australian Simulation Educator and Technician Training Program (AusSETT) which is used to educate educators in simulation with a curriculum and skillset to train other educators and technicians to provide a uniform instruction throughout Australia for use by all health professional educators (Nestel et al., 2016). The standardized program ensures that the curriculum for simulation-based education is taught the same throughout Australia. The program contains ten modules as seen in Table 6, 2 core modules (C), 4 educator modules (E) and 4 technician modules (T), administered via e-learning and workshops.

Table 6

Curriculum modules Australian Simulation Educator and Technician Training Program

Module	Description of Learning
C1	Module provides a background for the use of simulation in high-risk industries (aeronautical, military) and compares them with health care. Module provides theory and teaching strategies used in a simulation-based education. Introduces different fidelities used in simulation. History of simulation in healthcare is provided with current trends. Advantages and disadvantages of a simulation - based education. Improved safety and quality of education research is presented. Mandatory module for all learners.
C2	Principles of training the trainer are provided. Learn and practice new simulation skills. Provides education relating a safe learning environment, feedback and debriefing. Mandatory module for all learners.
E1	Module provides education different manikins and task-trainers including low and high fidelity. Different scenarios established and an overview of how to program manikins for use in the scenarios is completed.
E2	Module provides education on the employment and use of standardized patients in simulation.
E3	Module provides education on virtual reality as a simulation option and how to integrate this modality in the set curriculum.
E4	Module provides instruction on how to use different simulation modalities together to enhance the simulation activity.
T1	Module provides instruction on the equipment ranging from use to maintenance and repair. Also, the technician's role in simulation scenarios.

T2 Module provides instruction on low-fidelity technical aspects of simulation manikins including ability to operate the manikin and the use different supporting features.

T3 Module provides instruction on high-fidelity manikins and capabilities associated with each.

T4 Module incorporates the previous 3 technician modules and instructs how to set-up a simulation scenario and deliver the contents associated with the simulation learning activity for each manikin used.

Simulation educators should be certified and have an understanding of the pedagogical skills associated with a simulation-based teaching strategy and education. Instructor certifications are available through:

- Harvard Medical School, Center for Medical Simulation (https://harvardmedsim.org/course-type/instructor-training-at-cms/)
- Society for Simulation in Healthcare, Certified Healthcare Simulator Educator (https://www.ssih.org/Credentialing/Certification/CHSE)
- Drexel University, Certificate in Medical and Healthcare Simulation (http://catalog.drexel.edu/graduate/schoolofbiomedicalsciences/medicalandhealthcaresimulation/index.html)

Curriculum Integration

Early curriculum integration is a critical component in a simulation-based education for it to succeed and be effective (Motola et al., 2013). Simulation-based teaching strategy is a method healthcare educators can use within a curriculum to achieve learning outcomes. In a simulation-based teaching strategy the healthcare educator needs to define specific learning outcomes, once the outcomes are identified learning objectives can be established and different teaching

strategies can be explored to achieve the outcomes (Motola et al., 2013). One strategy for curriculum development is designing a curricular map pertaining to the concepts each simulation activity is attempting to achieve in order to create the appropriate learning opportunity for each course (Aebersold, 2018). This allows educators the ability to create simulation learning activities which focus on particular content without repeating previously learned information from other courses (Aebersold, 2018).

A curriculum planning committee with a designated course director is vital to the integration of a simulation-based education in a curriculum (Motola et al., 2013). Regular set meetings with a curriculum planning committee is required to ensure a proper timeline is maintained for the integration (Motola et al., 2013). Faculty must be supported throughout the integration process, allowing time for training, scenario development, and assessment processes (Motola et al., 2013). Technical support is an important aspect of a simulation-based educational program because the faculty needs to be properly trained on the different fidelities used and continued support form technicians is required to setup, maintain and repair the simulation equipment. An evaluation process of the curriculum should be on going and revisions made accordingly in order to achieve desired outcomes (Motola et al., 2013). The need to standardize curricula and ensure that learners achieve mastery of critical competencies for their profession makes a simulation-based teaching strategy particularly important (Motola et al., 2013).

Simulation Fidelity

Each simulation activity should have the appropriate fidelity required to achieve the outcomes associated with the learning activity. Simulations which are able to capture or recreate different patient experiences, problems and conditions are beneficial to the learner than a narrow

learning experience (Motola et al., 2013). In the design of a curriculum using simulation-based education the fidelity level should be appropriate for the educational level of training and the skill or task being taught (Munshi et al., 2015). Task-trainers should be utilized when the learner is learning a specific skill or procedure. Low-fidelity mannequins are used for simulation activities such as teaching cardiopulmonary resuscitation or intubation. High-fidelity mannequins are utilized for team-based simulation scenarios and simulation experiences in which a physiologic response to a treatment is required for learner competence. Virtual reality simulations are appropriate for e-learning and advanced skills procedure such as laparoscopy training in surgical education. Standardized patients are used in simulation to complement learning, actors are able to respond to clinical questioning regarding a disease or illness allowing the learner to interact with a patient in a manner which allows for individual confidence building and desirable patient interactions.

Learning Environment

A dedicated simulation center should be used when providing a simulation-based education and teaching strategy. A simulation center can be a dedicated facility which houses all of the available equipment required to run a simulation activity, or it can be a designated space within a learning center or hospital. Choosing the appropriate learning site for a simulation activity is an important component of the learning. Dedicated simulation center can be part of a hospital or academic center. In a dedicated simulation center the facility is maintained as a simulation learning environment, appropriate fidelity simulators are available, recording and audiovisual equipment is integrated into each room, dedicated post-simulation activity rooms are available for feedback and debriefing and simulation technician prepare and maintain all the equipment. There are also in-situ training rooms which are part of hospital within a department

which resemble the clinical work environment utilized to perform simulation activities which may be encountered on a daily basis enhance and strengthen team interactions (Sorensen et al. 2017).

Repetitive/Deliberate Practice/ Mastery Learning

A major advantage of a simulation-based education is that it allows educators the ability to create a learning environment that uses deliberate practice to ensure performance outcomes and competence in learners (Weller et al., 2012). Detailed skills assessment and learner feedback in a controlled learning environment are a key component in the learning associated with deliberate practice (Motola et al., 2013). The repeated or deliberate practice of a skill or task enhances a learners psychomotor and cognitive skills associated with the learning activity (Motola et al., 2013). A simulation-based education allows all learners to transition from novice to expert in the setting of repetitive deliberate practice. Mastery learning is acquired when learners are able to apply the theoretical knowledge learned and apply it to the skill or tasks associated with a procedure masterfully and competently. Providing learners an ideal environment promoting deliberate practice is key in a simulation-based teaching strategy.

Assessment/Feedback

In simulation-based education debriefing and feedback are identified as the most important components of effective learning (Sawyer[1] et al., 2016). The debriefing component of simulation should be a structured and informative session for the learner. Debriefing or feedback should be provided during a simulation activity if warranted, or at the completion (Motola et al., 2013). Educators require training in feedback and debriefing to effectively use this component of the educational process to reinforce learning (Motola et al., 2013). Educator or instructor guided

post simulation debriefing is the most common form of feedback used to recap the simulation activity allowing learners the chance to reflect on their actions and what they have learned from the simulation activity (Sawyer[1] et al., 2016). Training in the debriefing and feedback aspect of simulation for educators can be accomplished by reviewing the literature, view e-learning training modules, and formal instructor courses (Motola et al., 2013).

Continuing Medical Education

Simulation-based education is an excellent strategy to maintain skills for practicing healthcare providers. The simulation educational activities should be specific to the group being taught. Simulations focused on procedures or task should be limited to the number of training simulators available and the appropriate number of learners per instructors is 3-4 to 1 (Shanks et al., 2010). Team-based and intra-professional simulations are utilized for recertification of advanced cardiac life support, pediatric advanced life support and neonatal resuscitation programs. These programs require a team-based simulation-based educational program every two years to ensure provider competence.

Future Research

A simulation-based education and teaching strategy has been shown to provide competence in learners. Further research is still required to establish a standardized learner assessment across multiple medical and health science educational domains. A standardized assessment of learner outcomes and competence will ensure that the educational experience for each healthcare profession is the same regardless of the institution of higher learning. A standardized assessment of learner competence will further strength a simulation-based teaching strategy.

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